Exelon Generation

300 Exelon Way
Kennett Square, PA 19348

June 21, 2019

Ms. Celeste Stout
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
1315 East-West Highway
Silver Spring, MD 20910

Re: Eddystone Generating Station
Updated Individual Incidental Take Permit Application

Dear Ms. Stout:

As you requested, Exelon Generation Company, LLC ("Exelon") has updated its December 20, 2018 application for an Individual Incidental Take Permit ("IITP") for Atlantic sturgeon (*Ascipenser oxyrinchus*) and shortnose sturgeons (*A. brevirostrum*) under Section 10 of the Endangered Species Act for Eddystone Generating Station ("Eddystone") to remove the discussion of dredging as a covered activity. Maintenance dredging at Eddystone, along with other facilities on the Delaware River, is addressed under a U.S. Army Corps of Engineers ("USACE") permit issued to Weeks Marine, Inc. (Permit No. CENAP-OP-R-2013-0695-46). Furthermore, by letter dated September 5, 2014, National Marine Fisheries Service ("NMFS") concurred with USACE's conclusion that maintenance dredging at the facilities covered under Weeks Marine's USACE permit was not likely to adversely affect sturgeon species.

In summary, Exelon deleted the discussion of dredging as a covered activity throughout the application, added a paragraph in Section I updating the procedural history to explain the basis for the removal of dredging as a covered activity, and noted in Section I.B.4 that the reports required under 40 CFR 122.21(r) have been submitted to PADEP. Otherwise, the application is identical to the application Exelon submitted on December 20, 2018.

Per our discussions, we are only submitting an electronic copy of the complete application. Please feel free to contact Amy M. Hetherington (267-533-1149 or amy.hetherington@exelon.com), Maureen V. Heimbuch of AKRF, Inc. (646-388-9659 or mheimbuch@arkf.com), or me (610-765-5514 or robert.matty@exelon.com) if you have any questions or require additional information.

Respectfully submitted,

Robert M. Matty, Jr.
Manager – Environmental Programs

Encl. (1)

cc:	J. M. Dick, Exelon	(with enclosure)
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APPLICATION FOR AN INDIVIDUAL INCIDENTAL TAKE PERMIT UNDER THE ENDANGERED SPECIES ACT OF 1973 AND 50 CFR 222.307 AND HABITAT CONSERVATION PLAN

EDDYSTONE GENERATING STATION
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EDDYSTONE, PA 19022
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June 2019

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ASMFC	Atlantic States Marine Fisheries Commission
BTA	best technology available
°C	degrees Celsius
C&D	Chesapeake and Delaware
CCRS	closed-cycle recirculating system
cfs	cubic feet per second
Clean Water Act	Federal Water Pollution Control Act of 1972
cm	centimeters
cm/s	centimeters per second
Company	Exelon Generation Company, LLC
CUR	capacity utilization rate
CWIS	cooling water intake structure
CWP	circulating water pump
CWWS	cylindrical wedgewire screens
Delaware	Delaware River Estuary
ΔT	change in temperature above ambient
DIF	design intake flow
DO	dissolved oxygen
DPS	distinct population segment
DRBC	Delaware River Basin Commission
Eddystone	Eddystone Generating Station
ESA	Endangered Species Act
Exelon	Exelon Generation Company, LLC
°F	degrees Fahrenheit
fps	feet per second
ft	feet
gpm	gallons per minute
HCP	Habitat Conservation Plan
HDA	Heat Dissipation Area
HDR	HDR, Inc.
IITP	individual incidental take permit
in.	inches

km	kilometers
m	meters
m/s	meters per second
MGD	million gallons per day
mg/L	milligrams per liter
mi	miles
MLW	mean low water
MLLW	mean lower low water
mm	millimeters
MRTS	modified Ristroph traveling screens
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
OTCW	once-through cooling water
PADEP	Pennsylvania Department of Environmental Protection
PCB	polychlorinated biphenyls
PJM	PJM Interconnection, L.L.C.
PMP	Pollution Minimization Plan
ppt	parts per thousand
River	Delaware River Estuary
RKM	river kilometer
RM	river mile
RWP	river water pump
Services	NMFS and USFWS
Station	Eddystone Generating Station
SWQS	surface water quality standards
T/E	threatened or endangered
TL	total length
TMDL	total maximum daily loading
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
VSP	variable speed pump

WTP	wastewater treatment plant
YOY	young-of-the-year
Zone	Water Quality Zone

I. INTRODUCTION

Exelon Generation Company, LLC ("Exelon" or the "Company") is submitting its application for an individual incidental take permit ("IITP") to the National Marine Fisheries Service ("NMFS") for its Eddystone Generating Station ("Eddystone" or "Station"). This IITP application is being submitted pursuant to Section 10(a)(1)(B) of the Endangered Species Act ("ESA") of 1973, as amended, 15 U.S.C. 1531 et seq., and its implementing regulations at 50 CFR Parts 216 through 222, as applicable. Throughout the course of preparing this IITP application, Exelon has sought and received input and guidance from NMFS on the scope of the application and the analytical methods to be used, as identified below.

On February 28, 2017, Exelon held an initial pre-application meeting to advise NMFS that Exelon had initiated efforts to prepare an IITP application[1] and to review Exelon's analytical methods proposed for estimating potential incidental takes of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*A. brevirostrum*). On January 25, 2018, Exelon met again with NMFS to discuss Exelon's revised approach for estimating the potential incidental take of Atlantic sturgeon following the entrainment of a single larva at Eddystone in May 2017. Exelon also sought guidance on developing a Habitat Conservation Plan ("HCP") for the Station at this meeting. Additionally, NMFS provided input on the review and coordination between the NMFS offices in connection with the IITP and Eddystone's National Pollutant Discharge Elimination System permit renewal application, noting that the Silver Spring office would coordinate with its Greater Atlantic Regional Fisheries Office.

On June 28, 2018, Exelon held an additional meeting with NMFS to review its draft application and to obtain feedback from NMFS on its potential approach for addressing impingement mortality in the Station's National Pollutant Discharge Elimination System ("NPDES") renewal application. NMFS did not raise any objections to Exelon's proposal to rely primarily on reductions in flow to address impingement. NMFS did, however, request that Exelon revise the application to include a discussion of recent scientific literature on Atlantic sturgeon and provide additional information to address vessel strikes in the HCP.

On December 20, 2018, Exelon submitted its IITP application for Eddystone to NMFS that addressed the input provided by NMFS on the Company's draft application. In May 2019, NMFS raised questions concerning the potential that dredging would adversely affect sturgeons (Stout 2019a). In discussions with NMFS, Exelon noted dredging at the Station has been covered under permits issued by the U.S. Army Corps of Engineers ("USACE") to Weeks Marine, Inc. for maintenance dredging at 31 locations along the Delaware River, including Eddystone, but that the permit did not include a reference to a Section 7 consultation (Matty 2019). Exelon forwarded a copy of USACE permit number CENAP-OP-R-2013-0695-46 to NMFS in early June (Heimbuch 2019). Subsequently, NMFS (Stout 2019b) advised Exelon that the Weeks Marine, Inc. permit for maintenance dredging in the Delaware River had already undergone informal Section 7 consultation, which concluded that maintenance dredging was not likely to adversely affect sturgeon species (NMFS 2014c). NMFS further advised that Exelon did not need to evaluate the potential effects of dredging or include dredging-related provisions in the HCP. Exelon revised its IITP application accordingly and resubmitted the application on June 21, 2019.

Exelon is submitting this IITP application to address the potential for incidental take of Atlantic and shortnose sturgeon. Takes may occur as a result of the withdrawal of cooling water from the

[1] Since that time, Exelon has been collecting entrainment data, which was required to complete this IITP application.

Delaware River Estuary ("Delaware" or "River"), the discharge of heat and other pollutants to the River associated with the operations of the facility, and/or the transport of fuel oil to the Station via barge.

This IITP application addresses the Delaware in the immediate vicinity of Eddystone's cooling water intake structure ("CWIS"), including the circulating water pumps ("CWPs") and the river water pumps ("RWPs"), the areas potentially occupied by the Station's thermal discharge plume and other effluent waste streams, and the portions of the waterway affected by delivery of fuel oil via barge. This IITP application includes a proposed monitoring and reporting plan for entrainment and impingement. A single Atlantic sturgeon larva was collected in the 2017 entrainment sampling program. No sturgeon has been impinged at the Station; however, there is the potential for impingement as juveniles and subadults of both species utilize the River in the vicinity of the Station.

A. Covered Species

As noted above, Exelon is submitting an IITP application that addresses both Atlantic sturgeon and shortnose sturgeon. Exelon is seeking a take limit for the entrainment of early life stages of Atlantic sturgeon, take limits for impingement of both sturgeon species, and a take limit for Atlantic sturgeon mortality associated with vessel strikes. A brief description of the listing status and management populations for both species is given in this Section. More detailed life history information on each species is provided in Section IV.

1. Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)

NMFS recognizes five distinct population segments ("DPS")[2] of Atlantic sturgeon. Sturgeon present in the vicinity of Eddystone are expected to belong to the New York Bight DPS, which includes fish originating from the Hudson and Delaware Rivers.

In 1998, the Atlantic States Marine Fisheries Commission[3] ("ASMFC") established a coast-wide moratorium on the harvest of Atlantic sturgeon (ASMFC 1998). In 2007, the Atlantic Sturgeon Status Review Team (2007) reported that stocks were near historically low levels throughout the species' range. Based in part on this information, NMFS proposed listing Atlantic sturgeon under the ESA in October 2010. On February 6, 2012, NMFS designated the Gulf of Maine DPS as threatened under the ESA and the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs as endangered (NMFS 2012). In the preamble to the final regulations, NMFS noted that, "Based on surveys conducted in the Hudson and Delaware Rivers, entrainment and impingement does not appear to be a primary threat to Atlantic sturgeon" (NMFS 2012). On August 17, 2017, NMFS designated critical habitat for this species including the reach of the Delaware from the Trenton-Morrisville Route 1 Toll Bridge downstream to where the river mouth discharges into Delaware Bay (NMFS 2017b). In the critical habitat designation, NMFS identified an increase in sturgeon abundance through improved reproductive success and recruitment as a key conservation objective for the New York Bight DPS (NMFS 2017b). Further detail on the critical habitat designation for Atlantic sturgeon is provided in Section I.B.1. The Delaware River Basin Commission ("DRBC") (2017) recently passed Resolution 2017-4 that, in addition to recognizing

[2] Gulf of Maine DPS, New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, and South Atlantic DPS
[3] The ASMFC is comprised of representatives of state and federal agencies charged with cooperatively managing shared and migratory marine, coastal, and anadromous fish species with ranges that across inter-jurisdictional boundaries (i.e., state and federal) along the Atlantic coast.

the improved water quality within Water Quality Zones ("Zone") 3 and 4[4] and the northern part of Zone 5, included DRBC's intent to initiate a rulemaking to determine if the designated aquatic life uses should be amended to include fish propagation. DRBC recognized the need to conduct additional aquatic life and water quality studies before proposing new regulations and that these additional studies would include consultation with NMFS in connection with Atlantic sturgeon.

2. Shortnose Sturgeon (*A. brevirostrum*)

Within the geographic range of shortnose sturgeon from New Brunswick, Canada to Saint Johns River, Florida, NMFS recognizes nineteen distinct sub-stocks of shortnose sturgeon belonging to one of five distinct regional populations: Gulf of Maine, Connecticut/Housatonic Rivers, Hudson River, Delaware River/Chesapeake Bay, and Southeast Rivers (SSSRT 2010). Unlike Atlantic sturgeon, which are highly migratory and move among rivers and coastal ocean habitats, shortnose sturgeon are largely limited in distribution to their natal river. Shortnose sturgeon from other rivers are not likely to occur in the Delaware.

In 1967, the United States Fish & Wildlife Service ("USFWS") listed shortnose sturgeon as endangered throughout its range under the ESA; USFWS attributed the decline to a combination of overfishing, habitat loss, and historic water pollution (USFWS 1967). Subsequent to its listing, NMFS developed a biological assessment and recovery plan for the species (NMFS 1998; SSSRT 2010). Critical habitat has not been proposed or designated for this species.

B. Regulatory Framework

The key regulatory programs relevant to this IITP application include: Section 10(a)(1)(B) of the ESA of 1973 (15 U.S.C. 1539(a)(1)(B)) and its implementing regulations at 50 CFR Part 222; the Federal Water Pollution Control Act of 1972 (33 U.S.C. 1251 et seq.) as amended ("Clean Water Act"); the United States Environmental Protection Agency's ("USEPA") regulations implemented at 40 CFR Parts 122 and 125, including its recently promulgated regulations governing CWISs at §122.21(r) and Part 125 (collectively, NPDES), Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities, 40 CFR Parts 122 and 125 ["§316(b) Rule"]); Sections 3.8 and 11.2 of the Delaware River Basin Compact of 1961, administered by the DRBC; and Pennsylvania's Clean Streams Law, as amended, 35 P.S. Section 691.1 et seq.

1. Federal Endangered Species Act

In broad terms, the ESA establishes a framework for protecting any species listed as federally threatened or endangered ("T/E"). It prohibits any federal action that would jeopardize T/E species or destroy or adversely modify their critical habitat and further requires USFWS and NMFS (collectively, the "Services") to develop programs aimed at conserving and restoring these species. The ESA further prohibits the "take" of T/E species, which is broadly defined to mean "to harass, harm, pursue, hunt,

[4] Eddystone is located within Zone 4. See Section III for more information on Eddystone's location and the source waterbody.

shoot, wound, kill, trap, or collect, or attempt to engage in any such conduct." The ESA defines "critical habitat" for T/E species in Section 3[5] of the ESA as:

> (i) the specific areas within the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.[6]

The ESA also establishes civil and criminal penalties for violations of these prohibitions and authorizes action by private parties to bring enforcement actions, in cases where the Services do not comply with their statutory obligations. However, the ESA establishes a permitting program to afford private entities the ability to obtain a permit for lawful activities that would otherwise result in an unlawful take of a T/E species. This permitting program, under Section 10(a)(1)(B), is the provision of the ESA relevant to this IITP application. Section 10(a)(1)(B) provides that:

> The Secretary may permit, under such terms and conditions as he shall prescribe…any taking otherwise prohibited by section 9(a)(1)(B) if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

Section 10 further establishes the information that must be submitted to obtain an IITP. For example, section 10(a)(2)(A)[7] prescribes the information that must be included in the HCP, as follows:

> (2)(A) No permit may be issued by the Secretary authorizing any taking referred to in paragraph (1)(B) unless the applicant therefor submits to the Secretary a conservation plan that specifies—
>
> (i) the impact which will likely result from such taking; (ii) what steps the applicant will take to minimize and mitigate such impacts, and the funding that will be available to implement such steps; (iii) what alternative actions to such taking the applicant considered and the reasons why such alternatives are not being utilized; and (iv) such other measures that the Secretary may require as being necessary or appropriate for purposes of the plan.

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[5] 16 U.S.C. 1532(5)(A)
[6] As discussed in Section I.A, NMFS has designated critical habitat for Atlantic sturgeon in the Delaware, among other east coast rivers. The Services have not designated critical habitat for shortnose sturgeon.
[7] 16 U.S.C. 1539(a)(2)(A)

Additionally, Section 10(a)(2)(B)[8] defines the standards NMFS must apply when determining whether to issue an IITP:

> (B) If the Secretary finds, after opportunity for public comment, with respect to a permit application and the related conservation plan that—
>
> (i) the taking will be incidental; (ii) the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking; (iii) the applicant will ensure that adequate funding for the plan will be provided; (iv) the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and (v) the measures, if any, required under subparagraph (A)(iv) will be met; and he has received such other assurances as he may require that the plan will be implemented, the Secretary shall issue the permit. The permit shall contain such terms and conditions as the Secretary deems necessary or appropriate to carry out the purposes of this paragraph, including, but not limited to, such reporting requirements as the Secretary deems necessary for determining whether such terms and conditions are being complied with.

In addition to the language of the ESA, itself, NMFS has promulgated regulations at 50 CFR Part 222 that are also applicable to the IITP application process as well as a joint NMFS/USFWS guidance manual, The Habitat Conservation Planning and Incidental Take Permit Processing Handbook (USFWS and NMFS 2016), that specifically addresses the HCP, which includes the core components of an application. This manual also includes guidance for an expedited permitting process for "activities that are minor in scope and impact," which are referred to as "Low-Effect HCPs," and are defined as follows:

> Low-effect HCPs – Those HCPs involving minor or negligible effects on federally listed, proposed, or candidate species and their habitats covered under the HCP and minor or negligible effects on other environmental values or resources. For an HCP to qualify as low-effect, it must also qualify as a categorical exclusion under NEPA.

In determining whether an IITP application should be processed as a Low-Effects HCP, the Services may consider minimization and mitigation efforts. Accounting for such efforts may result in impacts so minor as to be considered negligible (USFWS and NMFS 2016).

On August 17, 2017, NMFS issued its final rule designating critical habitat for Atlantic sturgeon (NMFS 2017b). Under this rule, the Delaware River from the river mouth at the head of Delaware Bay (River Kilometer ["RKM"] 0 [River Mile ("RM") 0]) to the crossing of the Trenton-Morrisville Route 1 Toll Bridge (RKM 213.5 [RM 133.3]), which is upstream of Eddystone, is designated as critical habitat.

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[8] 16 U.S.C. 1539(a)(2)(B)

The final rule identified the habitat components necessary to support successful reproduction and recruitment[9] as including:

- hard bottom substrate in low salinity waters (i.e., 0.0-0.5 parts per thousand ([“ppt”] range) for settlement of fertilized eggs and refuge, growth, and development of early life stages;
- aquatic habitat with a gradual downstream salinity gradient of 0.5-30.0 ppt and soft substrate downstream of spawning sites for juvenile foraging and physiological development;
- water with appropriate depths[10] and without physical barriers to passage between the river mouth and spawning sites to allow unimpeded movement of adults to and from spawning sites; movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and staging, resting, or holding of sub-adults or spawning condition adults; and
- water, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, would support critical life history functions, including spawning, annual and interannual survival of juvenile and older sturgeon, and growth, development, and recruitment of larval, juvenile and sub-adult Atlantic sturgeon.[11]

2. Atlantic Coastal Fisheries Cooperative Management Act

The Atlantic Coastal Fisheries Cooperative Management Act of 1993 authorized the ASMFC to develop Fishery Management Plans that “provide for the conservation” of resources for coastal and anadromous fish species and define compliance criteria for all member states. These Fishery Management Plans, which are developed under the direction of an ASMFC-appointed management board, are based on the best understanding of biological status of the fishery, including social and economic considerations. Each management board has a technical committee of agency scientists to address “technical or scientific needs requested” by the board, including oversight of “developing stock assessments for Commission-managed species,” including Atlantic sturgeon.

Stock assessments provide the scientific basis for evaluating the status of each stock managed by the ASMFC; these assessments are conducted by species stock assessment subcommittees comprised of scientists with “expertise in stock assessments and fish population dynamics.” Benchmark stock assessments are reviewed by an independent panel of stock assessment experts who evaluate the quality of an assessment for providing scientific basis for management. Stock assessments are updated on a regular basis using the peer-reviewed models from the benchmark assessments and updated data in order to monitor stock status.

A recent benchmark stock assessment for Atlantic sturgeon, the first since 1998, was published by the ASMFC in October 2017(ASMFC 2017). The assessment concluded that all DPS, including the New York Bight DPS, are currently depleted relative to historical abundances from the late 1800s, as well as abundances at the time of the commercial fishing moratorium in 1998. Atlantic sturgeon abundance for the New York Bight DPS was determined to be above 1998 abundance and total mortality was

[9] A key conservation objective for the New York Bight DPS, identified in the critical habitat designation (NMFS 2017b) is to increase sturgeon abundance by facilitating increased successful reproduction and recruitment.
[10] Water depths in main river channels should be deep enough (e.g., ≥1.2 m [3.9 ft]) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.
[11] Water temperature and dissolved oxygen at lower depths should be 13°C to 26°C (55.4°F to 78.8°F) for spawning habitat, no more than 30°C (86°F) and ≥ 6 mg/L dissolved oxygen for juvenile rearing habitat.

estimated to be below the threshold for non-recovery. Although the statistical uncertainty of these results is relatively high, the results suggest that the New York Bight DPS is stable, if not slowly recovering, since the 1998 moratorium (ASMFC 2017).

3. Clean Water Act

The Clean Water Act establishes, among other matters, a national system for regulating discharges of pollutants to the surface waters of the United States under Section 402 (33 U.S.C. 1342(a)), the NPDES permitting program. Through the NPDES program, the USEPA and/or delegated state agencies, including the Pennsylvania Department of Environmental Protection ("PADEP"), issue NPDES permits pursuant to Section 402[12] of the Clean Water Act. These NPDES permits (1) impose technology-based effluent limits and/or water quality-based effluent limits[13] on the discharge of pollutants[14] identified under Section 301[15] of the Clean Water Act; (2) regulate the location, design, construction and capacity of CWISs under Section 316(b);[16] and (3) authorize variances from otherwise applicable technology-based and/or water-quality based effluent limits on heat or temperature so long as the applicant can demonstrate that the less stringent limits assure the protection and propagation of a balanced indigenous community in and on the waterbody under Section 316(a).[17]

In 2014, USEPA issued regulations implementing §316(b) at existing facilities (USEPA 2014a) that withdraw more than two million gallons of water per day ("MGD") from a water of the United States. The 2014 §316(b) Rule: (1) identifies the information an applicant must provide with its permit renewal application under §122.21(r),[18] including all information received from any field office of the Services[19] and information on T/E species that may be affected by the CWIS or its operations;[20] (2) establishes the timeframes for when this information must be submitted to permitting agencies;[21] (3) requires that permitting agencies forward applications and, in some instances, other materials to the Services for review and comment;[22] (4) requires permitting entities to obtain any additional information requested by the Services;[23] and (5) requires the submission of annual reports to the appropriate USEPA regional office pursuant to 40 CFR 125.97(g) for compilation and submission to the Services.[24]

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[12] 33 U.S.C. 1342

[13] USEPA and PADEP are authorized to impose these limits under Sections 301 and 304 of the Clean Water Act for facilities such as Eddystone.

[14] Pollutants are defined in the Clean Water Act to include: various toxic pollutants, biochemical oxygen demand, total suspended solids, fecal coliform, oil and grease, pH, heat, and any other pollutant not identified as either toxic or priority. USEPA's regulations at 40 CFR 401 also identify regulated pollutants.

[15] 33 U.S.C. 1311

[16] 33 U.S.C. 1326(b); Section 316(b) provides that: "Any standard established pursuant to section 301 or section 306 of this Act and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact."

[17] 33 U.S.C. 1326(a)

[18] 40 CFR 122.21(r) requires, among other matters, a characterization of the aquatic community in the vicinity of the CWIS and, for facilities operating with an actual intake flow of 125 MGD, at least two years of entrainment data collected within 10 years of the application's submittal date. Permitting agencies may require facilities with an actual intake flow of less than 125 MGD to collect this data.

[19] 40 CFR 122.21(r)(1)(ii)(H)

[20] 40 CFR 122.21(r)(4)(vi)

[21] See 40 CFR 125.95(a)(2), 40 CFR 125.98(b)(6), and 40 CFR 125.98(g).

[22] 40 CFR 125.98(h)

[23] 40 CFR 125.98(i)

[24] 40 CFR 125.98(j)

In addition, the §316(b) Rule establishes a suite of pre-approved technologies as best technology available ("BTA") for reducing impingement mortality at 40 CFR 125.94(c)(1) – (7) and authorizes applicants to seek less stringent standards under certain circumstances, including the facility's having a capacity utilization rate ("CUR") of 8% or less.[25] USEPA, however, determined that BTA for entrainment should be decided on a site-specific basis for each CWIS,[26] considering the factors identified in 40 CFR 125.98(f)(2) and (3). In addition, the §316(b) Rule authorizes permitting agencies to require impingement and entrainment monitoring as conditions in subsequent permits.

4. Eddystone's NPDES Permit

Eddystone's NPDES Permit No. PA0013714[27] (PADEP 2014) regulates the discharge of pollutants from various outfalls,[28] regulates the CWIS, and imposes various custom requirements to ensure that other components of the Clean Water Act and/or the Pennsylvania Clean Streams Law are properly addressed. Eddystone's current permit will expire on September 30, 2019; Exelon has prepared and submitted reports as required by §122.21(r).

5. Eddystone's DRBC Dockets

Eddystone's DRBC Dockets No. D-1992-066 CP-2 and No. D-2008-038 CP-2 regulate the discharges of non-contact cooling water and industrial wastewater treatment plant water and the withdrawal of surface water through the CWIS. Eddystone's current dockets will expire on August 31, 2019 and June 10, 2024, respectively. Exelon will prepare and submit requests for renewals of their dockets, consistent DRBC's Rules of Practice and Procedures.[29]

C. Coordination with Federal and State Agencies

In compliance with USEPA's 2014 §316(b) Rule, PADEP will coordinate with the Services during the renewal of the Station's NPDES permit and will further coordinate with NMFS over the course of Eddystone's IITP application, as it relates to the NPDES permit processing. Exelon further understands that there must be an internal consultation within NMFS on the issuance of this IITP, consistent with the provisions of Section 7 of the ESA as the issuance of this permit is, by definition, a federal action.

[25] 40 CFR 122.94(c)(12).
[26] 40 CFR 125.95(d)
[27] A copy of Eddystone's NPDES Permit is provided as Attachment 1.
[28] These outfalls are described in greater detail in Sections II.A.3 and II.A.4.
[29] 18 CFR 401

II. PROJECT DESCRIPTION AND COVERED ACTIVITIES

Eddystone is located in the Borough of Eddystone, Delaware County, Pennsylvania, less than 16 kilometers ("km") (10 miles ["mi"]) downriver of Philadelphia (Figure II-1). It is situated along the west bank of the Delaware at latitude 39.856208° and longitude -75.324882° at RKM 136 (RM 84.5).

A. Eddystone Generating Station Project

1. Station Operations

Eddystone presently consists of two natural gas/fuel oil-fired electric generating units, Units 3 and 4. Unit 1 was retired in 2011, and Unit 2 was retired in 2012. Units 3 and 4 are steam-electric generators, which became operational in 1974 and 1976, respectively. The summer normal net ratings[30] are 380 megawatts each for Units 3 and 4; these units have a nameplate or gross capacity of 395 megawatts. Currently, Eddystone operates as a peaking plant, typically running at higher levels of generation capacity during the summer and winter periods (Table II-1). Eddystone's average CUR from 2013 to 2017 was 1.9%. From January through August of 2018, its CUR was 1.0%. Exelon currently anticipates that Units 3 and 4 would be retired in 2033.

2. Cooling Water Intake Structure Operations

Units 3 and 4 are identical in design and operation. Cooling water for each unit is withdrawn from the Delaware through a CWIS, which is located along the west shore of the River, directly in front of the Station (Figure II-2). The CWIS was designed to reduce fish impingement mortality and entrainment and consists of four separate intake bays (two per unit) (Figure II-3) (Dickinson 1974; Exelon et al. 2008). Each intake bay is divided into two screen wells near the entrance so that two screens and two trash racks can be used to reduce intake velocities (Exelon et al. 2008). There is a curtain wall at the front of the CWIS. After the curtain wall, water passes through vertical-bar trash racks. Each trash rack is approximately 11 feet ("ft") 2 inches ("in.") with 0.5 in.-wide bars spaced 3.75 in., center to center. Behind the trash racks, there is an opening to the river to provide a fish escape. A stop log guide behind the fish escape allows each individual intake bay to be sealed off for maintenance. Traveling screens are located in wells behind the stop log guides (Figure II-4) (Exelon et al. 2008).

Each screen well contains a 0.375 in. (3/8 in.) traveling screen which is located directly on the shoreline and has a through-screen velocity of approximately 0.88 feet per second ("fps") at mean low water ("MLW") and design flow (Exelon et al. 2008). Each screen is a 48 ft vertical, chain-link, four-post-type machine, on which a continuous series of 54 screen panels travel vertically to collect material from the incoming water. Each screen panel is approximately 10 ft wide and is made of 304 stainless-steel mesh. The panels are equipped with debris troughs and a high-pressure spray wash system (HDR 2018c). The Eddystone screens presently run on a timer to operate one rotation every eight hours during non-freezing ambient conditions, one rotation every four hours during freezing conditions, and continuously as needed during the fall leaf season.

Each intake bay is equipped with a CWP designed to provide cooling water to the unit during Station operation. Each CWP has a rated capacity of 137,500 gallons per minute ("gpm") or approximately 198 MGD. Each intake bay is also equipped with a RWP designed to provide cooling

[30] A net rating equals a unit's gross electrical output less any power the unit uses to generate.

water to cool the auxiliary plant equipment and for miscellaneous uses (Exelon et al. 2008). One or more RWPs typically remain operational during periods when the units are not generating power and when CWPs are not in operation to provide water for essential Station support.[31] Each RWP has a rated capacity of 7,500 gpm (10.8 MGD). Therefore, Units 3 and 4 each have a design flow of 290,000 gpm (417.6 MGD), for a total Station design intake flow ("DIF") of 580,000 gpm (835.2 MGD) (Exelon et al. 2008). The Station's actual intake flow for 2013-2017 was substantially lower than the Station's DIF (Table II-2).

Although no longer in operation, Units 1 and 2 had a combined DIF of 440,000 gpm or approximately 634 MGD. Since the retirement of Units 1 and 2 in 2011 and 2012, respectively, the DIF of Eddystone has been reduced by 43.2% when compared to the combined DIF of Units 1 through 4.

3. Non-Contact Once-Through Cooling Water Discharge

The non-contact, once-through cooling water ("OTCW"), which is the water that is withdrawn through the CWIS and then passed through the condenser to cool the steam for reuse in the electric generation process, is discharged via Outfall 008 (Figure II-2). Outfall 008 consists of a 12 ft diameter pipe that extends 300 ft into the Delaware, along the river bottom (ERM 2014, included as Attachment 2). The OTCW effluent discharges to the River at a higher temperature than the river water being withdrawn into the CWIS. Both heat and other pollutants are discharged with the OTCW. The location and design of the discharge was selected to minimize the effect of the thermal effluent on the biological community by rapidly mixing the discharge within a small area adjacent to the outfall (Dickinson 1974).

a. Heat

The rates of net heat discharged and the increase in temperature above the intake water temperature ("ΔT") are dependent upon the Station's operations. Exelon continuously monitors the ambient temperature at the intake and the discharge temperature at the outfall for purposes of calculating ΔT, as required in the Station's NPDES permit. The rate of net heat discharged depends primarily on the rate at which electricity is generated and also on the operational efficiencies of the units. The magnitude of temperature change is directly proportional to the net heat discharge rate and inversely proportional to the circulating water flow rate. Flow rate, in turn, is dependent upon the number of CWPs in service and on hydraulic pressure losses in the pipes, which affect the efficiency of the pumps.

Eddystone's last hydrothermal assessment was conducted in 2014 in support of the Station's NPDES permit and DRBC docket renewals (Attachment 2). The hydrothermal assessment was completed using the DRBC CORMIX modeling procedure along with input data from the United States Geological Survey ("USGS"), the National Oceanographic and Atmospheric Administration ("NOAA"), and Exelon. For this simulation, the full capacity effluent discharge of 580,000 gpm was used. To account for seasonal changes, two temperature conditions were used. For the month of February, the ambient water temperature was assumed to be 2.2 degrees Celsius ("°C") (36 degrees Fahrenheit ["°F"]). For the month of August, the ambient water temperature was assumed to be 27.2°C (81°F). The ΔT was assumed to be 11.7°C (21°F), as established as the limit in Eddystone's NPDES permit (see Attachment 2). In 2018, Exelon requested that the results of the 2014 modeling effort be further examined in order to characterize the bottom characteristics of the plume (ERM 2018, included as Attachment 3). The thermal

[31] There were six days during the 2013-2017 period during which neither CWPs nor RWPs were running (November 29-December 1, 2015 and March 28-30, 2016).

plume was modeled as the area with a ΔT greater than 2.8°C (5˚F), based upon the requirements for heat dissipation areas ("HDAs") established by DRBC. Modeled plume characterizations demonstrated that during the simulation for February, the maximum extent of the 2.8°C (5°F) isotherm extended 21.8 meters ("m") (71.5 ft) downstream during ebb tide, 23.4 m (76.8 ft) upstream during flood tide, and 105.7 m (346.7 ft) laterally during slack tide. During the August simulation, the extent of the 2.8°C (5°F) isotherm extended 57.9 m (189.9 ft) downstream during ebb tide, 49.0 m (160.8 ft) upstream during flood tide, and 81.6 m (267.8 ft) laterally during ebb tide. Based upon the hydrothermal assessment, the HDA for Eddystone, defined by the extent of the 2.8°C (5°F) isotherm, extends 69.5 m (228 ft) upstream, 58.8 m (193 ft) downstream, and 121.9 m (400 ft) across the river (Attachment 2). Accordingly, NPDES and DRBC permitted an HDA of 64.0 m (210 ft) upstream and downstream of the outfall and 121.9 m (400 ft) offshore of the outfall at Eddystone. The bottom contact areas of the modeled thermal plume were small and varied with the tidal cycle, as was observed for the surface extent of the plume. In February, the area of bottom contact ranged from 6.3 to 175.2 m^2 (68 to 1886 ft^2) with an average of 157.8 m^2 (1699 ft^2). Generally, the areas of bottom contact were larger in August than in February, ranging from 19.0 to 250.3 m^2 (204 to 2694 ft^2) with an average of 201.0 m^2 (2164 ft^2) (Attachment 3).

b. Other Pollutants Present in the OTCW Discharge

The biocides ChemTreat C2189G, a bromide-based microbial control agent, and ChemTreat CL2005[32] in conjunction with ChemTreat A103G, molluscicides used to control Asiatic clam, are authorized to be added to the main CWPs when they are in service in accordance with Eddystone's NPDES permit and PADEP's (2017) list of approved chemical additives for water management systems. The biocide feeds are limited to two hours per day per generating unit while the unit is in service in order to protect the heat exchanger tubes from organic fouling, consistent with requirements under 40 CFR 423. Most of these biocides are consumed by the natural demand in the OTCW discharge and any residuals are discharged in conformance with limits in Eddystone's NPDES permit. Eddystone's NPDES permit also allows the use of corrosion inhibitors or other water treatment additives. OTCW effluents are monitored for total residual chlorine,[33] total suspended solids ("TSS"), ChemTreat CL2005, ammonia-nitrogen,[34] and bromide.[35]

4. Wastewater Treatment Plant Effluent Discharges

In addition to the discharge of non-contact OTCW via Outfall 008, Exelon is authorized to discharge other effluents under Eddystone's NPDES Permit. The Station's wastewater treatment plant ("WTP") processes low volume wastewaters and waste streams from floor and roof drains, cooling of plant equipment, fireside and associated equipment washes, chemical cleaning, reverse osmosis regeneration and reject water, and general equipment power washing as well as groundwater cleanup and stormwater. Chemicals that may be present in the WTP influent stream include ethylenediaminetetraacetic acid (EDTA), sodium hydroxide, citric acid, hydrochloric acid, ROClean P111, sodium bisulfite, Kathon, PW 76AS, Versine 100XL, and Hypersperse 772. These chemicals generally occur in small concentrations in the WTP influent, when present. The WTP removes oil present in the influents via an oil/water separator. The Station's WTP effluent is monitored at Monitoring Point

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[32] ChemTreatCL2005, manufactured by ChemTreat, Inc., is used for the same purposes as Spectrus CT 1300, which is manufactured by G. E. Betz, Inc. Both are approved by PADEP (2017) for use in cooling water systems.
[33] Total residual chlorine is a potential decomposition product of ChemTreat C2189G.
[34] Ammonia-nitrogen is a potential decomposition product of ammonium hydroxide, which is added to the boiler water.
[35] Bromide is a potential decomposition product of ChemTreat C2189G.

108 for TSS, total dissolved solids, oil and grease, total copper, total iron, polychlorinated biphenyls ("PCBs"),[36] and carbonaceous biological oxygen demand (CBOD20). Monitoring Point 108 is located upstream of the location where the WTP effluent empties into the discharge pipe and commingles with the OTCW effluent prior to being discharged via Outfall 008.

5. Stormwater

Eddystone is permitted to discharge stormwater to Crum Creek, a tributary of the Delaware, via Outfalls 001, 002, 004, and 005 and to the Delaware via Outfalls 007, 010, 013, and 014 under the Station's current NPDES permit. In 2005, the DRBC implemented the Pollution Minimization Plan ("PMP") rule requiring point sources with known likelihood of discharging PCBs to take steps to reduce or eliminate PCBs in their discharges. Wet weather PCB monitoring is required at Outfalls 001 and 005; further discussion of DRBC's PCB program and Eddystone's PMP (provided as Attachment 4) is provided in Section V.C.

6. Vessel Activity

At Eddystone, fuel oil is unloaded at a waterfront structure with a docking length of 695 ft that consists of six breasting dolphins. Since 2013, Eddystone has received 12 fuel oil deliveries, averaging 1.46 million gallons per delivery. These deliveries occurred at irregular intervals, one in 2013, five in 2014, five in 2015, and one in 2016. There were no deliveries in 2017.[37] Six vessel deliveries are anticipated for 2019: 3 roundtrip barge trips associated with the removal of oil from an existing storage tank at Eddystone to allow work on the tank and 3 roundtrip barge trips associated with oil deliveries to refill the storage tank following the completion of work.

The frequency of delivery depends on a variety of factors including the amount of fuel oil already in storage, the amount of time the Station operates, and contractual obligations for the purchase of fuel oil. Variability in these factors makes the frequency of future deliveries beyond 2019 difficult to predict. The majority of past fuel oil deliveries (i.e., 8 of 12) over the most recent 5-year period (2013 – 2017) have occurred between September 1 and March 14. The Station generally runs on natural gas outside the winter months, often eliminating the need to receive oil deliveries between March 15 and July 15, the period when adult sturgeon are likely present in the Delaware to spawn. However, other factors (e.g., availability, pricing, or reliability) may require Eddystone to schedule fuel oil deliveries between mid-March and mid-July. The barge deliveries currently anticipated for 2019 are tentatively scheduled for March (3 roundtrips) and June/July (3 roundtrips).

Between 2013 and 2017, a majority (i.e., 9 of 12) of deliveries originated from Philadelphia, Pennsylvania. The remaining deliveries originated from either Perth Amboy or Linden, New Jersey. Over this five-year period, fuel oil deliveries were made by barges with overall lengths ranging from 287 to 414 ft in length with drafts of 12 to 24 ft. These barges were maneuvered by tug boats ranging from 75 to 117 ft in length with drafts ranging from 10 to 16 ft. The anticipated barge deliveries for 2019 would transit between Eddystone and Croydon, PA for the oil removal and between Eddystone and a port located between New York Harbor and Philadelphia. The distance between Eddystone and Croydon is approximately 30 river miles (26 nautical miles). Transit time per trip would be approximately 3 hours one-way. The distance between Eddystone and Perth Amboy, NJ in New York Harbor is approximately

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[36] PCBs are monitored as part of DRBC's PCB total maximum daily loading plan. All active sources of PCBs have been removed from the Station (see Section V.C).
[37] To date, there has been a single delivery in 2018.

260 river miles (140 nautical miles). Transit time per trip would be approximately 14 hours one-way, assuming an average vessel speed of 10 knots. Barges travelling between Eddystone and Croydon (30,000 barrel capacity) would draft approximately 10 to 15 ft and barges travelling between Eddystone and New York Harbor (50,000 barrel capacity) would draft approximately 20 to 25 ft.

B. Covered Activities

1. Withdrawal of Cooling Water and Service Water

This IITP would cover Eddystone's withdrawal of water for the cooling and service water systems and for other necessary activities at the Station. The additional withdrawal of water through the CWIS for the purpose of sampling for any additional impingement and entrainment monitoring (if required under Eddystone's NPDES Permit) would also be covered.

2. Discharge of Thermal Effluent

The IITP would cover the discharge of heated water from the cooling water system into the River via Outfall 008 and the small discharges of heat from the cooling of auxiliary equipment via Outfall 010. The thermal effluent would be in accordance with Eddystone's existing NPDES Permit.

3. Discharge of Other Chemical Pollutants

This IITP would cover the discharge of chemical effluents, including the biocides applied to the cooling water, those chemicals discharged from the WTP, as described above in Sections II.A.3.b and II.A.4, and the discharge of other chemicals in the stormwater, groundwater, and condensate storage tank and/or city water tank run-off/overflow as described in and in accordance with Eddystone's existing NPDES permit limits (NPDES Permit No. PA0013714, included as Attachment 1).

4. Vessel Traffic

This IITP would cover the potential for take associated with vessel activity due to tug and barge traffic associated with fuel oil delivery and maintenance of fuel oil storage tanks at Eddystone.

III. ENVIRONMENTAL SETTING AND BIOLOGICAL RESOURCES

Eddystone is located on the western shore of the tidal freshwater region of the Delaware, approximately 12 mi downstream of Philadelphia at RKM 136 (RM 84.5) in the DRBC's Zone 4 (RKM 126.8-152.9 [RM 78.8-95.0]).

A. Environmental Setting

1. Hydrology

The reach of the River in which Eddystone is located is classified as tidal freshwater and is well above the median monthly salt front location, which ranges from RKM 107 to RKM 122 (RM 67 to RM 76)[38] (DRBC 2013). Tides at Eddystone are semi-diurnal and the mean tidal range is approximately -2.38 ft to +3.38 ft (HDR 2018c).

Average annual river flow between 1970 and 2016, measured at the USGS stream flow gage at Trenton, NJ (Gage # 01463500[39]), was 12,569 cubic feet per second ("cfs"), with a range of 6,365 cfs to 22,040 cfs. Average annual spring flow during April and May was 17,772 cfs and ranged from 5,074 cfs to 49,120 cfs over the same 46-year period (USGS 2018a).

2. Bathymetry

The width of the Delaware in the vicinity of Eddystone is approximately 1.9 km (6,000 ft). Water depths range from 2.4 to 8.2 m (8 to 27 ft) on the shoals just downstream of the discharge embayment to 13.7 m (45 ft) in the navigation channel. The area directly in front of the CWIS ranges in depth from about 4.9 to 8.2 m (16 to 27 ft) at MLW. The navigational channel in this reach of the River is located about 229 m (1,500 ft) offshore from Eddystone's CWIS and ranges from approximately 10.7 to 13.7 m (35 to 45 ft) in depth from east to west at mean lower low water ("MLLW") (Figure III-1).

3. Water Quality

The DRBC establishes surface water quality standards ("SWQS") for each of the various zones it has established for the River (Figure III-2). The SWQS are, in turn, adopted by the DRBC-member states' environmental agencies, including PADEP, for the zones of the Delaware within their respective jurisdictions. Eddystone is located within Zone 4, which extends from RKM 152.9 (RM 95.0) near Philadelphia to RKM 126.8 (RM 78.8) near the mouth of the Schuylkill River. The closest continuous monitoring gage for water temperature, salinity, and dissolved oxygen ("DO") is the USGS stream gage at Chester, PA (Gage #01477050) which is located approximately 2.7 km (1.7 mi) downstream of Eddystone, also within Zone 4. Pursuant to 25 Pa. Code §93.9(b), DRBC standards supersede Pennsylvania water quality criteria when the DRBC standards are more stringent than those set forth by the state. According to 25 Pa. Code §93.9g, DRBC standards override some Pennsylvania water quality criteria in Zone 4.

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[38] The farthest recorded upstream location of the salt front in the Delaware River was RKM 164 (RM 102) in 1964.
[39] The USGS gage # 01463500, Delaware River at Trenton, is the closest continuous monitoring gage to Eddystone for discharge data. It is located 50 mi upstream of Eddystone at RKM 216.4 (RM 134.5), just upstream of the reach of tidal influence.

a. Water Temperature

Average monthly water temperatures between 1970 and 2017at the USGS gage at Chester, PA ranged from 1.0°C to 29.3°C (33.8°F to 84.7°F) and mean annual spring water temperatures ranged from 10.5°C to 20.3°C (50.9°F to 68.5°F) (USGS 2018b).

b. Salinity

Salinity in the Delaware River varies widely due to several factors: the inflow of freshwater from tributaries, precipitation, tidal exchange, morphology, wind-induced circulation, and the salinity distribution of coastal waters near the mouth. Salinity averages in the River around Chester, PA range from 0.08 ppt to 1.1 ppt (USGS 2018b).

c. Dissolved Oxygen

DO levels near Eddystone are, on average, lowest in August and highest in February. Mean monthly average DO between 1970 and 2017 at the USGS stream gage at Chester, PA ranged from 4.4 milligrams per liter ("mg/L") in August to 9.8 mg/L in February (USGS 2018b). Average monthly DO recorded from 1995 to 2017 ranged from 4.4 mg/L to 12.3 mg/L. The lowest 24-hour average during this time period was 3.5 mg/L in June of 2001 (USGS 2018b), which is lower than the DO level of 6 mg/L for juvenile rearing habitat utilized by NMFS for Atlantic sturgeon critical habitat designation (NMFS 2017b), which includes the Delaware River in the vicinity of Eddystone. The DBRC 2016 Delaware River and Bay Water Quality Assessment reported that 100% of DO observations between October 1, 2010 and September 30, 2015 met both the daily mean water quality criteria and the seasonal water quality criteria in DBRC Zone 4, which uses data from the USGS gage at Chester, PA (DRBC 2016a) just 1.7 mi downstream of Eddystone. As noted in Section I.A.1, the DRBC (2017) recently passed Resolution 2017-4 that recognized the improvement in water quality, including DO, within Zones 3 and 4 and the northern part of Zone 5.

4. Climate

Eddystone is within 70 mi of the Atlantic Coast; its climate is considered more continental than maritime. Average annual air temperatures from 2010-2017 at the Philadelphia International Airport (PHL),[40] five mi from Eddystone, ranged from 13.1°C to 15.0°C (55.6°F to 59.1°F). Monthly average temperatures from 2010-2017 ranged from 1.0°C (33.8°F) in January to 27.1°C (80.7°F) in July. The minimum daily average temperature was -12.8°C (9°F), recorded in January 2014, and the maximum daily average temperature was 33.9°C (93°F), recorded in July 2011 (NOAA 2018). The weather station at PHL recorded 26 to 32 thunderstorms per year from 2010 to 2017; coastal storms occasionally impact the area. Total annual rainfall from 2010-2017 at PHL ranged from 90 to 163 centimeters ("cm") per year (35 to 64 in. per year) (NOAA 2018).

B. General Overview of Biological Resources

Despite being located upstream of the salt front in the tidal freshwater portion of the Delaware River, the aquatic community in the vicinity of Eddystone is strongly influenced by its connection to

[40] NOAA Aviation Weather Center for Philadelphia International Airport, about 5 mi northeast of Eddystone.

brackish waters and consists of a diverse assemblage of aquatic fish and invertebrate species that includes both seasonal transients and year-round residents.

Sampling of the fish community conducted by PSEG in 2014 in the tidal zone of the River indicated that a mixture of marine, estuarine, diadromous, and freshwater species occur at the nearest sampling zone, whose upstream boundary lies approximately 9 RKM (5.6 RM) downstream of Eddystone (PSEG 2014). Bottom trawl sampling of the fish community from this effort, conducted from April 2014 through October 2014, was dominated by hogchoker (*Trinectes maculatus*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*), white perch (*Morone americana*), and channel catfish (*Ictalurus punctatus*) at 38.1%, 22.0%, 19.6%, 9.8%, and 5.8% of the total catch in that zone, respectively. The New Jersey Department of Environmental Protection has conducted an annual beach seine survey on the Delaware since 1980. From 2012 to 2016, the most abundant species in the beach seine survey from the region where Eddystone is located were American shad (*Alosa sapidissima*), Atlantic menhaden (*Brevoortia tyrannus*), bay anchovy (*Anchoa mitchilli*), white perch, banded killifish (*Fundulus diaphanus*), blueback herring (*Alosa aestivalis*), Atlantic silverside (*Menidia menidia*), eastern silvery minnow (*Hybognathus regius*), striped bass (*Morone saxatilis*), and mummichog (*F. heteroclitus*) (NJDEP 2017). Ichthyoplankton entrainment sampling conducted at Eddystone in 2016-2017 was dominated by clupeids (i.e., blueback herring, alewife [*A. pseudoharengus*], and gizzard shad [*Dorosoma cepedianum*]), white perch, striped bass, and Atlantic croaker (NAI 2018). PSEG also conducted ichthyoplankton sampling in the River until 2004. Sampling conducted from April through July of 2004 in the sampling zone where Eddystone is located was dominated by white perch, Clupeidae, alewife, striped bass, and *Morone* spp. (PSEG 2004).

Within the tidal zone of the Delaware, the dominant zooplankton are cladocerans, primarily *Bosmina longirostris* but also *B. coregoni* and *Leptodora kindti*. Copepods (*Eurytemora affinis*) and rotifers (*Brachionus calyciflorus* and *B. plicantilis*) are also common (PSEG 1975, as cited in PSEG 2001). Benthic sampling was conducted on the New Jersey side of the River in 1998 in support of Mercer Generating Station's 2001 316(b) demonstration, approximately 74 RKM (46 RM) upstream of Eddystone. The macroinvertebrate and shellfish community in the vicinity of Mercer is dominated by oligochaete worms, which accounted for more than 85% of individuals collected (PSEG 2001). Scuds (*Gammarus* spp.), mayfly larvae (*Baetis* spp. and *Tricorythodes* spp.), midge larvae (Chironomidae), and Asian clams (*Corbicula fluminea*) were also commonly collected. Blue crab (*Callinectes sapidus*) are collected in NJDEP's beach seine survey within the sampling zone where Eddystone is located (NJDEP 2017).

IV. DESCRIPTION OF THE ENDANGERED SPECIES

Both Atlantic sturgeon and shortnose sturgeon utilize the Delaware. Figure IV-1 summarizes available data on locations where these species have been found in the River along with other information relevant to the descriptions of these species and their life histories presented in the following sections.

A. Atlantic Sturgeon

1. Species Description and Basic Life History

Atlantic sturgeon is a large-bodied, anadromous fish species of the family Acipenseridae and is one of the largest fish species in North America with a maximum recorded total length ("TL") of approximately 4 m (13.1 ft) (Bain 1997). The oldest recorded Atlantic sturgeon, estimated to be 60 years old, was collected from the St. Lawrence River (Gilbert 1989). Atlantic sturgeon are found in ocean waters and in large tidal rivers along the Atlantic coast, ranging from the Hamilton River in Labrador, Canada to the Saint Johns River in Florida (Gruchy and Parker 1980; ASSRT 2007). While Atlantic sturgeon spawn in freshwater and spend the first few years as juveniles in their natal river, they emigrate from the river to the Atlantic Ocean as sub-adults and spend the remainder of their lives primarily in marine environments, often undertaking long-distance migrations along the Atlantic Coast (Bain 1997). Atlantic sturgeon are slow to grow and mature. Sub-adult Atlantic sturgeon return to their natal river during the spring and summer months to forage. Once they reach reproductive maturity, adult females return to their natal river to spawn around age 15 or older, and males return to spawn at about 12 years (Bain 1997; Able and Fahay 2010).

Spawning occurs on an interannual basis ranging from two to five years for females and from one to five years for males (Vladykov and Greeley 1963). Fecundity (i.e., the number of eggs produced per spawn) of Atlantic sturgeon in the Delaware, typically ranges from 800,000 to 2.4 million eggs per female and is correlated with age and body size (Smith 1985). Atlantic sturgeon eggs are adhesive, deposited on hard substrates including clean gravel, cobble, and rock, and fertilized externally. After fertilization and hydration, eggs measure approximately 2.2 millimeters ("mm") (0.09 in.) in diameter (Hardy and Litvak 2004). Incubation time is inversely related to water temperature; at temperatures of 18°C and 20°C (64.4°F and 68°F), hatching occurs at approximately 140 and 94 hours, respectively, after spawning (Mohler 2003; ASSRT 2007). Upon hatching, larval Atlantic sturgeon (yolk-sac larvae) are about 7-9 mm (0.28-0.35 in.) TL and remain closely associated with the bottom (Bain et al. 2000). At this stage, yolk-sac larvae are photonegative and seek cover (Kynard and Horgan 2002). After about 8-12 days, the yolk-sac is absorbed and larvae (now classified as post yolk-sac larvae) become active swimmers, exhibiting vertical movement through the water column from the bottom to the surface while still associating closely with benthic habitat and cover (ASMFC 2012). Post yolk-sac larvae range in size from about 14 to 31.5 mm TL (0.56 to 1.2 in), at which point they begin to resemble adults and are considered to have passed from the larval to the pre-juvenile stage (Gilbert 1989). Around 16 days, post yolk-sac larvae generally resemble adults and emerge from cover to utilize benthic habitat for foraging, holding position for a day or two prior to migration downstream (Kynard and Horgan 2002). Juvenile transformation occurs at approximately 12 to 14 cm (4.7 to 5.5 in.) TL; it takes an average of 7 years for juveniles to reach 100 cm (3.2 ft) TL (Able and Fahay 2010).

2. Population Status in the Delaware River

The population of Atlantic sturgeon in the Delaware is likely among the smallest in the species' range, with an estimated population size of less than 300 adults (Wirgin et al. 2015). The Delaware River population has not recovered since the late 1800s due to a number of factors including habitat loss from dredging, saltwater intrusion, water quality degradation, harvest pressure, and bycatch mortality (Simpson and Fox 2007; Brown and Murphy 2010). Secor and Waldman (1999) estimated that Atlantic sturgeon landings in 1901 were only 6% of peak landings recorded in 1889 and the catch rates continued to decline through the mid-1990s (ASSRT 2007). The levels of juvenile production were extremely low in the late 20th century; however, reproductively active adult Atlantic sturgeon are present in the River, and spawning has been documented within the Delaware (Secor and Waldman 1999; ASSRT 2007; ASMFC 2017). In 2014, Hale et al. (2016) conducted a mark-recapture study to estimate the abundance of early juvenile (i.e., age 0 to 1) Atlantic sturgeon in the Delaware as 3,656 fish with a 95% confidence interval of 1,935 to 33,041 fish.

3. Distribution and Migrations

a. Seasonal Migration of Sub-Adults and Adults to Coastal Estuaries and Rivers

Sub-adult and adult Atlantic sturgeon spend most of their lives in coastal waters of the Atlantic Ocean, usually at depths less than 20 m (65.6 ft). Inshore-offshore migrations correspond to seasonal changes in water temperatures, with sub-adults and adults moving into deeper oceanic waters during the colder months and returning to shallow coastal and riverine environments as water temperatures increase in the spring (Able and Fahay 2010). In the Delaware, Brundage and Meadows (1982) found that sub-adults and adults up to 2 m (6.6 ft) TL were most common in Delaware Bay (rather than the Delaware River) during the spring, and smaller sub-adults and adults less than 1.5 m (4.9 ft) TL were found in the lower tidal River during the spring through fall months. Only small juveniles less than 20 cm (7.9 in.) TL were collected upstream of Marcus Hook (RKM 126 [RM 78]) to Scudders Falls (RKM 224 [RM 139]) in late summer and fall. None of the adult Atlantic sturgeon reported by Brundage and Meadows (1982) were in spawning condition. Based on manual tracking of telemetered juvenile and adult Atlantic sturgeon, upstream and downstream migration within the Delaware commonly occurs within the shipping channel (Shirey et al. 1998; Simpson and Fox 2007).

b. Spawning Migrations

While adult Atlantic sturgeon range widely in marine environments, mixing extensively among DPSs along the Atlantic coast, studies have shown that the majority of adults return to their natal river to spawn (Collins et al. 2000; ASSRT 2007). Spawning adults migrate from the Atlantic Ocean upriver to freshwater sites in the spring and early summer (April-May) in mid-Atlantic estuaries when water temperatures reach 18°C (64.4°F) (ASSRT 2007; Able and Fahay 2010); spawning may occur as late as mid to late June in the Delaware (Simpson and Fox 2007). As discussed further in Section IV.A.4.a, spawning habitat, identified based on the location of tagged adult Atlantic sturgeon during the presumed spawning season combined with substrate material and location of the salt front, generally occurs in the River between Stoney Creek (RKM 120 [RM 74]) and Trenton, New Jersey (RKM 211 [RM 131]), with areas of high sturgeon concentration near Claymont, Delaware (RKM 125 [RM 78]) and Chester, Pennsylvania (RKM 130 [RM 81])[41] (Simpson and Fox 2007; Breece et al. 2013; NMFS 2014a). Females typically migrate back to coastal waters four to six weeks after spawning, while males may remain in the River or lower estuary until the fall (Able and Fahay 2010). When present in the Delaware, the majority of adults were detected within 30 km [18.6 mi]) of the salt front, typically between New Castle, Delaware (RKM 99 [RM 61]) and the Schuylkill River (RKM 148 [RM 92]) (Breece et al. 2013).

c. Larval and Juvenile Residency and Movement in the River

Several days after emerging from refuge in the substrate, post yolk-sac larvae gradually begin to move downstream from freshwater spawning sites to brackish nursery grounds as they grow and develop higher tolerance to more saline conditions. During the first half of their downstream migration, larval Atlantic sturgeon remain essentially stationary on the bottom during the day and move downstream at night; later when larvae are more fully developed and more motile, downstream movement occurs during both day and night (Kynard and Horgan 2002).

Following metamorphosis from the post yolk-sac larval stage, juveniles continue to move farther downstream into brackish waters, where they may remain in the juvenile habitat for up to six years (Able and Fahay 2010). Some Atlantic sturgeon juveniles may occupy freshwater habitats for two or more years, while others move downstream to brackish waters when the water temperature decreases in the fall months (ASMFC 2012). Studies have found that movements of juveniles within the Delaware are seasonally driven. Sturgeon move into brackish and tidal freshwater regions in the spring and summer; they move downstream to overwintering areas in the lower estuary or nearshore ocean waters in the fall and winter (Brundage and Meadows 1982; Lazzari et al. 1986; Shirey et al. 1998; Brundage and O'Herron 2009). Burton et al. (2005) found that some juvenile Atlantic sturgeon in the River may also overwinter in tidal fresh water near Marcus Hook (RKM 126 [RM 78]).

In the Delaware, young-of-the-year ("YOY") Atlantic sturgeon have been collected in close proximity to potential spawning grounds near RKM 125 and RKM 130 (RM 78 and RM 81) (Breece et al. 2013). Juvenile Atlantic sturgeon have been found to concentrate in three main areas: Artificial Island (RKM 89 [RM 55]), Cherry Island Flats (RKM 110 [RM 68]), and Marcus Hook (RKM 126 [RM 78]). Juveniles tracked during 2012-2014 spent most of their time downstream of RKM 150 (RM 92.2), although several fish were detected intermittently as far upstream as RKM 200 (RM 124.2) (ERC 2015).

d. Sub-Adult Emigration to the Atlantic Ocean

By the time they reach approximately 76-92 cm (2.5-3.0 ft) TL and four to eight years of age, sub-adult (i.e., larger juvenile) Atlantic sturgeon begin moving to coastal marine waters where they develop into adults (ASSRT 2007). Genetic data indicate that once sub-adult and adult Atlantic sturgeon emigrate from estuarine to marine environments, they travel widely within their range, moving between coastal and estuarine habitats (ASSRT 2007; Able and Fahay 2010; Brown and Murphy 2010). Atlantic sturgeon from multiple DPSs tend to range within 7 km (4.5 mi) of the shoreline (at depths up to 20 m [65 ft]) and appear to use the marine waters near the mouth of Delaware Bay for extended periods of time (Dunton et al. 2010; Fox and Breece 2010).

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[41] The sturgeon concentration area near Claymont could serve as a transition area where Atlantic sturgeon acclimate to the lower salinities found above the salt front, and the concentration area near Chester could serve as a staging area where sturgeon rest between runs to spawning grounds further upstream (Kahn 2018, *pers. comm.*). See Section IV.A.4.a for more details.

4. Habitat Requirements

a. Spawning Habitat

Atlantic sturgeon spawn in flowing water with current velocities ranging from 46 to 76 centimeters per second ("cm/s") (1.5 to 2.5 fps) and temperatures from 13.3 to 17.8°C (56 to 64°F) (ASSRT 2007; ASMFC 2012). Optimal water depths for spawning range from 11 to 27 m (36 to 89 ft); however, spawning has been reported in waters as shallow as 3 m (9.8 ft) (ASSRT 2007; ASMFC 2012). Spawning occurs over hard substrates, such as cobble, limestone, gravel, hard clay, and/or bedrock outcrops in salinities below 0.25 ppt (ASSRT 2007; ASMFC 2012; Breece et al. 2013). This type of substrate provides well-oxygenated water and crevices that can later serve as shelter for larval Atlantic sturgeon.

Atlantic sturgeon spawning habitat in the Delaware has been identified based on the location of tagged adult Atlantic sturgeon during the presumed spawning season combined with substrate composition and location of the salt front (Simpson and Fox 2007; Breece et al. 2013; NMFS 2014a). Identified spawning habitat exists from Stoney Creek (RKM 120 [RM 74]) to the fall line near Trenton, New Jersey (RKM 211 [RM 131]) (Simpson and Fox 2007; NMFS 2014a); however, Breece et al. (2013) have suggested that spawning may occur as far downstream as RKM 85 [RM 53]. Within this range, Breece et al. (2013) found high concentrations of adult Atlantic sturgeon just upstream of the typical location of the salt front near Claymont, DE (RKM 125 [RM 78]) and Chester, PA (RKM 130 [RM 81]), areas which are comprised of coarse-grained and non-depositional bedrock substrate suitable for spawning; YOY have also been collected in that reach. If sturgeon follow the spawning migration pattern observed in telemetry studies in the York River, these two concentration areas may represent a transition area and staging area, respectively, used by Atlantic sturgeon during the spawning run in the Delaware (Kahn 2018, *pers.comm.*). Two lower-density concentrations of adult Atlantic sturgeon were found about 70 km and 95 km (43.5 mi and 59 mi) upstream of the salt front[42] (approximately RKM 170 [RM 106] and RKM 195 [RM 121]) during the spawning period, but overall, sturgeon remained within 30 km of the salt front (approximately RKM 70 [RM 43] to RKM 130 [RM 81]) for the majority of the time (Breece et al. 2013). Near these high concentration areas, suitable spawning habitat may exist between Marcus Hook (RKM 126 [RM 78]) and Tinicum Island (RKM 137 [RM 85]) in or near the shipping channel (Sommerfield and Madsen 2003; Simpson and Fox 2007). Breece et al. (2013) found Atlantic sturgeon adults as far upstream as Roebling, NJ (RKM 201 [RM 124]) between April and July, but determined that the presence of spawning adults in this area was a relatively unlikely occurrence.

b. Nursery and Juvenile Habitat

Based on evidence that Atlantic sturgeon eggs and early larvae have limited tolerance of saline conditions (i.e., low tolerance above 0.25 ppt), Van Eenennaam et al. (1996) speculated that spawning sites may require a significant length of freshwater habitat downstream of the spawning area to allow successful downstream migration of larvae to rearing grounds. YOY exhibit poor survival at salinities from 5 to 10 ppt (Kynard and Horgan 2002). Age-1 and age-2 juveniles may tolerate salinities up to 12 ppt in the Delaware (ASMFC 2012).

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[42] During this study, the average location of the salt front ranged from RKM 92 to RKM 112, which is consistent with the contemporary location of the salt front, reported by the authors to be at RKM 103.

During their downstream migration, early larvae require benthic structure for use as refugia during the day. Breece et al. (2013) found that juveniles tend to select areas with coarse and non-depositional substrates, a selection that is common throughout the species' range. Other studies have found that juveniles prefer waters greater than 10 m (32.8 ft) in depth near the saltwater-freshwater interface (Able and Fahay 2010).

Temperature and DO are important for juvenile Atlantic sturgeon during their first two summers when they are restricted to lower saline waters and are unable to seek thermal refuge in deeper waters (Secor and Gunderson 1998; Niklitschek 2001; Niklitschek and Secor 2005). During the summer when temperatures range from 22 to 27°C (72 to 81°F), DO concentrations of 4.3 to 4.7 mg/L can result in reduced growth for YOY aged 30 to 200 days (Secor and Niklitschek 2001). Mortality of juveniles has been observed at DO concentrations of 3.3 mg/L or less (Secor and Niklitschek 2001).

c. Foraging Habitat

Sturgeon foraging activity and growth rate vary based on life stage, water temperature, salinity levels, and DO concentrations. Mohler (2003) found that a noticeable decrease in feeding behavior occurred in Atlantic sturgeon when temperatures dropped to 10°C (50°F), and that sturgeon began to lose weight at temperatures below 5.4°C (42°F). Maximum growth and food consumption rates of YOY and age-1 Atlantic sturgeon have been observed at 20°C (68°F), salinities from 8 to 15 ppt, and greater than 70% DO saturation (ASMFC 2012). These salinities generally occur downstream of Eddystone (RKM 136 [RM 84.5]), roughly from Egg Island Point (RKM 35 [RM 22]) to the Chesapeake and Delaware ("C&D") Canal (RKM 95 [RM 59]), depending on the volume of freshwater flows from the River to Delaware Bay.

d. Overwintering Habitat

Juvenile Atlantic sturgeon overwinter in deep estuarine waters where water temperatures can reach 0°C (32°F), congregating by the time temperatures drop to about 9°C (48°F) (Dovel and Berggren 1983; Bain et al. 2000). Based on the substantial numbers of juveniles found in the shallow waters of Delaware Bay in early spring, juvenile Atlantic sturgeon likely overwinter in the bay (Brundage and Meadows 1982). This is similar to the pattern of seasonal movements of juvenile Atlantic sturgeon in the Hudson River, where juveniles overwinter in the deeper waters of the lower estuary and migrate inshore and upstream during the spring (Brundage and Meadows 1982). Sub-adult and adult Atlantic sturgeon typically emigrate from the River during September and October to overwintering habitats in coastal nearshore areas of the Atlantic Ocean; Atlantic sturgeon inhabit shallower waters during the fall and move to deeper waters in the winter (ASMFC 2012).

5. Diet

Sturgeon feeding habits vary based on life stage. Exogenous feeding begins after larval sturgeon have absorbed the yolk sac; post yolk-sac larvae are planktivorous, but little is known of the dietary composition of larval Atlantic sturgeon. Juvenile, sub-adult, and adult Atlantic sturgeon are benthic omnivores that feed on macroinvertebrates and demersal and benthic fishes. Juveniles consume aquatic insects, insect larvae, and other invertebrates, while adults feed on bivalve and gastropod mollusks, amphipods, isopods, worms, and demersal fish (Bigelow and Schroeder 1953; ASSRT 2007; Able and Fahay 2010). Foraging studies show that Atlantic sturgeon exhibit a strong preference for polychaetes and rely more heavily on isopods than amphipods (Johnson et al. 1997; Haley 1999, as cited in McLean et al. 2013; Dadswell 2006, as cited in McLean et al. 2013; Guilbard et al. 2007; Savoy 2007, as cited in McLean et al. 2013; McLean et al. 2013; Krebs et al. 2017). Small fish are consumed by Atlantic sturgeon, but their importance in the diet may vary with size and location. Of thirteen subadults sampled in the Hudson River, all had consumed fish (Krebs et al. 2017). However, in other areas, fish do not make up a significant portion of Atlantic sturgeon diets (Johnson et al. 1997; Guilbard et al. 2007; McLean et al. 2013). Documented fish prey species for Atlantic sturgeon include sand lance, Atlantic tomcod (*Microgadus tomcod*), and American eel (*Anguilla rostrata*) (Scott and Crossman 1973, as cited in Krebs et al. 2017; Guilbard et al. 2007; Krebs et al. 2017).

B. Shortnose Sturgeon

1. Species Description and Basic Life History

Shortnose sturgeon is a relatively small-bodied, anadromous fish species of the family Acipenseridae that is found in large tidal rivers along the Atlantic coast, ranging from New Brunswick, Canada, to the Saint Johns River, Florida. Unlike Atlantic sturgeon, shortnose sturgeon rarely enter coastal waters and generally do not venture outside of their natal rivers or estuaries; however, recent studies have suggested that some movement may occur between large natal rivers and smaller, nearby coastal rivers (Bemis and Kynard 1997; NMFS 1998; Fernandes et al. 2010; Zydlewski et al. 2011). The shortnose sturgeon is the smallest sturgeon species native to North America, reaching a maximum length of 1.1 m (3.6 ft) TL (Bain 1997). The oldest documented shortnose sturgeon was a 67 year-old female captured in the Saint John River, Canada (Dadswell et al. 1984). Shortnose sturgeon are slow to mature, and age at maturity varies latitudinally. In the Mid-Atlantic, males reach maturity in three to five years, and females reach maturity in six to ten years (Dadswell et al. 1984).

Spawning occurs for 3 to 30 days on an inter-annual basis ranging from every other year for males and every third year for females (Dadswell 1979; SSSRT 2010). Females can produce 27,000 to 208,000 eggs per spawning event, depending on the size of the female; egg production also varies widely throughout the species’ range depending on water temperature (NMFS 1998). Eggs are demersal, adhesive, and fertilized externally, usually during mid-April in the Delaware (Able and Fahay 2010). The eggs are broadcast over rocky substrates in fresh waters and adhere to the substrate. Once fertilized, eggs are an average of 3.0 mm (0.4 in.) in diameter (Able and Fahay 2010). Incubation periods of 8 days have been reported in water temperatures of 17°C (63°F) and 13 days when temperatures are between 8 and 12°C (46 and 54°F) (SSSRT 2010). Upon hatching, yolk-sac larvae can range in size from about 7 to 11 mm (0.3 to 0.4 in.) (Able and Fahay 2010). By the time they reach 15 mm (0.5 in.) TL, about 9-12 days after hatching, the yolk sac is completely absorbed, and post yolk-sac larvae are actively feeding on zooplankton (Buckley and Kynard 1981). Shortnose sturgeon generally resemble adults by the time they reach about 20 mm (0.59 in.) TL, and juvenile transformation occurs around 57 mm (2.2 in.) TL (Able and Fahay 2010). Juveniles achieve lengths of 14 to 30 cm (5.5 to 11.8 in.) TL in their first year and then grow more slowly over the next 8 to 9 years before reaching their maximum length (Bain 1997; SSSRT 2010). The juvenile stage lasts for three to ten years until sexual maturity.

2. Population Status in the Delaware River

Hastings et al. (1987) determined that the shortnose sturgeon population in the Delaware was healthy and stable during the 1980s and consisted of 6,400 to 14,000 adults. At the time, this was the largest individual stock estimate for shortnose sturgeon, comparable to that of the Hudson River population at the time (13,844 adults) (Dovel 1979; Kynard 1997). NMFS (1998) later determined that

Hastings et al. (1987) may have underestimated the total population size in the Delaware River, as the study was based on mark-recapture sampling and focused on a limited portion of the available habitat. NMFS later estimated that the Delaware population of shortnose sturgeon consisted of approximately 8,445 to 10,000 fish (NMFS 2002, 2004). It is thought that older adults make up a substantial portion of the population in the River (Hastings et al. 1987; SSSRT 2010).

3. Distribution and Migrations

a. Distribution of Adults in the River

Adult shortnose sturgeon can occur throughout the Delaware from the lower bay as far upstream as Lambertville, New Jersey (RKM 239 [RM 149]). They may occasionally enter the nearshore ocean off Delaware Bay but likely spend protracted periods of time at specific resting, aggregation, and/or feeding sites within the River (Hastings et al. 1987; SSSRT 2010). Adults typically spend summer days in deeper areas with little or no current and move into shallower water or exhibit upstream or downstream movement at night (Able and Fahay 2010). A large portion of the adult population may overwinter in freshwater areas near potential spawning sites in preparation for spawning in the spring (Dadswell 1979).

b. Movement of Adults to Spawning Grounds, Dispersal Following Spawning, and Movement to Overwintering Grounds

Adult shortnose sturgeon migrate seasonally between spawning habitat in the freshwater reaches of the River and foraging areas in brackish waters well downstream of spawning sites (SSSRT 2010). Spawning adults move upriver through the deep channel, continuing as far upstream as spawning habitat is available. In the Delaware River, spawning begins in late March or early April, reaching its peak by mid-April. Spawning activity is concentrated in non-tidal waters between Trenton (RKM 214 [RM 133]) and Scudders Falls (RKM 225 [RM 140]), but eggs have been found as far upstream as Lambertville (RKM 239 [RM 149]) (ERC 2008; SSSRT 2010; NMFS 2014a; ERC 2015). Females leave the spawning grounds relatively soon after spawning, while males tend to remain in the River for a longer period of time (O'Herron et al. 1993). After spawning, adults migrate downstream to brackish waters near Burlington Island (RKM 190 [RM 118]), moving at least as far downstream as Philadelphia (RKM 165 [RM 102]) before moving back upstream to areas of the River between Fieldsboro, New Jersey (RKM 205 [RM 127]) and Assunpink Creek (RKM 215 [RM 133]) (O'Herron et al. 1993).

In early to mid-winter, shortnose sturgeon migrate to overwintering areas where they congregate in sedentary groups between Burlington Island (RKM 190 [RM 118]) and Duck Island (RKM 210 [RM 130]), especially in the channel off Duck Island (O'Herron et al. 1993). A substantial portion of the overwintering population reaches its destination by November and remains there through late March or early April before beginning the upstream spawning migration when temperatures approach 7 to 10°C (44.6 to 50°F) (O'Herron et al. 1993; SSSRT 2010; Kynard et al. 2012). In general, spawning activity for shortnose sturgeon occurs in the River when water temperatures range between 6°C and 18°C (42.8°F and 64.4°F), with peak spawning activity at about 13°C (55.4°F) (ERC 2015).

Genetic studies have suggested that mixing of shortnose sturgeon populations among different river systems is unlikely and that most rivers and estuaries harboring shortnose sturgeon contain genetically distinct groups. However, some gene flow does occur between the Delaware River and Chesapeake Bay populations of sturgeon (Welsh et al. 2002; Wirgin et al. 2005), likely through the C&D Canal that connects the two estuaries. The lack of reproductively active shortnose sturgeon in the

Chesapeake Bay suggests that some Delaware River adults may make seasonal migrations into the Chesapeake Bay (Wirgin et al. 2005).

c. Downstream Movement of Post-Yolk Sac Larvae from the Spawning/Nursery Grounds

Aside from limited downstream movements, eggs and yolk-sac larvae may remain concentrated near the spawning site for up to four weeks after spawning (SSSRT 2010). For the first couple days after hatching, larvae are photonegative and exhibit vertical movement and drifting behavior, which allows them to move short distances downstream to locate benthic cover (Richmond and Kynard 1995). Yolk-sac larvae up to eight days old are still photonegative but become more strictly benthic and exhibit minimal swimming activity through the water column; these larvae continue swimming horizontally along the bottom until they find cover, at which point they cease downstream movement (Richmond and Kynard 1995; Parker and Kynard 2014). Beginning about 9 to 14 days after hatching, swimming ability improves and larvae begin to move short distances downstream, mostly at night (Richmond and Kynard 1995; Parker and Kynard 2014). Between 16 and 20 days of age, post yolk-sac larvae exhibit bottom-oriented foraging behavior and pronounced downstream migrations (Kynard and Horgan 2002). Larval shortnose sturgeon have been most frequently collected in deeper areas of the River, including the river channel, at depths of 9 to 20 m (30 to 65 ft) and at water temperatures up to 24.5°C (76.1°F) (Taubert and Dadswell 1980; Bath et al. 1981).

d. Dispersal of Juveniles Throughout the River

Juvenile shortnose sturgeon are thought to remain in deeper channels within freshwater environments upstream of the salt front for the first year (Dadswell et al. 1984; Kynard 1997). Brundage and O'Herron (2009) collected juvenile shortnose sturgeon from deep waters (greater than 6.1 m [20 ft]) in the lower tidal reach of the River spanning from Wilmington (RKM 110 [RM 68]) to Marcus Hook (RKM 130 [RM 81]) during all months except February, March, and April. Juveniles were found to remain upstream of Wilmington, where DO concentrations are higher, in the spring and summer, distribute widely throughout the River in fall, and congregate in the lower tidal reaches during the winter (Brundage and O'Herron 2009). Overwintering occurs between Philadelphia (RKM 165 [RM 102]) and Artificial Island (RKM 80 [RM 49]); juveniles do not overwinter in the same areas as adults (O'Herron et al. 1993; Brundage and O'Herron 2009).

4. Habitat Requirements and Feeding Habits

a. Spawning Habitat

Spawning begins when water temperatures reach 7 to 9.7°C (45 to 49.5°F) on days with about 13 hours of daylight and lasts until temperatures reach between 12 and 15°C (54 and 59°F) (Kynard 1997; Kynard et al. 2012). Preferred spawning habitat is characterized as river channels with rock or gravel substrate and moderate bottom current velocities between 0.4 and 0.8 meters per second ("m/s") (1.3 and 2.6 fps) (NMFS 1998; SSSRT 2010). Spawning areas are often located at the farthest accessible upstream reach of the river, possibly to allow enough suitable (i.e., freshwater) habitat downstream of the spawning ground for larval and YOY shortnose sturgeon to disperse (Kynard 1997; SSSRT 2010). In the Delaware, spawning occurs well upstream of Eddystone, primarily between Scudders Falls (RKM 223

[RM 139]) and the Trenton rapids (RKM 214 [RM 133]). In this reach, the River consists of pools, riffles, and rapids, and the substrate is composed primarily of sand, gravel, and cobble (SSSRT 2010).

b. Nursery and Juvenile Habitat

Larval and juvenile shortnose sturgeon most commonly occur in deeper (at least 9 m [29.5 ft]) channel habitat, where currents are strong and the substrate consists of sand or gravel that can provide cover (Able and Fahay 2010). Salinity tolerance of YOY shortnose sturgeon increases with body size during the first year (Ziegeweid et al. 2008b). Jenkins et al. (1993) found that 76 day-old YOY could not tolerate salinities above 15 ppt, but older YOY sturgeon could tolerate salinities as high as 20 ppt for short periods of time (i.e., up to 18 hours); none survived salinities greater than 30 ppt. Although juvenile shortnose sturgeon can tolerate higher salinities, they occur more commonly in freshwater habitats until they reach about 45 cm (1.5 ft) TL (Dadswell 1979).

Shortnose sturgeon have been reported at temperatures up to 30°C (86°F) in the Connecticut River (Dadswell et al. 1984). The optimal growth temperature for YOY shortnose sturgeon ranges from 26 to 28°C (79 to 82°F), with higher temperature optima at higher acclimation temperatures (Ziegeweid et al. 2008a). Upper limits of safe temperature (within 5°C [9°F] of the lethal thermal maximum) for YOY shortnose sturgeon acclimated to 19.5 and 24.1°C (67 and 75°F), respectively, are 29.8 and 31.1°C (86 and 88°F) (Ziegeweid et al. 2008a).

c. Foraging Habitat

Shortnose sturgeon foraging activity is affected by temperature, and preferred foraging habitat varies seasonally. Dadswell (1979) found that shortnose sturgeon in the northern part of their range feed only during the warmer seasons in freshwater reaches when water temperatures exceed 10°C (50°F); incidence of prey in the gut increased around the beginning of June and remained high through the summer before declining by November. In brackish waters, shortnose sturgeon were found to feed heavily in the fall, winter, and spring months (Dadswell 1979). Both juvenile and adult shortnose sturgeon primarily forage for benthic invertebrates over sandy or muddy substrates (Kynard 1997; SSSRT 2010).

d. Overwintering Habitat

Overwintering habitat for older juvenile shortnose sturgeon is characterized as saline waters at depths greater than 10 m (32.8 ft) with moderate tidal currents and water temperatures ranging from 2 to 13°C (36 to 55°F) (Dadswell 1979). Dadswell (1979) found that overwintering sites in the Saint John estuary were characterized by salinities averaging 20 ppt, such as those found in the lower Delaware and regions of Delaware Bay. Overwintering sites generally occur over sandy substrate, but in the Hudson River, sturgeon were reported to overwinter over substrates of sand, mud, and gravel (SSSRT 2010).

5. Diet

Larval shortnose sturgeon subsist on the yolk-sac prior to the onset of exogenous feeding, after which post yolk-sac larvae begin feeding on planktonic prey. Juvenile and adult shortnose sturgeon are benthic omnivores that undergo an ontogenetic shift in diet between the juvenile and adult stages (Gilbert 1989). Juveniles feed mainly on benthic crustaceans and insect larvae (Pottle and Dadswell 1979, as cited in Able and Fahay 2010; Carlson and Simpson 1987, as cited in Able and Fahay 2010). Adults forage mostly on mollusks though they will also consume polychaetes and small benthic fish (Dadswell et al. 1984). The two fish species that have been identified in shortnose sturgeon diets are American eel and winter flounder (*Pseudopleuronectes americanus*) (McCleave et al. 1977; Dadswell et al. 1984).

V. POTENTIAL BIOLOGICAL IMPACTS OF THE PROPOSED ACTIVITIES AND TAKE ASSESSMENTS

This section addresses each covered activity discussed in Section II.B and their potential impact and take assessments.

A. Interactions with the Cooling Water Intake Structure

As described in Section II.A.2, CWPs and RWPs at Eddystone withdraw water from the Delaware for condenser cooling and for other critical Station operations via the CWIS. Due to the location of Eddystone on the River, the Station's use of CWPs and RWPs, and the life history characteristics of Atlantic sturgeon and shortnose sturgeon in the Delaware, Eddystone operations have the potential to result in the incidental take of sturgeon by the CWIS.

Two modes of interaction between the Eddystone CWIS and sturgeon are identified: entrainment and impingement. For the purposes of this IITP application, entrainment and impingement are defined, as follows. Entrainment means the transport through the cooling water system of sturgeon that pass through the 3/8 in. mesh openings of the intake screens as they are too small to be retained by the traveling screens. Impingement means physical contact with the intake screens during Eddystone's withdrawal of cooling water by sturgeon large enough to be retained by the 3/8 in. mesh screens. Consistent with the ESA's broad definition of take, Exelon is using this definition of impingement for the purposes of identifying take for this IITP application. Specifically, sturgeon collected on the traveling screens at Eddystone are included as take due to impingement.

The definition for impingement provided above, which is consistent with generally accepted historical usage, is not consistent with USEPA's definition from the §316(b) Rule. It defines impingement in terms of entrapment, rather than temporary contact with the operating CWIS:

> Impingement means the entrapment of any life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of intake water withdrawal. (40 CFR 125.92(n))

> Entrapment includes but is not limited to: Organisms caught in the bucket of a traveling screen and unable to reach a fish return; organisms caught in the forebay of a cooling water intake system without any means of being returned to the source waterbody without experiencing mortality; or cooling water intake systems where the velocities in the intake pipes or in any channels leading to the forebay prevent organisms from being able to return to the source waterbody through the intake pipe or channel. (40 CFR 125.92(j))

Given the broader context of entrapment, the potential for impingement on the intake trash racks and entrapment within the intake forebays will also be evaluated.

1. Atlantic Sturgeon

a. Type of Anticipated Take

All life stages of Atlantic sturgeon could be present in the vicinity of Eddystone's CWIS during some part of the year. Atlantic sturgeon spawning has been documented from RKM 125-211 (RM 78-131) during the spring and summer, and YOY Atlantic sturgeon rear between RKM 105 and 199 (RM 65 and 124) from late fall to early spring (NMFS 2017c). Subadult and adult Atlantic sturgeon may be present in the waters adjacent to Eddystone as they spawn, forage, or move between spawning and overwintering habitats.

i. Entrainment

Early life stages (i.e., eggs and larvae) of Atlantic sturgeon may occur in the vicinity of Eddystone's CWIS. Tracking of acoustic tagged adults by Breece et al. (2013) during the spring spawning season has indicated that the largest densities of potential spawning adults occur just upstream of the salt front near Claymont, DE (RKM 125 [RM 78]) and Chester, PA (RKM 130 [RM 81]). While the highest densities of spawning adults occur downstream from Eddystone, spawning has been documented from Marcus Hook Bar (RKM 125 [RM 78]) to Trenton, NJ (RKM 211 [RM 131]). As sturgeon eggs are adhesive and demersal, it is unlikely that sturgeon eggs would be entrained. However, larvae could be present in the water column, and one yolk-sac larva was entrained at the Station in 2017. Therefore, larval Atlantic sturgeon could be susceptible to entrainment from Eddystone's CWIS.

ii. Impingement on the Traveling Screens

Older life stages of Atlantic sturgeon, which could be present in the vicinity of the Station, are too large to be entrained at Eddystone. However, these life stages could be vulnerable to impingement on the traveling screens at the CWIS.

Swimming performance information reflects the morphology of a species and its life stage and body size (Webb 1984). Knowledge of swimming performance provides information on the ability of a fish to move through the aquatic environment under typical and extreme conditions (i.e., current velocity and water temperature). Common metrics of swimming performance include sustained speeds (swim speeds that fish maintain for extended periods of time, i.e., greater than 200 minutes) and burst speeds, which are indicative of the maximum swim speed over short periods (i.e., less than 30 seconds). Sustained speeds are associated with migrations and small-scale movements while burst speeds are associated with predator avoidance, prey capture, and other situations requiring a short, but energetically costly, burst of energy. Swim tunnel performance studies of juvenile and sub-adult Atlantic, white, and lake sturgeon have demonstrated that fish are capable of burst swim speeds of approximately 65 cm/s (2.1 fps) and prolonged swim speeds of 45 cm/s (1.5 fps) (Clarke 2011, as cited in NMFS 2014b). Critical swim speeds for juvenile Atlantic sturgeon under exposure to a range of sediment concentrations varied from 21 to 31 cm/s (0.7 to 1.0 fps) (Wilkens et al. 2015).

Members of the *Acipenser* genus, in general, share similar morphological characteristics; therefore, given the limited information available for Atlantic sturgeon, it is reasonable to consider swimming performance of other *Acipenser* species in North America (i.e., green, lake, pallid, shortnose, shovelnose, and white sturgeon). Swimming performance studies of lake and pallid sturgeon report sustained swim speeds of juveniles (< 18 cm [7 in.]) ranging from 10 to 45 cm/s (0.3 to 1.5 fps) (Hoover et al. 2011). A study examining movements of larger-bodied (sub-adult to sexually mature adult) green sturgeon (1.0 to 1.5 m [3.3 to 5.0 ft] TL) in San Francisco Bay found that fish had average swimming speeds of 50 to 60 cm/s (1.6 to 2 fps) and reached a maximum of 2.1 m/s (7 fps) (Kelly and Klimley 2012). Reported maximum burst speeds for white, lake, and pallid sturgeon range from 40 to 70 cm/s (1.3 to 2.3 fps) (Boysen and Hoover 2009; Hoover et al. 2011). Critical swim speed of shovelnose, lake, and white sturgeon appears to be linearly related to fish length for fish measuring less than 20 cm (7.9 in.) to approximately 1.2 m (3.9 ft), ranging from near 20 cm/s (0.66 fps) to over 1.0 m/s (3.28 fps). Swimming performance of shortnose sturgeon is described in Section V.A.2.a.ii. Sturgeon also employ bottom holding behaviors; some studies suggest this behavior peaks at intermediate flow speeds between 20 to 50 cm/s (0.7 to 1.6 fps) while others show that the frequency of bottom holding increases at flows greater than 40 cm/s (1.3 fps) (Adams et al. 1997, 1999, as cited in Peake 2004).

The collective insight from these studies of sturgeon swimming performance helps to bound the expected performance of Atlantic sturgeon under typical and more extreme environmental conditions. The traveling screens at Eddystone have a through-screen velocity of 26.8 cm/s (0.88 fps) and an approach velocity of 13.1 cm/s (0.43 fps) at MLW when the Station is operating at design flow. Based upon the swim performance described above, juvenile Atlantic sturgeon should be capable of avoiding impingement at velocities equal to or greater than those experienced at Eddystone. According to NMFS (2013), adult Atlantic sturgeon should be able to avoid impingement at velocities up to 3 fps, velocities well in excess of those experienced at the Station's CWIS. Therefore, the potential for impingement of Atlantic sturgeon on the traveling screens at Eddystone is likely very low.

iii. Impingement on the Intake Trash Racks

As described in Section II.A.2, the Eddystone CWIS includes trash bars in front of the intake forebay. Each bar is 0.5 in. wide and is spaced 3.75 in. on center. Approach velocity and velocity through the trash rack are less than 16.8 cm/s (0.55 fps) (Exelon et al. 2008).

Sturgeon too large to pass through the trash bars would be adults and would be capable of avoiding impingement at velocities well in excess of the velocities at the Eddystone trash rack. According to NMFS (2013):

> …assuming the condition of the fish and environmental factors in the river are similar to those in the laboratory studies previously discussed, we would not anticipate any impingement of shortnose sturgeon at the trash racks, because sturgeon that are big enough to not be able to pass through the racks (i.e., those that have body widths greater than three inches) would be adults. If their swimming ability is not compromised, these fish should be able to avoid impingement at velocities of up to 3 feet per second and should be able to readily avoid getting stuck on the trash racks." (from page 67 for shortnose sturgeon, and repeated on page 82 for Atlantic sturgeon).

Given this conclusion and the fact that the approach and through-rack velocities are well below 3 fps, impingement of sturgeon on the trash racks at Eddystone is not considered a potential mode of take by Eddystone's CWIS operations.

iv. Entrapment within the Intake Forebay

The space between the trash racks and the traveling screens is referred to as the intake forebay. As noted above, USEPA includes entrapment in the forebay as part of its definition of impingement. At Eddystone, between the trash racks and the traveling screens there is an opening to the river designed to allow fish to escape from the forebay.

The question of whether fish that enter an intake forebay and do not return to the source waterbody through trash racks would become entrapped in the forebay was addressed by Fletcher (1990). Fletcher found that fish unable to return to the source waterbody through the trash racks (in his experiments because he installed a fixed screen at the trash racks) were removed from the forebay by impingement on the traveling screens.

Therefore, entrapment within the intake forebay at Eddystone is not considered a form of take separate from impingement on the traveling screens. It is anticipated sturgeon encountering an operating forebay will either return to the River through the trash racks or the fish escape or be collected by the traveling screens.

b. Estimated Take Number

i. Entrainment

As described in Appendix A ("Eddystone Generating Station – Atlantic Sturgeon – Estimated Annual Numbers Entrained – Estimates for Historical Water Withdrawal Rates and Evaluation of Alternative Sampling Intensities for Future Entrainment Sampling"), entrainment sampling was conducted at Eddystone in 2005-2006, 2016, and 2017. One Atlantic sturgeon yolk-sac larva was collected in the three years of sampling. Data from those entrainment sampling programs were used to estimate average annual numbers of Atlantic sturgeon entrained historically from 2013-2017. The annual estimates were based on average entrainment rates over the three years of entrainment sampling and year-specific historical water withdrawal rates at Eddystone.

Two statistical models,[43] with slightly different underlying assumptions, were used to estimate annual numbers entrained, expressed as age-1 equivalents. For the two models, the five-year averages (2013-2017) of annual estimates of numbers of Atlantic sturgeon entrained at Eddystone were 0.2 and 0.3 age-1 equivalent sturgeon.[44] For the two models, the five-year averages of the annual upper 95% confidence limits for the estimates of annual numbers entrained, expressed as age-1 equivalents, were 0.8 and 1.1 age-1 equivalent Atlantic sturgeon (Appendix A). These upper confidence intervals were rounded up to the nearest integer for the purpose of estimating take.

Based on the results of the estimates of historical entrainment at Eddystone (i.e., based on historical cooling water withdrawal rates), the estimated annual take for entrainment of Atlantic sturgeon

[43] Based on a previous recommendation from NMFS, AKRF used a zero inflated Poisson probability distribution model to develop take estimates; Personal communication. J. Kahn, NMFS, to D. Heimbuch, AKRF. February 3, 2016.
[44] Estimated numbers of Atlantic sturgeon entrained are presented in terms of age-1 equivalents to facilitate comparisons to other forms of take.

is 2 age-1 equivalents, commensurate with the average of upper 95% confidence limits of estimated annual numbers entrained.

ii. Impingement

As described in Appendix B ("Eddystone Generating Station – Atlantic and Shortnose Sturgeon – Estimated Annual Numbers Impinged Based on Historical Impingement Sampling Data"), impingement sampling was conducted at Eddystone in 1976-1978, 1987-1992, and 2005-2006. No Atlantic sturgeon were collected during those years of impingement sampling. Data from those impingement sampling programs were used to estimate average annual numbers of Atlantic sturgeon impinged at Eddystone.

Two approaches were used to estimate annual numbers impinged. A likelihood function analysis was performed based on the observation (or lack thereof) of Atlantic sturgeon in impingement samples at Eddystone. A Bayesian posterior probability distribution analysis was also performed utilizing impingement sampling results to inform the prior for annual number impinged. The results of the likelihood function analysis showed a very low likelihood that the annual number of Atlantic sturgeon impinged is greater than one. The Bayesian analysis also resulted in a very low likelihood (0.01) that the annual number of Atlantic sturgeon impinged at Eddystone is greater than one (Appendix B).

Based on the results of the likelihood function and Bayesian analyses, the estimated annual take of Atlantic sturgeon due to impingement is 1 YOY or older sturgeon.

c. Proposed Take Limit

i. Entrainment

During the June 2018 meeting with NMFS, described in Section I, NMFS approved expressing take estimates in terms of age-1 equivalents, as presented in this application. However, NMFS noted that take limits would likely be issued in the context of the number of sturgeon larvae encountered in monitoring conducted under the IITP (Section VI.B.1.a). Therefore, AKRF evaluated historical operations at Eddystone and planned operations under the Station's selected impingement compliance option for §316(b) to develop potential entrainment sampling schedules for IITP monitoring; AKRF then used the potential sampling schedules to estimate the number of larval Atlantic sturgeon that would be collected in entrainment sampling (Appendix C). The results of this evaluation indicated that a take estimate of 2 age-1 equivalent Atlantic sturgeon (Section V.A.1.b.i) would be equivalent to the collection of 0 to 2 Atlantic sturgeon larvae in entrainment sampling. As a take limit for an IITP cannot be zero, the annual take estimate was increased to 3 age-1 equivalent Atlantic sturgeon, resulting in an estimate of 1 to 3 Atlantic sturgeon larvae potentially collected in entrainment sampling, depending on the number of days of operation for the CWPs and the number of sampling days (Appendix C). Therefore, Exelon is proposing an annual take limit of 3 Atlantic sturgeon larvae in entrainment sampling, commensurate with an annual take estimate of 3 age-1 equivalents.

ii. Impingement

As noted in Section V.A.1.c.i, take limits for the Station's IITP are expected to be expressed in terms of the number of sturgeon encountered in IITP monitoring, described in Section VI.B.1.b. Therefore, AKRF developed potential impingement sampling schedules for IITP monitoring based on historical operations at the Station and planned operations under Eddystone's selected impingement compliance option for §316(b). These potential sampling schedules were then evaluated to estimate the number of Atlantic sturgeon that would be collected in impingement sampling (Appendix C). The results of this evaluation indicated that a take estimate of 1 Atlantic sturgeon (Section V.A.1.b.ii) would be equivalent to the collection of 0 Atlantic sturgeon in impingement sampling. As a take limit for an IITP cannot be zero, the annual take estimate was adjusted to 7 Atlantic sturgeon, which resulted in an estimate of 1 to 3 young-of-the-year or older Atlantic sturgeon collected in impingement sampling, depending on the number of days of operation for the CWPs and the number of sampling days (Appendix C). Therefore, Exelon is proposing an annual take limit of 3 YOY or older Atlantic sturgeon in impingement sampling, commensurate with an annual take estimate of 7 YOY or older Atlantic sturgeon.

d. Effects of the Take on the Listed Species

The estimated annual incidental take due to impingement and entrainment, commensurate with the proposed take limits (Section V.A.1.c, Appendix C) is 10 Atlantic sturgeon. Therefore, it is anticipated that only a small fraction of the population of Atlantic sturgeon in the Delaware will experience mortality or injury due to interaction with the operating CWIS.

2. Shortnose Sturgeon

a. Type of Anticipated Take

Shortnose sturgeon spawning occurs between Trenton and Lambertville (RKM 214-238 [RM 133-148]), and eggs and larvae rear above RKM 214 (RM 133) (NMFS 2017d), well upstream of Eddystone. Therefore, early life stages would not be expected to occur in the vicinity of the Station. However, juveniles and adults may be present at certain times of the year. Juveniles rear upstream of the salt wedge between Wilmington and Philadelphia (RKM 114-148 [RM 71-92]) (Burton et al. 2005, as cited by NMFS 2017c). Shortnose sturgeon forage between Trenton and Artificial Island (located at RKM 79 [RM 49]) (SSSRT 2010) and may overwinter in the reach of the River adjacent to Eddystone (ERC 2006, as cited by NMFS 2017c; Brundage and O'Herron 2009, as cited by NMFS 2017c).

i. Entrainment

As stated above, egg and larval shortnose sturgeon would not be present in the vicinity of Eddystone's CWIS. Therefore, this species is not likely susceptible to entrainment at the Station.

ii. Impingement on the Traveling Screens

Juvenile and older shortnose sturgeon may occur at times in the vicinity of Eddystone, as described above. When present in waters adjacent to Eddystone, shortnose sturgeon could be susceptible to impingement from the Station's operating CWIS.

The critical swimming speed of YOY shortnose sturgeon was measured at approximately 34 cm/s (1.0 fps), but performance depended on temperature and was lower at reduced temperatures (e.g., at 5°C [41°F]). At 10°C (50°F), critical swimming speeds were 26.0 to 28.9 cm/s (0.9 to 1.0 fps) (Kieffer et al. 2009; Deslauriers and Kieffer 2012). YOY shortnose sturgeon were found to be vulnerable to impingement at velocities greater than 30.5 cm/s (1.0 fps), but larger juvenile and adult shortnose sturgeon (greater than 58 cm [22.8 in.] TL) were not impinged at velocities up to 91.4 cm/s (3.0 fps) (Kynard et al. 2005, as cited in NMFS 2016a). Because morphology and body size are indicative of swimming performance (Webb 1984), swimming performance is expected to be similar among sturgeon species at a given body size. Therefore, the information on swimming performance provided for Atlantic sturgeon and other North American sturgeons in Section V.A.1.a.ii can also be used to evaluate swimming performance of shortnose sturgeon of similar body size.

As described in Section V.A.1.a.ii, the traveling screens at Eddystone have a through-screen velocity of 26.8 cm/s (0.88 fps) and an approach velocity of 13.1 (0.43 fps) at MLW when the Station is operating at design flow. Based upon the swim performance described above, juvenile and adult shortnose sturgeon should generally be capable of avoiding impingement at velocities equal to or greater than those experienced at Eddystone; adult shortnose sturgeon should also be capable of avoiding impingement entirely, given the 0.88 through-screen velocity. Therefore, the potential for impingement of shortnose sturgeon on the traveling screens at Eddystone is likely very low.

iii. Impingement on the Intake Trash Racks

Any shortnose sturgeon too large to pass through the trash racks at Eddystone would be adults. As described in Section V.A.1.a.iii, the velocities encountered at the trash racks (less than 16.8 cm/s [0.55 fps]) are well below the 91.4 cm/s (3.0 fps) at which shortnose sturgeon adults can avoid impingement. Therefore, impingement of shortnose sturgeon on the trash racks at Eddystone is not considered a potential mode of take by Eddystone's CWIS operations.

iv. Entrapment within the Intake Forebays

As noted in Section V.A.1.a.iv, entrapment within the intake forebay at Eddystone is not considered a form of take separate from impingement on the traveling screens. It is anticipated that sturgeon encountering an operating forebay will either swim through the openings in the trash racks or the fish escapes to return to the River, or be collected by the traveling screens.

b. Estimated Take Number

As described in Section V.A.1.b.ii, impingement sampling was conducted at Eddystone in 1976-1978, 1987-1992, and 2005-2006. No shortnose sturgeon were collected during those years of impingement sampling. Data from those impingement sampling programs were used to estimate average annual numbers of shortnose sturgeon impinged at Eddystone using the same method as was utilized for Atlantic sturgeon (see Section V.A.1.b.ii and Appendix B). The results of the analyses indicated that the likelihood that the annual number of shortnose sturgeon impinged is greater than one is very low (Appendix B). Therefore, the estimated annual take of shortnose sturgeon due to impingement is 1.

c. Proposed Take Limit

As noted in Section V.A.1.c.i, take limits for the Station's IITP are expected to be expressed in terms of the number of sturgeon encountered in IITP monitoring, described in Section VI.B.1.b. Therefore, AKRF developed potential impingement sampling schedules for IITP monitoring based on historical operations at the Station and planned operations under Eddystone's selected impingement compliance option for §316(b). These potential sampling schedules were then evaluated to estimate the number of shortnose sturgeon that would be collected in impingement sampling (Appendix C). The results of this evaluation indicated that a take estimate of 1 shortnose sturgeon (Section V.A.2.b) would be equivalent to the collection of 0 sturgeon in impingement sampling. As a take limit for an IITP cannot be zero, the annual take estimate was adjusted to 7 shortnose sturgeon, which resulted in an estimate of 1 to 3 YOY or older shortnose sturgeon collected in impingement sampling (Appendix C). Therefore, Exelon is proposing an annual take limit of 3 YOY or older shortnose sturgeon collected in impingement sampling, commensurate with an annual take estimate of 7 YOY or older shortnose sturgeon.

d. Effects of the Take on the Listed Species

The estimated annual incidental take due to impingement commensurate with the proposed take limit (Section V.A.2.c) is seven shortnose sturgeon. Therefore, only a small fraction of the population of shortnose sturgeon in the Delaware could be expected to experience mortality or injury due to interaction with the operating CWIS.

B. Interactions with the Thermal Plume

As described in Section II.A.1, over the past several years Eddystone has operated as a peaking plant, typically running at higher levels of generating capacity on days (and for the hours) when the demand for electric energy was high. As described in Section II.A.3, Eddystone's non-contact OTCW is discharged at the bottom of the River, through a 12 ft diameter pipe that extends approximately 300 ft offshore of the Station, via Outfall 008. The discharge port is located at a depth of approximately 37 ft and discharges water horizontally along the river bed, towards the southeast. The OTCW discharge contains both heat and chemical pollutants. The potential effects of exposure to heat for sturgeon are discussed in this section

Heated effluent discharged from Eddystone warms water temperatures in the River above ambient temperatures. Between 2011 and 2014, monthly maximum discharge temperatures at Eddystone's Outfall 008 from March through May ranged from 13.3 to 28.9°C (56.0 to 84.0°F). Summer monthly maximum discharge temperatures ranged from 28.2 to 34.1°C (82.8 to 93.4°F) from June through August. From 2015 to 2017, average monthly discharge temperatures from March through May ranged from 10.1 to 36.1°C (50.1 to 79.0°F). Summer monthly average temperatures ranged from 25.2 to 32.6°C (77.4 to 90.7°F) from June through August.

As described in Section II.A.3.a, Eddystone's thermal plume was modeled in 2014 in support of the Station's NPDES permit and DRBC docket renewals (Attachment 2). Modeling assumed a discharge rate of 580,000 gpm, the rate associated with the Station operating at full capacity, and a ΔT of 11.7°C (21°F).[45] Based on the results of this modeling effort, DRBC and PADEP authorized an HDA of 121.9 m (400 ft) in width, extending 64.0 m (210 ft) upstream and downstream of the outfall (Figure V-1). Outside this HDA, effluent temperatures may not exceed 2.8°C (5°F) above ambient river temperatures with a maximum of 30°C (86°F). Within the HDA, these limits may be exceeded. The results of the 2014 modeling effort were further evaluated in 2018 to quantify the bottom contact area of the thermal plume. The maximum bottom contact size was 250.3 m^2 (2,694 ft^2) (Attachment 3).

In Sections V.B.1 and V.B.2, the available information on the biological effects of temperature and the thermal tolerances for Atlantic sturgeon and shortnose sturgeon are discussed. This information is

[45] The ΔT of 11.7°C (21°F) is the effluent temperature rise associated with Units 3 and 4 operating at full capacity (ERM 2014).

then used to evaluate the results of the thermal modeling in terms of the potential impacts to both sturgeon species as a result of exposure to elevated temperatures in Eddystone's thermal plume.

1. Atlantic Sturgeon

a. Spawning Adults

As discussed in Section IV.A.3.b, adult Atlantic sturgeon primarily spawn during the spring and early summer; spawning habitat for this species has been identified between Stoney Creek, PA and Trenton, NJ. The greatest concentration of adults during the spawning season occurs more than 5.6 km (3.5 mi) downstream of Eddystone and well beyond the influence of the thermal plume.[46] If this concentration represents the primary spawning grounds, most spawning adults would spawn before passing Eddystone. However, some could spawn within the reach of the River adjacent to Eddystone or upstream of the Station. Therefore, elevated water temperatures of Eddystone's thermal plume could affect spawning adults in the vicinity of the Station.

Atlantic sturgeon require water temperatures between 13°C (55°F) and 26°C (79°F) for spawning (NMFS 2017b). Temperatures within Eddystone's thermal plume would never exceed the maximum spawning temperature for this species outside the HDA. If Eddystone were operating at maximum generating capacity, spawning temperatures could be exceeded within the HDA in May and June. While spawning activity could be limited within the HDA due to effluent temperatures, the maximum area of bottom contact is only 250.3 m^2 (2,694 ft^2), occupying less than 0.01% of available Atlantic sturgeon spawning habitat in the Delaware.[47] Further, the HDA occurs outside the primary concentration areas for Atlantic sturgeon during the spawning season.

While the thermal plume could impact spawning in the immediate vicinity of Eddystone's discharge, the high concentration areas downstream of the Station may represent transition and staging areas, indicating that spawning occurs farther upstream from the Station (see Section VI.A.4.a). If Atlantic sturgeon spawning habitat within the Delaware lies upstream of Eddystone and beyond the influence of the thermal plume, the discharge of heated effluent at the Station would have no influence on spawning adults. Under these two potential spawning habitat scenarios, the Station's thermal discharge would affect 0.01% or less of available spawning habitat for Atlantic sturgeon. Therefore, the thermal plume at Eddystone is not expected to have any significant effect on spawning adults.

b. Juveniles and Non-Spawning Adults

Juvenile and non-spawning adult Atlantic sturgeon may use the tidal freshwater portion of the River as far upstream as Trenton (Lazarri et al. 1986; Breece et al. 2013) and may, therefore, encounter elevated temperatures in the vicinity of Eddystone's thermal plume. Atlantic sturgeon have been observed in riverine habitats at temperatures up to 30°C (86°F) (Dadswell et al. 1984). Because of the limited information on thermal tolerance for Atlantic sturgeon, results from studies of shortnose sturgeon were used to supplement the existing information for Atlantic sturgeon.

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[46] Eddystone's HDA extends only 0.06 km (0.04 mi) downstream of the Station.
[47] There is an estimated 61.1 km^2 (23.6 mi^2) of benthic habitat at depths greater than three feet (NMFS 2017b) between Stoney Creek and Trenton Falls.

During late spring and summer when daily average ambient temperatures range from 18 to 27°C (65 to 80°F), the thermal preference and growth optima for juvenile shortnose sturgeon range from 26.2 to 28.3°C (79.2 to 83°F) (Ziegeweid et al. 2008b). The critical thermal maximum during this time of the year ranges from 33 to 35°C (91 to 95°F) (Ziegeweid et al. 2008b); at these temperatures, sturgeon lose equilibrium and the ability to swim effectively. Based on this critical thermal maximum, the corresponding upper limit safe temperatures (i.e., 5°C [9°F] less than the critical thermal maximum) during this time period would range from 28 to 30°C (82.4 to 86°F) (Ziegeweid et al. 2008b). Lethal thermal maxima for juvenile shortnose sturgeon have been estimated at 35 and 36°C (95 and 97°F), with corresponding ΔT values ranging from 8 to 18°C (14 to 32°F) during the late spring and summer. That is, at a daily average ambient temperature of 18°C (65°F), which would occur during late May, an increase of 17 to 18°C (30 to 32°F) would result in elevated temperatures of 35 to 36°C (95 to 97°F) in the thermal plume. Similarly, at a daily average ambient temperature of 27°C (80°F), which would occur during July, an increase of 8 to 9°C (15 to 17°F) would result in elevated temperatures of 35 to 36°C (95 to 97°F) in the thermal plume. This assessment assumed that juvenile and adult sturgeon would avoid water temperatures greater than 29°C (84°F), which is the mid-point of the upper limit safe temperature derived above.[48]

Based on their thermal tolerance, movement by juvenile and non-spawning adult Atlantic sturgeon through the River in the vicinity of Eddystone would not be obstructed by the thermal plume. Discharge temperatures could exceed avoidance temperatures for Atlantic sturgeon from June through October, when ambient temperatures are expected to range from 21.1°C (70°F) to 27.2°C (81°F), if the Station is running at full capacity. However, temperatures drop below avoidance temperatures within the HDA during June, September, and October and drop below avoidance temperatures just outside the HDA in July and August. Therefore, Atlantic sturgeon are generally excluded from less than 0.01 square miles of the River due to Eddystone's thermal plume. At Eddystone, the Delaware is approximately 1.9 km (6,000 ft) wide (Figure III-1). The area from which Atlantic sturgeon could be excluded is approximately 400 ft wide, indicating that more than 93% of the river width would be available for Atlantic sturgeon passage.

Juvenile and adult Atlantic sturgeon are able to avoid temperatures that approach the upper limit of thermal tolerances by moving within the water column or by moving laterally across the river channel. The maximum impact of the thermal plume on the zone of passage would occur at the outfall, where ΔTs are greatest. The area where avoidance temperatures could be exceeded is relatively small. Therefore, juvenile and adult Atlantic sturgeon are not likely to be adversely affected by elevated temperatures in the vicinity of Eddystone's thermal plume.

Cessation of most or all thermal discharges during winter could adversely affect overwintering Atlantic sturgeon, if they were using Eddystone's heated discharge as a thermal refuge. Adult Atlantic sturgeon return to the ocean during the fall and winter months, and juveniles migrate to the lower Estuary and nearby ocean waters where they spend the winter. These life stages are not generally found in the vicinity of Eddystone during the winter and, therefore, are not likely to be adversely impacted from cold shock resulting from any unexpected shutdowns.

Because oxygen is essential to aerobic respiration and its availability is related to water temperature, the potential influence of Eddystone's thermal effluent discharge on DO concentrations was

[48] At cooler ambient water temperatures during early spring, sturgeon may temporarily avoid areas of the River that are less than the upper limit safe temperature of 29°C (84°F), but they would eventually acclimate to those temperatures.

also evaluated. Between October 1, 2010 and September 30, 2015, 100% of DO observations at the USGS gage at Chester, PA in DRBC Zone 4, just 1.7 mi downstream of Eddystone, met both the daily mean criterion (not less than 3.5 mg/L) and the seasonal criterion (not less than 6.5 mg/L) for the protection of wildlife, fish, and other aquatic species (DRBC 2016a). In terms of critical habitat for Atlantic sturgeon, daily average DO levels during the 5-year period from 2013-2017 at the USGS gage were less than 6.0 mg/L[49] during 20% of days each year, primarily between June and September, when ambient water temperatures exceeded 22°C. Water temperatures within the thermal plume were modeled at up to 8°C (15°F) above ambient, but did not exceed 0.6°C (1°F) above ambient beyond a distance of several hundred feet from the outfall (ERM 2014). Depending on the ambient temperatures in the river it is possible that DO levels within some or all of the plume were less than ambient (i.e., reduced due to the elevated water temperatures in the plume); however, because of the very small spatial extent of the plume, the effect of any reduction in DO levels would be undetectable or not measurable in terms of effects to sturgeon. Additionally, the thermal plume lies upstream of identified concentration areas for juvenile Atlantic sturgeon (Section IV.A.3.c). Moreover, the buoyancy of the thermal plume in the water column means that DO levels in benthic habitat at the bottom of the river are less likely to be affected by the influence of elevated water temperatures in the plume. Therefore, the influence of Eddystone's thermal plume on DO levels would not have a significant effect on Atlantic sturgeon.

c. Egg and Larval Atlantic Sturgeon

As discussed in Sections IV.A.3.b and V.B.1.a, Atlantic sturgeon spawn between Cherry Island and Trenton, NJ. Although the greatest concentration of spawning activity occurs more than 5.6 km (3.5 mi) downstream of Eddystone and well beyond the influence of the thermal plume,[50] some sturgeon spawn within the reach of the River adjacent to Eddystone or upstream of the Station. After hatching, the yolk-sac larvae will remain in the substrate on the spawning ground as they continue to develop. Around the time that the yolk sac is absorbed, post yolk-sac larvae begin the downstream migration (i.e., past Eddystone, if they were spawned upstream of the Station). Therefore, elevated water temperatures of Eddystone's thermal plume could affect growth and development of the early life stages of Atlantic sturgeon within the vicinity of the Station.

There have been no published studies on the thermal tolerance of Atlantic sturgeon eggs. Therefore, studies from other North American sturgeons will be used as a surrogate. White and lake sturgeon eggs experience mortality above 20°C (68°F) (Wang et al. 1985). Van Eenennaam et al. (2005) determined that the upper thermal limit of optimal temperatures for green sturgeon eggs was 17 to 18°C (62.6 to 64.4°F) and that all embryos died at temperatures above 23°C (73.4°F). In a study on Atlantic and shortnose sturgeon larvae, Hardy and Litvak (2004) reared larvae at a range of temperatures from 13 to 21°C (55.4 to 69.8°F). While growth rate increased with rearing temperature, survival was greater at lower temperatures with larval mortality increasing rapidly after absorption of the yolk-sac. At 21°C (69.8°F), Atlantic sturgeon larvae experienced 100% mortality 18 days after hatching, approximately 10 days after yolk-sac absorption (Hardy and Litvak 2004).

Atlantic sturgeon eggs could be present in the vicinity of Eddystone from April through June. Temperatures could exceed the mortality threshold for Atlantic sturgeon eggs at the outfall in May and in the entire HDA in June. However, these are the same months in which spawning temperatures would be exceeded within the HDA. Therefore, it is unlikely that Atlantic sturgeon eggs would be present in the

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[49] 6.0 mg/L is identified as a juvenile rearing habitat requirement in the designation of critical habitat for Atlantic sturgeon (NMFS 2017b). See Section I.B.1.

[50] Eddystone's HDA extends only 0.06 km (0.04 mi) downstream of the Station.

area affected by Eddystone's thermal plume. Given that yolk-sac larvae generally remain on their spawning grounds and eggs are not likely to be found within the Station's thermal plume, yolk-sac larvae are not likely to be affected by Eddystone's thermal effluent. Post yolk-sac larvae spawned upstream of Eddystone may experience sub-optimal temperatures as they travel downstream past Eddystone. However, the bottom area affected by Eddystone's thermal plume is very small (less than 0.01% of benthic habitat area in the spawning reach of Atlantic sturgeon) and larvae would not be exposed to elevated temperatures for a sufficient duration to experience negative effects. Therefore, the thermal plume at Eddystone is not expected to have a significant effect on egg or larval Atlantic sturgeon.

d. Prey Resources for Atlantic Sturgeon

Prey organisms for juvenile and adult Atlantic sturgeon include demersal and benthic fishes and macroinvertebrates (Section IV.A.5). It is possible that when sturgeon habitat is limited due to warming from thermal discharge, their prey could also be affected during the same time (Section V.B.1.b). However, because the thermal plume is relatively small, it is unlikely that the plume would have a significant adverse impact on sturgeon prey. If the thermal discharge were to affect sturgeon prey on these fine scales, sturgeon would likely avoid that small portion of affected habitat and forage elsewhere.

e. Type of Anticipated Take and Estimated Take Number

Results of hydrothermal modeling of Eddystone's thermal plume in the Delaware in the context of the available biological information on the life history and thermal tolerances of Atlantic sturgeon have been reviewed, as detailed in Sections V.B.1.a-d. While the presence of elevated temperatures in the vicinity of Eddystone's thermal plume may cause minor behavioral changes in movement, foraging, or resting, the effects of those behavioral changes would not prevent sturgeon from resting, foraging, or migrating, would not have a measureable effect on the growth or fitness of individual sturgeon, and are therefore expected to be insignificant. For these reasons, no incidental take of Atlantic sturgeon is anticipated as a result of exposure to elevated water temperatures in the vicinity of Eddystone's thermal plume.

f. Effects of the Take on the Listed Species

Because no incidental take related to Eddystone's thermal plume is expected, there would be no effect on the Atlantic sturgeon population in the Delaware associated with the Station's thermal discharge.

2. Shortnose Sturgeon

a. Spawning Adults

As discussed in Section IV.B.3.b, adult shortnose sturgeon spawn above Trenton, over 78 km (48.5 mi) upstream of Eddystone. Therefore, Eddystone's thermal plume is expected to have no effect on spawning behavior of shortnose sturgeon.

Adult sturgeon may migrate past Eddystone en route to upstream spawning areas in March and April. Based on expected ambient temperatures (4.4 to 8.3°C [40 to 47°F]) and Eddystone's ΔT of 11.7°C (21°F), shortnose sturgeon would not experience temperatures in excess of their avoidance temperature of 29°C (84°F) (see Section V.B.1.b) within Eddystone's thermal plume in these months. Therefore, the Station's thermal effluent would not influence the zone of passage for migrating spawning adults.

Given that spawning does not occur in the reach of the River adjacent to Eddystone and that Eddystone's thermal plume is expected to have no effect on zone of passage for migrating spawning adults, elevated temperatures in the vicinity of Eddystone's OTCW discharge are not expected to adversely affect spawning adult shortnose sturgeon.

b. Juveniles and Non-Spawning Adults

Shortnose sturgeon juveniles and non-spawning adults are expected to occur in the vicinity of Eddystone throughout most of the year. Since the thermal tolerances of this species are expected to be similar to those of juvenile and adult Atlantic sturgeon, the results of the assessment for Atlantic sturgeon apply to those life stages of shortnose sturgeon (see Section V.B.1.b). Movement by juvenile and non-spawning adult shortnose sturgeon through the River in the vicinity of the Station would not be obstructed by the thermal plume. Shortnose sturgeon would generally be excluded from less than 0.01 square miles of the River due to elevated temperatures in Eddystone's thermal plume, and more than 93% of the river width would be available for shortnose sturgeon passage. Sturgeon at these life stages are able to avoid temperatures that approach the upper limit of thermal tolerances by moving in the water column or by moving laterally across the river channel. The maximum impact of the thermal plume on the zone of passage would occur at the outfall, where ΔTs are greatest, and the area where avoidance temperatures could be exceeded is relatively small. Therefore, juvenile and adult shortnose sturgeon are not likely to be adversely affected by temperatures in Eddystone's thermal effluent.

Most shortnose sturgeon adults in the Delaware River overwinter between Burlington Island (RKM 190 [RM 118]) and Duck Island (RKM 210 [RM 130]) (see Section IV.B.3.b), though some may be found below RKM 116 (RM 72). Juveniles overwinter between Philadelphia (RKM 165 [RM 102]) and Artificial Island (RKM 80 [RM 49]) (see Section IV.B.3.d). In the event of any unexpected shutdown of one or both Units during the winter, juvenile or adult shortnose sturgeon in the vicinity of Eddystone could potentially experience cold shock. The extent of the potential impact of cold shock to fish depends on the magnitude of the resulting temperature drop, the ambient water temperature, the affected species, and the access to thermally suitable habitat. Any unexpected shutdown of one or both Units would not result in immediate temperature drops, and the area affected by the thermal plume is relatively small (less than 0.01 mi^2). Thus, adverse impacts to juvenile and adult shortnose sturgeon from cold shock are unlikely.

The general improvements in water quality and, specifically, in DO levels in the Delaware that benefit Atlantic sturgeon (Sections III.A.3.c and V.B.1.b) also benefit shortnose sturgeon.

c. Egg and Larval Shortnose Sturgeon

Shortnose sturgeon spawning and nursery habitat in the Delaware River is located over 78 km (48.5 mi) upstream of Eddystone and beyond the extent of the thermal plume. Because of the location of the spawning and nursery grounds, shortnose sturgeon eggs and larvae would not be exposed to elevated temperatures in the vicinity of Eddystone; the thermal plume would have no effect on these life stages.

d. Prey Resources for Shortnose Sturgeon

Prey organisms for juvenile and adult shortnose sturgeon include demersal and benthic fishes and macroinvertebrates (Section IV.B.5). Because the bottom contact area of the thermal plume is small (approximately 250 m^2), it is unlikely that the plume would adversely impact sturgeon prey. It is possible that when sturgeon habitat is limited due to warming from thermal discharge, their prey could also be affected during the same time (Section V.B.2.b). If the thermal discharge has an adverse impact on sturgeon prey on these fine scales, sturgeon would likely avoid those habitats and forage elsewhere.

e. Type of Anticipated Take and Estimated Take Number for the Delaware River Population of Shortnose Sturgeon

Results of hydrothermal modeling of Eddystone's thermal plume in the Delaware in the context of the available biological information on the life history and thermal tolerances of shortnose sturgeon have been reviewed, as detailed in Sections V.B.2.a-d. While the presence of elevated temperatures in the immediate vicinity of Eddystone's thermal discharge may cause minor behavioral changes in movement, foraging, or resting, the effects of those behavioral changes would not prevent sturgeon from resting, foraging, or migrating and would not have a measureable effect on the growth or fitness of individual sturgeon. Therefore, these effects are expected to be insignificant. For these reasons, no incidental take of shortnose sturgeon is anticipated as a result of exposure to elevated water temperatures in the vicinity of Eddystone's thermal discharge.

f. Effects of the Take on the Listed Species

Because no incidental take related to Eddystone's thermal plume is expected, there would be no effect on shortnose sturgeon in the Delaware.

C. Interactions with Other Chemical Discharges

Sections II.A.3.b and II.A.4 identify the pollutants, other than heat, that are present in Eddystone's discharges to the Delaware. Exelon has evaluated the potential for adverse effects due to the discharge of these pollutants. PADEP and DRBC SWQS set limits on pollutants that are protective of human health and aquatic life. Eddystone's NPDES permit and DRBC docket establish technology-based effluent limits for some pollutants that are potentially harmful to aquatic life but only monitoring requirements for others. Effluent monitoring from January 2011 through December 2017 show that the Station's effluents have been in compliance with permitted levels for potential contaminants (i.e., TSS, total dissolved solids, total residual chlorine, and petroleum hydrocarbons) aside from July 2015 when the Station exceeded their permit limits for daily maximum TSS and instantaneous maximum total residual chlorine.

In the early 2000s, DRBC (2005) initiated an effort to develop a total maximum daily loading ("TMDL") for PCBs in the Delaware. In 2005, the DRBC implemented the PMP rule requiring point sources with known likelihood of discharging PCBs to take steps to reduce or eliminate PCBs in their discharges. Although the program is "non-numeric" (i.e., it does not establish discharge limits), it has been effective at reducing point source discharges of PCBs in the River. However, concentrations in the River currently exceed the established TMDL (DRBC 2016a). The ultimate goal of the PMP is to bring about compliance with the SWQS for PCBs and eliminate the associated fish consumption advisories. Eddystone completed its PMP in 2006 in accordance with the TMDL for PCBs for the Delaware established by the DRBC. At the Station, transformers and circuit breakers that had contained high-PCB oils have been retro-filled with low- or non-PCB oils. As part of the PMP requirements, Eddystone submits an Annual PMP Report that includes data for its required annual PCB sampling. Exelon's continued participation in the PMP ensures that it has taken and will continue to take steps to further reduce the potential for PCBs to be discharged to the River from the Station.

Although contaminants may pose a potential threat to Atlantic sturgeon and shortnose sturgeon health in the Delaware, the overall water quality of the Delaware has improved greatly since the passing and implementation of the Clean Water Act in the 1970s. As noted in Sections I.A.1 and III.A.3.c, DRBC's recently passed Resolution 2017-4 recognized that water quality has improved within Zones 3 and 4 and the northern part of Zone 5. Eddystone continues to be in compliance with permitted discharge standards in its current NPDES permit, and the chemical constituents in Eddystone's effluent are not expected to have an adverse effect on Atlantic sturgeon or shortnose sturgeon. Eddystone is similarly expected to achieve compliance with limits to be imposed in its renewal permit. Therefore, incidental take is not expected for either sturgeon species due to the discharge of pollutants from the Station.

D. Interactions with Vessel Activity due to Oil Deliveries

Vessel traffic, including commercial cargo ships, tankers, tug boats, fishing boats, and recreational motorboats, has recently been identified as a significant source of sturgeon mortality in the Delaware, James, and Hudson Rivers (Brown and Murphy 2010; Balazik et al. 2012; NMFS 2016b; ASMFC 2017). Many of the reported mortalities involve large Atlantic sturgeon with severe injuries (e.g., lacerations that have severed the fish into one or more parts). Given the size of the fish, the nature of the injuries, and the depths at which sub-adult and adult Atlantic sturgeon swim, these mortalities are likely caused by deep-draft ($\geq$ 20 ft) commercial vessels with large propellers (Brown and Murphy 2010). Fewer vessel-related mortalities involving shortnose sturgeon have been reported in the Delaware compared to those reported for Atlantic sturgeon (6 vs. 15 during the period from 2008-2016), suggesting that the risk of vessel strike for shortnose sturgeon is relatively low (NMFS 2017a).

The density of commercial vessel traffic on the Delaware is concentrated from Delaware Bay to ports in Philadelphia (RKM 175 [RM 109]), with some vessel traffic extending upriver to the port at Fairless Hills (RKM 200 [RM 124]) (www.marinetraffic.com). In the River reach between Eddystone and Croydon, which includes Philadelphia, the controlling depth in the navigation channel is approximately 24 to 45 ft (Figure III-1[51]). A tug/small barge (30,000 barrel capacity) with a draft of 15 ft would have 9 to 30 ft of clearance with the river bottom at MLLW. A tug or large barge with a draft of 25 ft (i.e., those most likely to cause injury to sturgeon, see Brown and Murphy 2010) would have slightly less clearance at less than 20 ft.

In order to evaluate the potential risk of vessel interaction with sturgeon during vessel activity to and from Eddystone, the vessel activity in the Delaware associated with Eddystone's oil deliveries was considered in the context of existing commercial vessel traffic (USACE 2017). Existing vessel traffic between Philadelphia and the Atlantic Ocean at the entrance to Delaware Bay during 2011 to 2015 ranged from 34,993 to 51,574 trips annually (41,402 trips on average). The anticipated number of barge trips traveling through this area of the river between Eddystone and the Atlantic Ocean en route potentially to New York Harbor during 2019 is three trips (i.e., six one-way trips). The number of vessel trips in 2019 represents 0.01% of the overall annual vessel traffic in the area (i.e., 6 trips out of 41,402 total trips).

[51] Controlling river channel depths at MLLW tabulated from surveys by the U.S. Army Corps of Engineers Report, April 2016.

Vessel traffic upriver of Philadelphia to Trenton ranged from 4,100 to 5,384 trips annually (5,022 trips on average). The anticipated number of barge trips between Eddystone and Croydon for 2019 is three trips (i.e., six one-way trips). The number of vessel trips in 2019 represents 0.1% of the overall annual vessel traffic in the area (i.e., 6 trips out of 5,022 total trips).

As Atlantic sturgeon are most susceptible to injury from vessels with drafts of 20 ft or more (Brown and Murphy 2010), traffic of vessels with a draft of 20 ft or greater was analyzed separately. Existing traffic of vessels with draft depths greater than or equal to 20 ft ranged from 4,983 to 5,469 trips annually from 2011 to 2015 (5,244 trips on average). In 2014, Eddystone received no oil deliveries from vessels with a draft of 20 ft or more. In 2015, Eddystone received 3 deliveries from vessels with a draft greater than or equal to 20 ft, resulting in 6 one-way trips. In 2019, there are 3 roundtrip vessel deliveries anticipated by tugs/barges with drafts greater than or equal to 20 ft (i.e., 6 one-way trips). This number of trips made to Eddystone by vessels of this size represents 0.12% of the average annual vessel traffic within this size category (i.e., 6 trips out of 5,244 total trips).

For both sturgeon species, NMFS (2017a) has evaluated the potential impacts of increased vessel traffic (23 annual one-way trips) in the Delaware between Delaware Bay and the C&D Canal (RKM 94.3 [RM 58.6]) and up to 350 annual one-way trips in the Atlantic Ocean between New York Harbor and the Delaware River in connection with demolition disposal for the Tappan Zee Bridge Replacement Project. For the Delaware River portion of the analysis, NMFS determined that:

> given this very small increase in traffic and the similar very small increase in risk of strike and a calculated increase in the number of strikes that is very close to zero, we conclude that any increase in the number of sturgeon struck in this reach because of the increase in traffic resulting from disposal vessels transiting the Delaware River is extremely unlikely. Therefore, the effects of this increase in traffic are discountable.

Similarly, for the Atlantic Ocean portion of the vessel analysis, NMFS concluded:

> Given the small additional increase in vessel traffic and the generally low risk of vessel strike in the ocean, we do not expect that any increase in risk of vessel strike could be meaningfully measured or detected. Therefore, effect of an increase in vessel traffic in the Atlantic Ocean resulting from disposal of Tappan Zee bridge materials is insignificant.

NMFS calculated that the increased vessel traffic in the Delaware River for the Tappan Zee Bridge Replacement Project could result in an additional 0.0125 Atlantic sturgeon struck by project vessels each year and concluded that this was discountable. The number of vessel trips evaluated by NMFS for the Delaware River (i.e., 23 annual one-way trips) is more than four times the annual vessel traffic generated by oil deliveries to Eddystone between 2014 and 2015. If the number of vessel deliveries under consideration is limited to March 15 through July 15, the period when adult sturgeon are likely present in the Delaware to spawn, the number of vessel trips evaluated by NMFS is more than 15 times the annual vessel traffic generated by oil deliveries to the Station. Similarly, the number of vessel trips evaluated by NMFS for the Atlantic Ocean (i.e., 350 annual one-way trips) is significantly greater than the 6 annual one-way trips anticipated for oil deliveries between New York Harbor and Eddystone.

The very small number of vessel traffic generated by Eddystone (i.e., 12 one-way trips anticipated in 2019) and the relatively short travel distance between Eddystone and Croydon compared to the 94.3 km (58.6 mi) trip from Delaware Bay to the C&D Canal would likely result in a lower risk of vessel strike compared to NMFS' evaluation. Therefore, NMFS' (2017a) conclusions that the increased project-related vessel traffic would be insignificant or discountable would also be valid for the potential take being evaluated in this IITP application.

1. Atlantic Sturgeon

a. Type of Anticipated Take

All life stages of Atlantic sturgeon could be present in the vicinity of Eddystone's receiving dock during some part of the year; however, early life stages (i.e., eggs and larvae) are not vulnerable to vessel strike and small juveniles appear to be less vulnerable than larger juveniles (i.e., subadults) and adults, based on reported mortalities (Brown and Murphy 2010). Atlantic sturgeon spawning has been documented from RKM 125-211 (RM 78-131) during the spring and summer (NMFS 2017c). Subadult and adult Atlantic sturgeon may be present in the waters adjacent to Eddystone as they spawn, forage, or move between spawning and overwintering habitats.

b. Estimated Take Number

Only one of 28 vessel-struck Atlantic sturgeon reported between 2005 and 2008 was found between Eddystone and Philadelphia (Brown and Murphy 2010); more recently, NMFS (2017a) reported that an estimated 25 vessel-related mortalities of Atlantic sturgeon may occur annually in the Delaware. Given the distribution of reported vessel mortalities in the Delaware from the earlier period (2005-2008), it is reasonable to assume that few of the 25 annual mortalities (i.e., approximately one out of 25 based on the results presented by Brown and Murphy 2010) occur between Eddystone and Philadelphia. Assuming conservatively that 10% of the 25 annual vessel mortalities (i.e., 3 sturgeon mortalities) occur between Eddystone and Philadelphia, and given that the maximum annual number of oil delivery trips to Eddystone by vessels with drafts of at least 20 ft account for 0.12% of the annual traffic of vessels of this size, less than 0.01 Atlantic sturgeon could be struck by vessels traveling to or from Eddystone. More conservatively, if all 25 sturgeon mortalities occurred between Philadelphia and Eddystone, there could be an annual increase of 0.03 sturgeon mortalities associated with oil delivery vessels transiting to and from the Station. These levels of sturgeon mortality are close to zero, and the mortality associated with assuming that all 25 vessel-related sturgeon mortalities occur between Eddystone and Philadelphia (i.e., 0.03 sturgeon annually) is comparable in magnitude to the annual mortality that NMFS (2017a) concluded would not result in an incidental take (i.e., 0.0125 sturgeon annually). However, over a 10-year operating period, the number of vessel-related sturgeon mortalities is estimated to be 0.30 sturgeon (i.e., 0.03 sturgeon per year * 10 years).

Based on the historical estimates of vessel-related sturgeon mortalities in the Delaware River, the recent level of vessel activity associated with oil deliveries to Eddystone between 2013 and 2017, and the level of vessel activity anticipated for Eddystone in 2019, Exelon proposes a ten-year take limit for vessel activity of 1 Atlantic sturgeon, commensurate with the rounded up value of 0.3 sturgeon over 10 years.

2. Shortnose Sturgeon

The risk of vessel strike for shortnose sturgeon appears to be less than that for Atlantic sturgeon based on the low number of reported vessel strikes for shortnose sturgeon in the Delaware (NMFS 2017a), which was less than half that reported for Atlantic sturgeon based on vessel mortalities reported between 2008 and 2016. Moreover, NMFS (2017a) does not expect shortnose sturgeon to occur along the vessel transit routes in the Atlantic Ocean. For these reasons, vessel activity associated with operations at Eddystone is not likely to adversely affect shortnose sturgeon. Therefore, no incidental take of shortnose sturgeon is expected as a result of vessel activity associated with the Station.

VI. HABITAT CONSERVATION PLAN

This HCP has been developed consistent with the requirements of Section 10 of the ESA, its implementing regulations at 50 CFR Part 222, and the Habitat Conservation Plan and Incidental Take Permit Processing Handbook (USFWS and NMFS 2016). Section 10(a)(1)(B) of the ESA allows a private party to incidentally take a listed species provided the proposed activities are conducted pursuant to a conservation plan that is designed to conserve the species and avoid jeopardy to its continued existence. The operation of the CWIS at Eddystone and vessel activity associated with Station operations are only anticipated to have minor or negligible effects on federally-listed species (i.e., Atlantic and shortnose sturgeons). Likewise, the activities described in Section II.B are anticipated to have minor or negligible effects on sturgeon habitats and other environmental values or resources. Therefore, Exelon anticipates that the HCP developed for this IITP application will qualify for a National Environmental Policy Act Categorical Exclusion and will receive a "low-effect" designation from NMFS. This HCP is based on the "best scientific and commercial data available" and includes an analysis of anticipated impacts, measures to monitor, minimize and mitigate impacts, adequate funding to implement such measures, alternatives that were considered and reasons they were not carried forward, and a list of all sources of data.

A. Analysis of Anticipated Impacts

1. Listed Species

An analysis of potential impacts is included in Section V. Potential effects due to the CWIS (i.e., impingement and/or entrainment), the thermal plume, chemical discharge, and vessel activity associated with operations at Eddystone were evaluated for this analysis. The only activities anticipated to result in incidental take of sturgeon is the operation of the CWIS and vessel activity associated with fuel delivery to the Station. Exelon proposes an annual incidental take limit associated with the CWIS of 3 Atlantic sturgeon larvae in entrainment sampling and an annual take limit of 3 Atlantic sturgeon and 3 shortnose sturgeon in impingement sampling. As explained in Section V, these annual take limits are commensurate with an overall annual take estimate for entrainment and impingement of 10 Atlantic sturgeon and 7 shortnose sturgeon (see Section V.A and Appendices A-C); Exelon proposes an incidental take limit of 1 Atlantic sturgeon due to vessel activity over a 10-year period (see Section V.D). This level of incidental take is not expected to have a significant impact on this species.

2. Critical Habitat

As discussed in Section I.B.1, Eddystone lies within designated critical habitat for Atlantic sturgeon (NMFS 2017b). As noted above, critical habitat includes those physical or biological features essential to the conservation of the species which may require special management considerations or protection. Physical or biological features are defined as, "the features that support the life-history needs of the species, including water characteristics, soil type, geological features, sites, prey, vegetation, symbiotic species, or other features" (NMFS 2017b). The physical or biological features identified in the critical habitat designation for the New York Bight DPS of Atlantic sturgeon, detailed in Section I.B.1, include: hard bottom substrate in low salinity waters; aquatic habitat with a gradual downstream salinity gradient and soft bottom substrate; waters that allow unimpeded movement, staging, and resting; and water with appropriate temperature, salinity, and oxygen for critical life history functions.

The operation of Eddystone, including all activities described in Section II.B, is not expected to affect salinity within the Delaware and or have an appreciable effect on DO. As noted in Section III.A.3.c, 100% of DO observations between October 1, 2010 and September 30, 2015 in Zone 4 met both the daily mean water quality criteria and seasonal water quality criteria established by DRBC (DRBC 2016a). Eddystone's operations are not expected to have a significant effect on bottom substrate. Eddystone's thermal discharge could affect water temperature in the immediate vicinity of the Station. However, Eddystone's HDA is small and is not expected to impede sturgeon movement or have a significant impact on critical life history functions. The operation of Eddystone is not expected to significantly affect any of the physical or biological features identified in the NMFS's (2017b) critical habitat designation; therefore, Station operations will not result in the destruction or adverse modification of critical habitat.

NMFS's (2017b) critical habitat designation determined that a key conservation objective for the New York Bight DPS of Atlantic sturgeon is to increase abundance by facilitating increased reproduction and recruitment to the marine environment. The final rule specifically recognized that, "the ability of subadults to find and access food is necessary for continued survival, growth, and physiological development to the adult lifestage" (NMFS 2017b). *Gammarus* spp. are among the most abundant macroinvertebrates in the Delaware, and this taxon has been identified as an important component of age-0 Atlantic sturgeon diets in the St. Lawrence Estuary (Guilbard et al. 2007; Nellis and Munro 2007). *Gammarus* spp. are entrained at Eddystone, and this taxon was enumerated in entrainment samples collected during 2017. To evaluate the potential for entrainment of prey species to affect critical habitat for Atlantic sturgeon, entrainment densities of *Gammarus* spp. were compared to *Gammarus* spp. densities in the Delaware in the vicinity of Eddystone. Abundance of *Gammarus* spp. was evaluated from 2002 to 2004 as part of Public Service Enterprise Group's Biological Monitoring Program, the most recent study on *Gammarus* spp. in the Delaware. Ichthyoplankton trawls were conducted between April and July, and densities of target taxa, including *Gammarus* spp., were reported for each sampling zone. In the zone closest to the Station, mean monthly densities (n/1,000 m^3) of *Gammarus* spp. ranged from 4,945 to 367,535 between April and July with a mean seasonal density of 143,794 (Table VI-1) (PSEG 2002, 2003, 2004). Monthly mean entrainment densities (n/1,000 m^3) at Eddystone between April and July during 2017 ranged from 734 to 6,148 with a seasonal mean density of 3,349 (NAI 2018), approximately 97.7% lower than the mean density in the River in the vicinity of the Station over the period when the ichthyoplankton trawl was conducted (Table VI-1).

The mean discharge rate of the Delaware River from April through July was 13,559.28 cfs (8,763.59 MGD) over the period from 1970 to 2016 (USGS 2018a). Average actual intake flows at the Station from 2013 to 2017 for the same seasonal period was 277.3 MGD (Table II-2), approximately 3.16% of the River's discharge. Given the low entrainment density of *Gammarus* spp. compared to the density in the River in the vicinity of the Station and the low water withdrawal rate compared to the discharge rate of the Delaware, entrainment of *Gammarus* spp. at Eddystone is not expected to significantly deplete the forage base for Atlantic sturgeon and would, therefore, not result in adverse modification of critical habitat for this species.

B. Measures to Monitor, Minimize, and Mitigate Impacts

1. Monitoring

a. Entrainment

Shortnose sturgeon are not susceptible to entrainment at Eddystone (see Section V.A.2.a.i), but Atlantic sturgeon larvae may be vulnerable to entrainment at the Station.[52] Exelon proposes to conduct the following entrainment monitoring program for Atlantic sturgeon at Eddystone during the first three years of the IITP. This sampling effort is intended to provide data that can be used to estimate annual entrainment of Atlantic sturgeon to ensure the Station is in compliance with its permitted take limit. Entrainment sampling will be conducted when the CWPs are operating during the months of the year when larval Atlantic sturgeon could be present in the vicinity of Eddystone. Accordingly, entrainment sampling is planned for April through July.

A 10,000 iteration Monte Carlo simulation was conducted to evaluate alternative levels of sampling intensity for future entrainment sampling for Atlantic sturgeon (Appendix A). The results indicated that sampling more than twice per week (i.e., eight days per month) would not result in an appreciable increase in the confidence of annual entrainment estimates. Therefore, Exelon proposes scheduling entrainment sampling two days per week for every week of April, May, June, and July during which the CWPs are operating. Although entrainment sampling will be scheduled to occur two days per week, if Eddystone is not operating CWPs on a scheduled sampling day, no entrainment sample will be collected. Sampling will be rescheduled for a day later in the week if the CWPs are running.

Entrainment sampling will be conducted by an experienced biological consulting firm. On each day of sampling, four entrainment samples will be collected at approximately six-hour intervals, resulting in a collection representative of a full 24-hour day, following the protocol utilized for the 2016-2017 entrainment characterization study at the Station (NAI 2018). Samples will be collected behind the traveling screens of the operating unit using a permanently mounted sample pipe (Figure VI-1). A 4-inch pump will pump water from the sample pipe into a 500-micrometer plankton net suspended in a large tank of water. Target sample volume will be 100 m^3. Approximately half of the sample volume will be collected from a depth of 32 feet below MLW (i.e., approximately 3 feet above the bottom of the intake forebay), and approximately half of the sample will be collected from a depth of approximately 22.5 feet below MLW. At the end of each sampling period, the net will be washed down so the contents collect in the cod end. The contents of the cod end will be strained through a 500-micrometer sieve, and the material collected on the sieve will be transferred to a labeled sample jar and preserved with formalin.

Preserved samples will be shipped to the contractor’s ichthyoplankton laboratory under Chain of Custody. The field staff will include a Chain of Custody document with each shipment that includes the collection date, collection time, and identification number for each sample in a shipment as well as the total number of samples in the shipment. Upon receipt of the shipment, laboratory staff will verify that all shipped samples were received, and will sign and date the Chain of Custody document. Samples will be sorted by trained technicians and any Atlantic sturgeon larvae will be identified and counted. Exelon will notify NMFS within 24 hours of a confirmed identification of an Atlantic sturgeon larva.

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[52] In three years of entrainment sampling, one Atlantic sturgeon yolk-sac larva was collected.

Exelon will prepare and submit monthly monitoring reports for April through July and an annual monitoring report for each year covered under the IITP. Monthly reports will be submitted within one month of the end of the monthly reporting period, and annual reports will be submitted within three months of the end of the annual reporting period. Monthly reports will include: 1) the volume of cooling water withdrawn on each day of the month; 2) the days on which entrainment sampling was scheduled, any reasons sampling did not occur as scheduled, and the days on which sampling was actually conducted; 3) the volume of water sampled and the number and life stage of Atlantic sturgeon collected (if any) for each entrainment sample; and 4) a narrative describing any issues encountered that interfered with implementation of the HCP. Annual reports will include: 1) an estimate of annual take of Atlantic sturgeon due to entrainment, with a 95% confidence limit, computed using the methods described in Appendix A; 2) an annual data set compiled from the data provided in the monthly monitoring reports; and 3) a narrative describing any issues encountered during the year that interfered with implementation of the HCP including a description of any corrective actions taken or any proposed issue resolution.

After completion of the first three years of monitoring, entrainment sampling intensity will be re-evaluated in consultation with NMFS, and an updated monitoring plan for the remaining term of the IITP will be developed based on the results from entrainment sampling during the first three years of the IITP.

b. Impingement

No Atlantic or shortnose sturgeon have been collected in impingement samples at the Station and impingement risk for these species is low (Section V.A and Appendix B); however, impingement risk could increase over the IITP term if abundance of these species were to increase in the Delaware. Exelon proposes to conduct the following impingement monitoring program for Atlantic and shortnose sturgeons at Eddystone for the first three years of the IITP. This sampling effort is intended to provide data that can be used to estimate annual impingement of Atlantic and shortnose sturgeons to ensure the Station is in compliance with its permitted take limit and inform adjustments to the take limit in the future, if such adjustments were necessary and appropriate.

An experienced biological consulting firm will conduct impingement sampling once per week for every week when the CWPs are in operation throughout the year. On each day of sampling, a single 24-hour sample will be collected. Prior to initiation of sampling, the screens, screenhouse, and sluiceways will be flushed of fish and debris by operating the screens continuously for one full rotation. Additionally, contents of the screen-wash dumpster will be flattened and a layer of plastic sheeting will be put down to separate fish collected during the 24-hour sampling period from previously collected fish and debris. At the end of each sampling period, all fish on top of the layer of plastic sheeting will be separated from the debris, and any Atlantic or shortnose sturgeon will be identified and assessed to determine live/dead status.

If a live Atlantic or shortnose sturgeon is collected in an impingement sample, the following handling procedures will be followed:

1. The personnel handling the sturgeon will don the appropriate protective equipment as expeditiously as possible while ensuring personnel safety.

2. The live sturgeon will be placed in a tub filled with ambient river water of a sufficient depth to cover the fish.

3. The following information will be collected while giving priority to sturgeon survival over data collection: fork length (cm); photographs of the dorsal, ventral, and lateral sides of the sturgeon; and documentation of any external tags or markings.

4. The sturgeon will be returned to the river as quickly and gently as possible.

For dead Atlantic or shortnose sturgeon, the following procedures will be followed:

1. The fish will be measured and fork length and total length (cm) will be recorded; photographs of the dorsal, ventral, and lateral sides of the sturgeon will be taken; and external tags or markings will be documented.
2. The dead sturgeon will be retained by the monitoring crew and stored frozen until its disposition is discussed with NMFS.

Exelon will notify NMFS within 24 hours of a confirmed identification of an Atlantic or shortnose sturgeon collected in impingement sampling. Additionally, Exelon will prepare and submit monthly monitoring reports and an annual monitoring report for each year covered under the IITP. Exelon will submit monthly reports within one month of the end of the monthly reporting period, and annual reports within three months of the end of the annual reporting period. Monthly reports will include: 1) the volume of cooling water withdrawn on each day of the month; 2) the days on which impingement sampling was conducted; 3) the volume of water sampled and the number of Atlantic or shortnose sturgeon collected, if any, along with any additional information collected, as described in the handling procedures above; 4) a narrative describing any issues encountered that interfered with implementation of the HCP. Annual reports will include: 1) an estimate of annual take of Atlantic and shortnose sturgeon due to impingement; 2) an annual data set compiled from the data provided in the monthly monitoring reports; and 3) a narrative describing any issues encountered during that year that interfered with implementation of the HCP, including a description of any corrective actions taken or any proposed issue resolution.

After completion of the first three years of monitoring, impingement sampling intensity will be re-evaluated in consultation with NMFS, and an updated monitoring plan for the remaining term of the IITP will be developed based on the results for impingement sampling performed during the first three years of the IITP.

c. Vessel Deliveries

Monitoring for incidental take of sturgeon related to vessel deliveries is confounded by the fact that the likelihood of detecting a vessel strike is relatively low, particularly for large, deep-draft vessels, unless the vessel operator feels or hears the collision or unless the sturgeon is observed in the wake of the vessel. In order to monitor for take, Exelon proposes to submit an annual report to NMFS documenting the date, duration, and number of one-way vessel trips to and from Eddystone. In the event that the number of vessel trips exceeds the greatest annual number used to estimate take in this application (i.e., ten one-way trips), Exelon would submit the report within 30 days of the completion of the eleventh trip.

2. Avoidance and Minimization of Take

As noted above in Section V, the numbers of Atlantic and shortnose sturgeons anticipated to be taken due to Eddystone's operations are very low. To avoid and minimize take of sturgeon, Exelon will only operate Eddystone's CWPs: (1) when the Station is generating electricity, which includes 2 days for ramp-up (which includes 36 hours to address contingencies) and 10 days for ramp-down; and (2) for incidental maintenance or testing (generally once per month) (referred to collectively as "Essential Station Operations"); or as required by a governmental agency or other entity with jurisdiction to require operations. Depending on Station generation and ambient water temperatures, Exelon will also limit operations to one CWP per unit when possible. In addition, Exelon will rely on the RWPs to provide cooling water for other critical Station operations outside of Essential Station Operations. These measures will avoid and minimize the incidental take of sturgeon due to entrainment or impingement by eliminating or reducing water withdrawals at times when such withdrawals are not specifically required for Essential Station Operations or for governmental agency-mandated use. Additionally, Exelon will make all reasonable efforts to schedule fuel oil deliveries outside of the March 15-July 15 time period.[53] For oil deliveries scheduled between March 15 and July 15, the monitoring plan described in Section VI.B.1.c will be implemented.

3. Mitigation of Unavoidable Take

For Eddystone's NPDES permit renewal in 2019, Exelon is evaluating alternative technologies for entrainment and impingement mortality reduction, as required under 40 CFR 122.21(r)(6), (10), and (11). Based on the BTA determination for their permit, Exelon may be required to install additional impingement mortality and/or entrainment reduction technologies.

C. Funding Availability

Exelon's corporate environmental policy states that the Company, including all of its facilities (i.e., Eddystone), shall "promote a corporate culture in which [Exelon is] accountable to our communities and the environment and in which full compliance with environmental laws and regulations is the minimum level of acceptable performance" (Exelon 2014). This policy requires the Company to "comply with all applicable environmental laws, regulations, and other commitments, with the objective of moving beyond compliance." Exelon implements this corporate environmental policy by maintaining a "corporate-wide Environmental Management System conformant with the International Organization for Standardization (ISO) 14001 Environmental Management System (EMS)."

Exelon's policy clearly requires that Eddystone, along with all Exelon facilities, operate in compliance with various federal and state permits, approvals, and/or plans[54] and requires that there be mechanisms in place to ensure that all of these programs, including implementation of this IITP and its HCP, are adequately staffed and funded.

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[53] This time period was recommended by NMFS to avoid take of sturgeon during vessel deliveries (Kahn 2018).

[54] These include but are not limited to its NPDES Permit, which requires monthly sampling and reporting, maintenance of its WTP, and routine renewals of its permit, among other matters. Exelon also operates Eddystone in conformance with its air permits and DRBC Dockets.

D. Alternatives Considered

Section 10(a)(2)(A)(iii) of the ESA requires that an applicant's HCP specify: "what alternative actions to such taking the applicant considered and the reasons why such alternatives are not being utilized." As Sections V and VI.A of this application indicate, the potential for incidental take of sturgeon at Eddystone is very low and is primarily associated with the operation of its CWIS (i.e., impingement and/or entrainment); therefore, the majority of this analysis focuses on alternatives to reduce these potential effects on sturgeon. In connection with developing regulations implementing §316(b), USEPA has evaluated technological and operational measures capable of reducing impingement and/or entrainment and/or the mortality associated with those effects.[55] The Services have also evaluated potential options for addressing the potential for an incidental take of sturgeon at CWISs in its Biological Opinion for the 2014 §316(b) Rule (NMFS 2014a). In addition, Exelon is required to make site-specific evaluations of alternative technologies and/or operational measures to address entrainment of aquatic species, which would include sturgeon, in its upcoming NPDES permit renewal for Eddystone.

In addition to potential take associated with operation of the CWIS, there is an even lower potential for incidental take due to vessel traffic associated with oil deliveries to Eddystone. Therefore, an alternative to the current operational practice of using a tug and fuel barge to make fuel deliveries to the Station is included in this analysis.

As part of its §316(b) submittal to PADEP, Exelon is proposing to maintain a low CUR to address impingement; this option will also reduce entrainment. Exelon is evaluating six additional alternatives for this HCP: (1) retrofitting the Station to operate with a closed-cycle recirculating system ("CCRS") utilizing plume-abated mechanical draft cooling towers; (2) installation of fine-mesh modified Ristroph traveling screens ("MRTS") and a fish handling and return system; (3) rebuilding the existing intake to utilize cylindrical wedgewire screens ("CWWS"); (4) replacing the existing constant speed pumps with variable speed pumps ("VSPs"); (5) retrofitting the Station's existing traveling screens to MRTSs with a fish handling and return system; and (6) receiving fuel oil via rail or tanker truck delivery. Alternatives 1 through 5 address take due to interactions with the CWIS (i.e., entrainment and/or impingement). Alternative 6 addresses take due to interactions with vessel activity. The technologies being considered to address potential take due to impingement or entrainment (i.e., Alternatives 1 through 5) have been evaluated for engineering feasibility, and capital and operations and maintenance ("O&M") cost estimates have been estimated; economic benefit valuations for these technologies are currently being performed.

1. Proposed Alternative: Low Capacity Utilization Rate

a. Description of Operational Measure

Eddystone's CUR was below 2% from 2013 to 2017. Therefore, Exelon is requesting a less stringent impingement mortality standard for the Station, as authorized under 40 CFR 125.94(c)(12). Exelon is proposing criteria to comply with the impingement mortality standard under the §316(b) Rule, including:

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[55] See for example, 79 Fed. Reg. 48300 et seq., the Preamble to the 2014 §316(b) Rule, and other associated reports developed in support of that rule, including the Technical Development Document (USEPA 2014c).

1. Maintaining an average 24-month CUR of less than 8%.[56]

2. Limiting CWP operations to Essential Station Operations (i.e., when Eddystone is generating electricity, ramping-up or ramping-down before and after generating, or performing incidental maintenance) or compliance with regulatory requirements that mandate the operation of the CWPs.

3. Operating the RWPs to provide water for cooling other Station equipment when the CWPs are not in service.

4. Reporting CUR and actual intake flow on a monthly basis to PADEP; such reports will also identify any hours that Eddystone generated power to meet emergency conditions declared by PJM Interconnection, L.L.C ("PJM").

Should the Station exceed an average 24-month CUR of 8% in a given year due to circumstances other than responding to an emergency condition declared by PJM, Exelon will notify PADEP and NMFS and will, after consultation with the agencies, evaluate different impingement mortality compliance options, identify an alternative impingement mortality compliance option and, as appropriate, re-initiate consultation with NMFS to update take limits and minimization measures for addressing take due to impingement at Eddystone.

b. Ability to Minimize/Mitigate Take

It is difficult to predict future operations at Eddystone, but no changes are expected in the Station's CUR over its remaining period of operation. The CUR over 2018 through August was 1.0%. Assuming that the Station continues to operate at its current CUR, the operational measures described in Section VI.D.2.b.i will result in lower volumes of cooling water withdrawn from the Delaware. As USEPA (2014a) considers entrainment and impingement reductions to occur commensurate with reductions in cooling water flow, these operational measures would result in reduced levels of impingement and entrainment at Eddystone. Moreover, Exelon can implement this alternative without the need for detailed engineering, permitting, or construction; therefore, reductions in the potential for take would begin immediately.

2. Alternative #1: Closed-Cycle Cooling

a. Description of Technology

Exelon is evaluating retrofitting Eddystone to operate with a CCRS with plume-abated mechanical draft cooling towers as part of its §316(b) Report addressing 40 CFR 122.21(r)(10). For wet mechanical draft cooling towers, the heat in the discharged warm condenser water would be transferred to ambient air induced to flow through the cooling tower by fans. Cooling would be provided mostly through the evaporation of a small percentage of the heated water as it contacts the air, and the remaining recirculating cooling water would be recycled through the condenser.

[56] If the Station were required to generate electricity to maintain grid reliability during emergency conditions, the megawatt hours associated with providing energy during these conditions would not be included in determining compliance with the 8% average capacity utilization rate.

If the Station were retrofitted to operate with a CCRS, Eddystone would withdraw a much smaller volume of cooling water from the River to replace the water lost through evaporation and to maintain the appropriate water chemistry and solids loading in the recirculating water. HDR (2018c) estimated that the Station would withdraw 11.4 MGD for make-up water and discharge 1.4 MGD as cooling tower blowdown. The blowdown volume would be substantially smaller than the current OTCW discharged to the Delaware.

Eddystone is currently limited to treating its OTCW with biocides for a maximum of two hours a day per Unit. If the Station were retrofitted to operate with a CCRS, it would likely require constant biocide treatment of the recirculating water. Due to this increased biocide treatment, Eddystone may be required to install and operate a dechlorination system to treat the cooling tower blowdown prior to its discharge to the River in order to meet its NPDES permit limits. In addition to the likely need for continued chlorination/dechlorination, additional chemicals would be required for maintaining the CCRS and the cooling tower that are not currently used at Eddystone to treat the OTCW.

b. Feasibility of Installation

HDR, Inc. ("HDR") (2018c) evaluated the engineering feasibility of retrofitting the Station to operate with a CCRS with plume-abated mechanical draft cooling towers. Such an undertaking would entail a difficult and complex engineering, scheduling, and construction effort. The retrofit would involve installing new CWPs, constructing two cooling towers, and modifying the existing CWIS, which would require construction in the Delaware. It would be necessary to relocate several buildings at the Station and result in a long outage. While this retrofit was determined to be technically feasible, it would be impractical and, assuming the retrofit project were to begin in 2020, the CCRS would not likely be operational until 2025, which is less than 10 years before Eddystone's anticipated retirement date of 2033 (HDR 2018c).

c. Costs of Technology

HDR (2018b) estimated the capital costs of retrofitting Eddystone to operate with CCRS to be $227,600,000. In addition, HDR (2018b) estimated that Exelon would incur an additional $2,150,000 in annual O&M costs for an estimated total cost of $246,950,000 (HDR 2018b).

d. Adverse Environmental Impacts

Operation of a CCRS at Eddystone would affect air quality, ambient noise, and aesthetics, and there would be increases in the consumptive losses of fresh water through evaporative loss.

Air quality impacts associated with CCRS would include increased pollutant emissions[57] and effects associated with the cooling tower drift, such as impaired visibility and deposition. As a result of direct contact between the air passing through the cooling tower and the source water, some of the liquid water and associated particulate matter would be entrained in the air stream and carried out of the tower as drift. Particulate matter dispersed in a cooling tower plume contains fine particles and salts or minerals

[57] Increased emissions would include particulate matter, including PM^{10} and $PM^{2.5}$, at the site as well as an increase in offsite emissions of particulate matter, carbon dioxide, nitrogen oxides, and sulfur dioxides at whichever offsite facilities would be called into service to replace the generation no longer produced at Eddystone.

present in the source water, which can cause damage to surrounding property and vegetation and to human health at sufficient levels (USEPA 2014b).

USEPA (2014c) estimates that the rate of cooling water evaporation is 1.5–2 times higher in a CCRS compared to a once-through system. Evaporative emissions of water from towers at Eddystone would measure up to 6,937 gpm; during the course of one day's operation at full load this would equal 10.0 MGD of fresh water (HDR 2018d). According to DRBC (2016c), the amount of water within its jurisdiction used to generate electricity accounts for about one third of consumptive use. Cumulative consumptive use can lead to water shortages in drought conditions. In the lower river basin, DRBC manages drought by releasing water from Merrill Creek Reservoir to replace evaporative losses caused by power generation (DRBC 2016b). Exelon would be required to enter into an agreement with the Merrill Creek Reservoir Owners Group, assuming the reservoir has excess capacity, to provide water to account for the evaporative losses associated with the use of a CCRS, and approvals would be required from the DRBC for this increase in consumptive water use.

A CCRS would also have aesthetic and noise effects. The size and height of a plume-abated mechanical draft tower would have a visual and aesthetic impact on the surrounding area. Even with plume-abated towers, which minimize or eliminate the visibility of the plume, it is likely that there would be a visible plume during certain times of the year. Noise emissions of 55 decibels or more would typically occur within 400 ft of the tower (HDR 2018d). This noise level is the permitted limit for continuous noise from 9:00 PM to 7:00 AM established by the adjacent Township of Ridley; USEPA (2014c) also considers 55 decibels to be protective of public health and welfare.

e. Ability to Minimize/Mitigate Take

Closed-cycle cooling systems withdraw significantly less cooling water than OTCW systems. USEPA (2014a) asserts that optimized cooling towers can achieve flow reductions of 97.5% for freshwater sources. USEPA (2014a) also considers entrainment and impingement reduction to be proportional to reductions in cooling water flow.[58] A CCRS installed at Eddystone could reduce the intake flow to 7,928 gpm (11.4 MGD) (HDR 2018c), which would correspond to a 98.6% reduction in flow when compared to the Station's DIF of 835 MGD and, therefore, a corresponding reduction in impingement and entrainment (NMFS 2014a).

f. Summary of Why Alternative is not Practicable

Retrofitting Eddystone to operate with a CCRS is not practicable given the complexity of the engineering retrofit that would be required, the adverse effects on the environment, the anticipated costs to accomplish the retrofit, and the limited number of years when it would be operable before Eddystone's anticipated retirement date. Requiring Exelon to invest in a CCRS retrofit would place an undue financial burden on the Station and the Company, especially given the low number of potential incidental takes projected to occur. In addition, requiring such an action would be inconsistent with what NMFS has required at other steam electric facilities that NMFS has reviewed through the Section 7 consultation process, including PSEG Nuclear LLC's Salem Generating Station on the lower Delaware.

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[58] According to USEPA (2014a), "Impingement rates are related to intake flow, intake velocity, and the swimming ability of the fish subject to impingement. Entrainment is generally considered to be proportional to flow and therefore a reduction in flow results in a proportional reduction in entrainment..." (79 FR 48331, footnote 48).

3. Alternative #2: Fine-Mesh Modified Ristroph Traveling Screens

a. Description of Technology

Exelon is evaluating the replacement of its existing coarse-mesh traveling screens with 2 mm fine-mesh MRTS for its 2019 §316(b) Report. The new fine-mesh screens would also meet the requirements for MRTS at 40 CFR 125.94(c), including fish buckets, a fish return trough, and a low pressure spray screen wash system for fish removal and a high pressure spray screen wash system for debris removal (HDR 2018c). The reduction in screen mesh size from 6 mm to 2 mm will result in an increased through-screen velocity to 33.5 cm/s (1.1 fps) at MLW (HDR 2018c), compared to the current velocity of 26.8 cm/s (0.88 fps) at MLW (Exelon et al. 2008).

b. Feasibility of Installation and Operation

Installing fine-mesh MRTS at Eddystone would involve removal of the eight existing coarse-mesh screens and installing eight new fine-mesh screens with fish buckets in the existing screen bays and a fish handling and return system. Due to the added weight of the fish buckets, it may be necessary to install a new screen chain. Additionally, a second set of screen spray wash nozzles would be required. The fine-mesh MRTS would be operated continuously when the CWPs are in service to prevent excess debris accumulation and head loss. Removal and replacement of the existing screens could be done within a day, but reconnecting electrical and water connections would require additional time. Further, final engineering of the fish handling and return system would be required, and the requisite federal, state and local permits would be required before construction could begin. HDR (2018c) anticipated that this technology could be operational by 2024, nine years before Eddystone is anticipated to retire.

c. Costs of Technology

HDR (2018b) estimated the capital costs to replace Eddystone's existing traveling screens with fine-mesh MRTS to be $8,000,000. Exelon is expected to incur an additional $310,000 in annual O&M costs for an estimated total cost of $11,100,000 (HDR 2018b).

d. Ability to Minimize/Mitigate Take

It is unlikely that the installation of fine-mesh MRTS would minimize or mitigate the take. Instead, there could be an increase in impingement risk for sturgeon associated with the higher through-screen velocity. While the 1.1 fps through-screen velocity associated with fine-mesh screens is not likely to affect sub-adult and adult sturgeon, juvenile Atlantic sturgeon and age-1 shortnose sturgeon are vulnerable to impingement at velocities greater than 1.0 fps (Kynard et al. 2005, as cited in NMFS 2016a; Wilkens et al. 2015). Therefore, the installation of fine-mesh screens could result in take of sturgeon due to impingement on the traveling screens. While the fine-mesh screens would likely reduce the number of larvae entrained compared to the number entrained by coarse-mesh screens, the majority of these life stages would be impinged on the 2 mm fine-mesh screens. USEPA (2014a) recognized, based on the results of recent scientific studies, that fine-mesh screens that physically exclude organisms from being entrained do not necessarily reduce the mortality of those organisms. Instead, USEPA (2014c) found that the survival of entrainable organisms impinged on fine-mesh screens was very poor and that mortality of larvae was greater than 80%. Since larvae are the only life stage of Atlantic sturgeon entrained at

Eddystone, there would be little, if any, reduction in the take due to entrainment mortality associated with the installation of this technology.

e. Summary of Why Alternative is not Practicable

Fine-mesh MRTS screens are not expected to be a practicable alternative for application at Eddystone because: (1) the higher through-screen velocity may actually increase the potential for an incidental take to occur; and (2) recent studies demonstrate that larval survival on fine-mesh screens is very low. There would be: limited, if any, reductions in the take of early life stages of Atlantic sturgeon, an increase in the potential for take of juvenile sturgeon, no appreciable difference in the potential for take of adult sturgeon, and additional costs associated with their installation and operation. Therefore, fine-mesh screens are not anticipated to be a practicable alternative for Eddystone.

4. Alternative #3: Cylindrical Wedgewire Screens

a. Description of Technology

Exelon is evaluating rebuilding its existing CWIS to utilize 6 mm CWWS for its 2019 §316(b) Report. CWWS are a passive intake type that relies on a hydraulic differential to draw water through the screen into a wet well where intake pumps are located. The efficacy of CWWS relies on ambient sweeping water velocities; these screens are generally positioned parallel to currents in the waterbody to maximize sweeping velocities past the screen. CWWS consist of V-shaped wires wrapped around a cylindrical frame, creating a screen mesh. The wire shape and passive water intake lead to low through-screen velocities. The maximum anticipated through-screen velocity for CWWS at Eddystone is 0.48 fps (HDR 2018c).

b. Feasibility of Installation

HDR (2018c) evaluated the engineering feasibility of rebuilding the intake at Eddystone to utilize 6 mm CWWS. At the Station, 12 screens (six per unit) would be required to achieve through-screen velocities below 15.2 cm/s (0.5 fps). Such an undertaking would involve significant construction within the River, including disturbing the river bottom, and along the shoreline. A new, larger intake forebay would need to be built, and sluice gates between the pumps for the two units may be needed. The new CWWS screens would extend a considerable distance into the Delaware compared to the current intake structure. The installation would require sequentially taking the Units out of service while a cofferdam would be installed to enclose that Unit's portion of the intake, the existing traveling screens and trash racks are removed, the forebay is demolished, and a new forebay wall is built (HDR 2018c). This technology would not be in operation until 2024.

c. Costs of Technology

HDR (2018b) estimated the capital costs to rebuild Eddystone's existing intake structure and install CWWS at $15,200,000. Exelon would be expected to incur an additional $80,000 in annual O&M costs for an estimated total cost of $16,000,000 (HDR 2018b).

d. Ability to Minimize/Mitigate Take

CWWS have been shown to reduce larval entrainment at Eddystone by an average of 77% (AKRF and NAI 2011), which would lead to a reduction in take of Atlantic sturgeon. Additionally, the low through-screen velocity would likely eliminate take of Atlantic and shortnose sturgeon due to impingement.

e. Summary of Why Alternative is not Practicable

Rebuilding Eddystone's intake structure and installing CWWS may not be practicable given the significant construction activity the undertaking would involve. Potential take of sturgeon at the Station is very low (see Section V). Therefore, installing CWWS at Eddystone at this time would not likely result in an appreciable benefit to the Atlantic or shortnose sturgeon populations. Given the lack of appreciable benefit to the species, the costs of installing the CWWS are not justified.

5. Alternative #4: Variable Speed Pumps

a. Description of Technology

Exelon is evaluating replacing Eddystone's existing pumps with VSPs as an alternative entrainment control technology at the request of PADEP. VSPs allow a station to increase or decrease pumping rates to vary water withdrawal rates based on the amount of water needed for station operations. While VSPs allow the withdrawal of smaller volumes of water, which could potentially reduce entrainment and impingement, reducing pump speed while maintaining the same level of power generation leads to increased discharge temperatures. By using VSPs, Eddystone could reduce its water withdrawal up to 29% without violating the thermal limits of its NPDES permit (HDR 2018c).

b. Feasibility of Installation

As each Eddystone Unit has a common condenser inlet, both pumps for each Unit would need to be replaced, and a building would need to be constructed to house the pump drivers (HDR 2018c). This technology would be in operation by 2023, 10 years before the Station's anticipated retirement date.

c. Costs of Technology

HDR (2018b) estimated the capital costs to replace the existing constant speed pumps at Eddystone with VSPs at $13,000,000. Exelon is expected to incur an additional $37,000 in annual O&M costs for a total cost of $13,407,000 (HDR 2018b).

d. Ability to Minimize/Mitigate Take

The installation of VSPs at Eddystone could reduce take of sturgeon through entrainment and impingement. USEPA (2014a) considers entrainment and impingement reduction to be proportional to reductions in cooling water flow; therefore, the replacement of Eddystone's current pumps with VSPs could result in up to a 29% reduction in entrainment and impingement.

e. Summary of Why Alternative is not Practicable

While replacing Eddystone's existing constant velocity pumps with VSPs is feasible, given the very low potential take of sturgeon at the Station (see Section V), installing VPSs at Eddystone at this time would not likely result in an appreciable benefit to the Atlantic or shortnose sturgeon populations. Given the lack of appreciable benefit to the species, the costs of installing the VSPs are not justified.

6. Alternative #5: Modified Ristroph Traveling Screens with a Fish Handling and Return System

a. Description of Technology

Six of Eddystone's eight traveling screens were replaced with new traveling screens in 2015; the remaining two screens would be replaced by the end of 2019. Exelon evaluated retrofitting these conventional traveling screens to meet the definition of MRTSs at 40 CFR 125.92(s). The retrofit would require replacing the screen panels on each screen with new smooth-mesh panels with fish buckets, installing low-pressure screenwash headers, installing a bi-directional fish return trough, and routing additional water to each screen for the low-pressure screenwash and the fish trough. In addition, a fish handling and return system would be installed.

b. Feasibility of Installation

The MRTS screen retrofit, described in Section VI.D.6.a, would require additional modifications to the screens to support the new screen panels and screenwash headers. The existing screen chains would need to be replaced with a chain rated to handle the heavier load associated with the new screen panels with fish buckets. A spacer would need to be added to the screen frame to make room for the low-pressure screenwash headers, requiring a new splash housing to accommodate the taller screen structure (HDR 2018a).

The installation of a fish handling return system may require relocation of the existing debris trough at the Station. As noted in Section VI.D.6.a, the low-pressure screenwash headers would require more water to be routed to each screen, and the fish trough would require supplemental flow. Additionally, the MRTSs would be operated continuously. The addition of low-pressure screenwash headers and the increased operation of the screens would require 485 gpm of water for each screen, resulting in an increased screenwash water demand of 1,080 gpm for each unit (HDR 2018a). The increased screenwash water demand combined with the 192 gpm supplemental flow required for the fish trough would necessitate the installation of new pumps in the CWIS to supplement the existing RWPs (HDR 2018a).

While the screen retrofit could be performed during the regularly scheduled maintenance outages, time would be required to complete the final engineering for the fish handling and return system and to obtain the requisite federal, state and local permits. HDR (2018a) anticipated that this technology could be operational by 2024 (HDR 2018a), nine years before the Station is anticipated to retire.

c. Cost of Technology

HDR (2018a) estimated the capital costs to retrofit Eddystone's existing traveling screens to MRTSs and install a fish handling and return system at $7,100,000. Exelon is expected to accrue an additional $280,000 in annual O&M costs for an estimated total cost of $9,900,000 (HDR 2018a).

d. Ability to Minimize/Mitigate Take

Modified Ristroph traveling screens have documented performance of collecting impinged fish and returning them to the source waterbody with little or no injuries (Fletcher 1990). USEPA accepts modified Ristroph traveling screens as a pre-approved technology that satisfies the requirements of BTA for impingement (40 CFR 125.94(c)(5)). Therefore, it is anticipated that only a small fraction, if any, of the Atlantic or shortnose sturgeon impinged on MRTSs at Eddystone would experience mortality or severe injury due to the interaction with the operating CWIS.

e. Summary of Why Alternative is not Practicable

While retrofitting Eddystone's existing traveling screens to MRTSs is feasible, given the very low potential take of sturgeon at the Station (see Section V), retrofitting the traveling screens at Eddystone at this time would not likely result in an appreciable benefit to the Atlantic or shortnose sturgeon populations in the Delaware. Given the lack of appreciable benefit to the species, the costs of retrofitting the traveling screens are not justified.

7. Alternative #6: Rail or Tanker Truck Delivery of Fuel Oil

a. Description of Operational Measure

Eddystone currently receives periodic fuel oil deliveries from fuel barges (Section II.A.7). Exelon is evaluating the potential alternative of replacing the fuel deliveries received via tug and barge under their current operational practice with fuel deliveries received via railroad or tanker truck.

b. Feasibility of Implementation

From 2013 to 2017, Eddystone received fuel oil deliveries ranging from approximately 20,000 barrels to 100,000 barrels with an average delivery volume of 37,588 barrels. Each of these deliveries was performed by a single barge. Based on the capacity of a typical fuel rail car (approximately 598 barrels) or tanker truck (approximately 191 barrels), an average fuel oil delivery would require the use of 63 rail cars or 197 tanker trucks (Kruse et al. 2017).

c. Adverse Environmental Impacts

Switching from barge deliveries to rail or tanker truck deliveries would result in adverse environmental impacts due to fuel consumption, emission production, and spill risk. Between the three potential modes of fuel delivery, barge delivery is the most fuel-efficient and results in the generation of the lowest emissions (Kruse et al. 2017). Barge deliveries use approximately 25% less fuel than train deliveries and 75% less fuel than tanker trucks (Kruse et al. 2017). Train deliveries generate approximately 1.4 times the greenhouse gas emissions as barge deliveries, and tanker truck deliveries produce almost 10 times the greenhouse gas emissions as barge deliveries (Kruse et al. 2017). Additionally, rail delivery of hazardous materials from 2001 to 2014 resulted in approximately 3.7 times the number of spills compared to delivery via water; truck delivery resulted in approximately 12.5 times the number of spills (Kruse et al. 2017). This occurrence of spills resulted in approximately three times the volume of hazardous materials spilled when transported via railroad or truck compared to water (Kruse et al. 2017).

d. Ability to Minimize/Mitigate Take

Utilizing rail cars or tanker trucks rather than fuel barges for oil deliveries would eliminate the potential for incidental take of Atlantic sturgeon due to vessel interaction by eliminating the associated vessel traffic from the Delaware River.

e. Summary of Why Alternative is not Practicable

Replacing Eddystone's oil deliveries via fuel barge with oil deliveries via rail or tanker truck is not likely to be practicable based on the significantly greater number of rail cars or tanker trucks required to deliver the same volume of fuel oil and the adverse environmental impacts that would arise from these potential delivery methods. Given that the likelihood of incidental take of Atlantic sturgeon associated with fuel oil deliveries via fuel barge is very low (see Section V.D), the use of alternate delivery methods would not likely result in an appreciable reduction in the incidental take of Atlantic sturgeon.

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Appendix A

Eddystone Generating Station
Atlantic Sturgeon
Estimated Annual Numbers Entrained

Estimates for Historical Water Withdrawal Rates and
Evaluation of Alternative Sampling Intensities for
Future Entrainment Sampling

June 2019

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I. INTRODUCTION

A. Background

Eddystone Generating Station ("Eddystone") is located on the Delaware River ("Delaware" or "River") at river kilometer (RKM) 136 (river mile [RM] 84.5), south of Philadelphia, PA. Non-contact, once-through cooling water for Eddystone is withdrawn from the River. Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) spawning occurs in the Delaware between Stoney Creek (RKM 120 [RM 74]) and Trenton, NJ (RKM 211 [RM 131]) with the highest concentration of spawning activity found between Claymont, DE (RKM 125 [RM 78]) and Chester, PA (RKM 130 [RM 81]) (Simpson and Fox 2007; Breece et al. 2013; NMFS 2014). Spawning adults migrate from oceanic waters upriver to freshwater spawning sites in the spring and early summer (April-May) in the Mid-Atlantic when water temperatures reach 18°C (64.4°F) (ASSRT 2007; Able and Fahay 2010). In the Delaware, spawning may occur through mid- to late June (Simpson and Fox 2007). As spawning occurs in the vicinity of Eddystone, Atlantic sturgeon eggs and larvae may be present in the adjacent reach of the River from April through July. Sturgeon eggs are demersal and adhesive, but pelagic larvae may be susceptible to entrainment at Eddystone.

This report documents estimates of potential numbers of Atlantic sturgeon entrained at Eddystone over the past five years (2013-2017) based on three years (2005-2006, 2016, and 2017) of entrainment sampling, which included the spring and summer months, at Eddystone. Estimated numbers of Atlantic sturgeon entrained are presented in terms of age-1 equivalents to facilitate comparisons to other forms of take.

B. Report Organization

Section II of this report summarizes the three years of entrainment sampling at Eddystone. Section III describes data analysis methods used to calculate estimates of numbers entrained and to compute age-1 equivalents. Section IV describes the input parameter estimates used in the calculations. Section V describes results including intermediate parameter estimates and estimated numbers entrained. An evaluation of alternative levels of sampling intensity for future entrainment sampling is presented in Section VI.

II. ENTRAINMENT SAMPLING AT EDDYSTONE GENERATING STATION

Entrainment sampling was conducted at Eddystone during 2005-2006, 2016, and 2017. All fish that were collected were taxonomically identified. In all years of sampling, only one Atlantic sturgeon yolk-sac larva ("ysl") was collected in May 2017.

The sampling design, including sampling intensity and months of sampling, and sampling methods for each year of entrainment sampling are summarized in the following sections.

A. 2005-2006

Entrainment sampling at Eddystone was conducted weekly from April 18 through August 26, 2005, monthly from September through December 2005, and biweekly from January to March 2006 for a total of 33 sampling dates (NAI 2008). Additional weekly sampling was conducted from April 5 through April 25, 2006, but only full spring/summer sampling from 2005 is included in the current analyses. Samples were collected at the cooling water intake structure (CWIS) for Units 1 and 2, downstream of Eddystone's cylindrical wedge-wire screens; samples for Units 3 and 4 were collected at the CWIS downstream of the traveling screens. At Units 1 and 2, samples were collected at a depth of 13 ft, approximately at the midpoint of the opening between the curtain wall and the bottom of the forebay where the circulating pump withdraws water. At Units 3 and 4, half of a sample was collected at a depth of 30 ft, approximately 5 ft above the bottom of the forebay, and half was collected at a depth of 13 ft, the approximate depth of the circulating pumps. Sampling at these locations and depths ensured that specimens collected were representative of entrainment at Eddystone (NAI 2008).

Samples were collected with a 4 in. pump that withdrew water from the intake forebay through a 4 in. diameter pipe that faced into the intake flow. The pump speed was set to a minimum rate of approximately 240 gallons per minute. At this speed it took approximately 2 hours to collect a 100 cubic meter (m^3) sample. Samples were discharged into a 0.5 mm mesh conical plankton net suspended in a water tank. The contents of the net were rinsed with ambient water and transferred to sample containers where they were preserved with a 10% buffered formalin solution. This procedure was repeated every 6 hours so that 4 samples were collected per 24-hour sampling period (NAI 2008).

In the laboratory, ichthyoplankton was removed from the samples, identified to the lowest taxon possible (generally species), and counted. Larvae and juveniles were categorized by life stage (NAI 2008). No Atlantic sturgeon were collected in the 2005-2006 entrainment study.

B. 2016

In 2016, entrainment sampling at Eddystone was conducted monthly in January and February, three times in March, weekly from April through July, twice per month from August through October, and monthly in November and December for a total of 31 sampling dates. On each sampling date, four diel samples were collected resulting in a total of 124 samples collected in the 2016 study (NAI 2018). Samples were collected from Unit 3 or Unit 4, downstream of the traveling screens. Half of the sample was collected at a depth of 32 ft, approximately 3 ft above the bottom of the forebay, and half was collected at a depth of 22.5 ft, the approximate elevation of the circulating pumps (NAI 2018). Sampling at these locations and depths ensured that specimens collected were representative of entrainment at Eddystone.

Samples were collected with a 4 in. pump that withdrew water from the intake forebay through a 4 in. diameter pipe that faced into the intake flow. Samples were discharged into a 0.5 mm mesh conical plankton net suspended in a water tank. The contents of the net were rinsed to collect in the cod end of the net. Contents were sieved through a 0.5 mm sieve, transferred to sample jars, and preserved with formalin (NAI 2018).

In the laboratory, ichthyoplankton were sorted, identified to the lowest practicable taxonomic level, quantified, assigned a life stage, and measured (NAI 2018). No Atlantic sturgeon were collected during entrainment sampling in 2016.

C. 2017

In 2017, entrainment sampling at Eddystone was conducted once in January, twice a month in February and March, weekly from April through July, twice a month from August through October, and once a month in November and December. The sampling methodology was identical to the 2016 entrainment study, described in Section II.B. One Atlantic sturgeon ysl was collected in May.

III. DATA ANALYSIS METHODS

A. Estimation of Numbers Entrained

Count data from entrainment sampling was modeled as coming from a zero inflated Poisson probability distribution:

$$\Pr(Y_{i,j} = y_{i,j}) = \begin{cases} \omega_j + (1-\omega_j)e^{-\lambda_{i,j}} & \text{for } y_{i,j} = 0 \\ (1-\omega_j)\dfrac{\lambda^{y_{i,j}} e^{-\lambda_{i,j}}}{y_{i,j}!} & \text{for } y_{i,j} = 1,2,3,\ldots \end{cases} \qquad (1)$$

where,

$Y_{i,j}$ = count (number collected) in sample, *i*, during month, *j*,
$\lambda_{i,j}$ = Poisson parameter for sample, *i*, in month, *j*, and
ω_j = zero inflation parameter for month, *j*.

and,

$$E(Y_{i,j}) = (1-\omega_j)\,\lambda_{i,j} \qquad (2)$$

The Poisson parameter, $\lambda_{i,j}$ (which is bounded to be non-negative) was modeled as function of sample volume, $v_{i,j}$, (in units of the standard sampling volume of 100 m^3) and a continuous variable, β_j (with a range of $-\infty$ to $+\infty$), representing month-specific density:

$$\lambda_{i,j} = v_{i,j}\ e^{\beta_j} \qquad (3)$$

It was linked to linear predictors through a logarithmic transformation:

$$g(\lambda_{i,j}) = \ln(\lambda_{i,j}) = \ln(v_{i,j}) + \beta_j \qquad (4)$$

The zero inflation parameter, ω_j (which is bounded on the range 0 to 1), was modeled as a function of a continuous variable, γ_j (with a range of $-\infty$ to $+\infty$), representing month-specific additional probability of zero count:

$$\omega_j = \frac{1}{1+e^{-\gamma_j}} \qquad (5)$$

It was linked to linear predictors through a logit transformation:

$$h(\omega_j) = \ln\left(\frac{\omega_j}{1-\omega_j}\right) = \gamma_j \qquad (6)$$

The input dataset consisted of one record for each sample collected. Each record contained two variables, the number of sturgeon collected in the sample ($y_{i,j}$) and the volume of the sample ($v_{i,j}$). All samples collected during the three years of entrainment sampling were included in the input dataset. For a month-specific model, the analysis was conducted separately for data collected in May – the only month in which any sturgeon were collected in any of the years of entrainment sampling. A total of 72 samples were collected during May (of all years). For a seasonal model, the analysis was conducted separately for data collected from April through July – the months in which larval sturgeon could be present in the vicinity of Eddystone. A total of 260 samples were collected from April through July (in all years).

Maximum likelihood estimates, $\hat{\beta}_j$ and $\hat{\gamma}_j$, of the underlying parameters, β_j and γ_j, were calculated using the generalized linear models procedure, PROC GENMOD, in SAS. The probability distribution was set to "zip" (zero-inflated Poisson), the link for the Poisson portion of the distribution was set to "log", the link for the zero inflation portion of the distribution was set to "logit", and the offset was set equal to the logarithm of the sample volume.

Estimates of the annual number of sturgeon entrained historically (2013-2017) and 95% confidence limits for the estimates were calculated by Monte Carlo simulation based on the parameter estimates, $\hat{\beta}_j$ and $\hat{\gamma}_j$. For each year, estimates of the number of sturgeon entrained were randomly simulated based on the underlying zero-inflated Poisson distribution. For each iteration, *k*, the estimate of the number of sturgeon entrained, $\widetilde{X}_{y,k}$, was computed as:

$$\widetilde{X}_{y,k} = \sum_{j=m1}^{m2} \left(\frac{\sum_{i=1}^{n_j} \widetilde{Y}_{i,j,k}}{(100 \times n_j)} \times V_{y,j} \right) \tag{7}$$

where,

$V_{y,j}$	=	historical water withdrawal rate in month, *j*, of year, *y* (m^3 per month),
n_j	=	historical number of entrainment samples collected (over all years) during month, *j*, and
$\widetilde{Y}_{i,j,k}$	=	randomly simulated count of sturgeon from iteration, *k*, in sample, *i*, during month, *j*, for a standard sample size of 100 m^3 per sample.

$$\Pr(\widetilde{Y}_{i,j} = y_{i,j}) = \begin{cases} \hat{\omega}_j + (1-\hat{\omega}_j)e^{-\hat{\lambda}_{i,j}} & \text{for } y_{i,j} = 0 \\ (1-\hat{\omega}_j)\dfrac{\hat{\lambda}^{y_{i,j}} e^{-\hat{\lambda}_{i,j}}}{y_{i,j}!} & \text{for } y_{i,j} = 1,2,3,\ldots \end{cases} \tag{8}$$

$$\hat{\lambda}_{i,j} = e^{\hat{\beta}_j} \tag{9}$$

and,

$$\hat{\omega}_j = \frac{1}{1+e^{-\hat{\gamma}_j}} \tag{10}$$

For the month-specific model, *m1* and *m2* in equation (7) were set to 5. For the seasonal model, *m1* was set to 4 and *m2* was set to 7.

The estimate, $\hat{X}_y$, of the number of sturgeon entrained in each year, *y*, was computed as the mean of the randomly simulated $\widetilde{X}_{y,k}$ from 10,000 iterations of equation (7):

$$\hat{X}_y = \frac{1}{10{,}000} \sum_{k=1}^{10{,}000} \widetilde{X}_{y,k} \tag{11}$$

For each annual estimate of the number of sturgeon entrained, the 95% confidence intervals were computed based on the cumulative frequency distribution of the $\widetilde{X}_{y,k}$ from the

Monte Carlo simulation. The lower 95% confidence limit was calculated as the 2.5th percentile, and the upper 95% confidence limit was calculated as the 97.5th percentile so that 95% of the distribution falls between the lower and upper limits.

Estimates and 95% confidence limits were expressed in terms of age-1 equivalents based on the estimated early life stage survival fractions described in the following section.

B. Estimation of Age-1 Equivalents

For each life stage entrained, a separate estimate of the number of age-1 equivalents entrained was computed by: (1) estimating the survival fraction from the middle of the life stage entrained to age-1 and, (2) multiplying the estimated number entrained by that survival fraction.

At Eddystone, the only Atlantic sturgeon collected in entrainment sampling was a ysl. Therefore, the survival fraction from the middle of the ysl life stage to age-1 was computed as the product of: (1) the survival fraction for the juvenile ("juv") life stage (from the date of transformation to the juv stage to age-1), (2) the survival fraction for the post yolk-sac larval ("pysl") life stage, and (3) the survival fraction from the middle of the ysl life stage to the beginning of the pysl life stage. The survival fraction from the middle of the ysl stage was estimated as the square root of the survival fraction for the entire ysl stage. Accordingly, annual estimates of entrainment expressed in terms of age-1 equivalents ($A\hat{1}E_y$) were computed as:

$$A\hat{1}E_y = \hat{X}_y \left(S_{juv} S_{pysl} \sqrt{S_{ysl}} \right) \quad (12)$$

Estimates of the life stage-specific survival fractions were computed in two steps. First, the age-0 survival fraction was estimated using the method described by Boreman (1997) based on an estimate of replacement eggs per female recruit (EPR) for the New York Bight Distinct Population Segment (DPS) of Atlantic sturgeon presented in the 2017 Benchmark Stock Assessment (ASMFC 2017). For this analysis, 50% of the unfished EPR ($EPR_{50\%}$) for the population was selected as a conservative (i.e., suitable for stock rebuilding) estimate of replacement EPR based on the work of Boreman (1997).[1] Second, the age-0 survival fraction was allocated to life stages based on weights at age for larvae and juveniles and on a general relationship between pelagic fish weights (larvae and older) and mortality rates (Peterson and Wrobleswki 1984).

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[1] The use of $EPR_{50\%}$ as replacement EPR is consistent with the 2017 Benchmark Stock Assessment for Atlantic sturgeon (ASMFC 2017).

1. Eggs per Recruit and Age-0 Survival

Boreman (1997) describes a method for estimating the age-0 survival fraction based on fecundity and mortality of age-1 and older fish:

> "To maintain stationary population abundance, i.e., population abundance that is neither increasing nor declining over generations, the survival rate of a female egg to age 1 (S_0) must be equal to two times the reciprocal of the *EPR*-value (assuming the sex ratio of deposited eggs is 50:50), so that: *EPR* x S_0 = 2." (Boreman 1997)

and therefore, $S_0 = \frac{2}{EPR}$.

2. Daily Survival Fractions for Larvae and Juveniles

The age-0 survival fraction, S_0, is the product of the egg survival fraction and all daily survival fractions for larvae and juveniles:

$$S_0 = S_e \prod_{t=(H+1)}^{365} S_t \qquad (13)$$

where,

- S_e = survival fraction of eggs,
- H = life stage duration of eggs,
- S_t = daily survival fraction for age-*t* (in days) larvae or juveniles,

and,

$$S_t = e^{\left(-M(w_t)\right)} \qquad (14)$$

where,

- $M(w_t)$ = daily instantaneous mortality.

Daily survival fractions for larvae and juveniles were estimated using the general equation (15) described by Peterson and Wrobleski (1984) for pelagic larval and older fishes. That equation describes $M(w_t)$ as a function of dry weight:

$$M(w_t) = ckw_t^{-x} \qquad (15)$$

where,

k = weight coefficient for growth rate (k= 5 x 10^{-8}/second, or 0.00432/day),
w_t = dry weight in grams on day t,
x = weight exponent of metabolism (x=0.25), and
c = a scaling coefficient that accounts for growth efficiency and prey-predator size ratio.

Peterson and Wroblewski (1984) note:

> "…the general expression for fish mortality as a function of size, $M(w) = ckw^{-x}$ yields values that are encouragingly close to observed mortalities. Parameters k and x are well founded in bioenergetics, while c can be calculated."

For this application, a value for the coefficient, c, was selected such that $S_0 = \frac{2}{EPR}$.

3. Allocation of S_0 to Age-0 Life Stages

An estimate of the survival fraction for each age-0 life stage (ysl, pysl, and juv) was computed from the daily age-specific survival fractions for individuals within the size range of the life stage:

$$S_{ls} = \prod_{t=(H+1)}^{365} S_t \Delta_t \qquad (16)$$

Δ_t = 1 if w_t is within the size range of life stage, *ls*, individuals, and
Δ_t = 0 otherwise.

IV. INPUT PARAMETER ESTIMATES

A. Input to Age-0 Survival Estimate

The replacement EPR (i.e., $EPR_{50\%}$) for the New York Bight DPS of Atlantic sturgeon presented in the 2017 Benchmark Stock Assessment, 570,000 eggs (ASMFC 2017), was used to estimate S_0 based on the relationship presented by Boreman (1997) (Section III.B.1).[2]

B. Inputs to Stage-Specific Age-0 Survival Estimates

Egg stage survival has not been estimated for Atlantic sturgeon. Therefore, an estimate of egg stage survival of 19.3% for fertilized shortnose sturgeon eggs was taken from Buckley and Kynard (1981) as reported in Dadswell et al. (1984). An estimate of days from spawn to egg hatching (8 days) was taken from Snyder (1988). Length at hatch and length at age at various points in the larval stage were also taken from Snyder (1988). These lengths along with an estimate of total length at the end of the first year of life (i.e., day 365) from NMFS (2014) were used to interpolate length at age for the intervening days.

Weights at length for Atlantic sturgeon were reported by Dovel and Berggren (1983), Gilbert (1989), and Mohler (2003). These weights were used to determine the relationship between length and weight for Atlantic sturgeon, and weights at age for age-0 individuals were approximated using this relationship. For age-0 fish, total length was assumed to approximate fork length. The dry weight of age-0 fish was assumed to be 20% of wet weight. Hafs and Hartman (2014) reported 15%-25% dry weight in 48-115 mm age-0 brook trout, and Jonas et.al. (1996) reported approximately 20% dry weight in age-0 muskellunge.

Age-0 Atlantic sturgeon less than 13 mm TL were assumed to be ysl (Snyder 1988, page 26). Those between 14 mm TL and 62 mm TL were assumed to be pysl, and those age-0 fish over 62 mm TL were assumed to be juveniles (Snyder 1988).

C. Historical Water Withdrawal Rates

For the month-specific model, historical water withdrawal rates during May at Eddystone for the years 2013 through 2017 are listed in Table 1. For the seasonal model, historical water withdrawal rates during the period in which larval Atlantic sturgeon could be present in the vicinity of Eddystone (i.e., April through July), are listed in Table 2.

[2] The model used to estimate $EPR_{50\%}$ presented in the 2017 Atlantic sturgeon Benchmark Stock Assessment (ASMFC 2017) incorporated bycatch and ship strike mortality in addition to natural mortality, providing a more complete picture of non-fishing mortality experienced by the DPS.

V. RESULTS

A. Intermediate Calculations

Estimates of age-0 life history parameters derived from the estimate of EPR and equations (13) through (16), and used in equation (12) are listed in Table 3. The scaling coefficient, *c*, in equation (15) was set to 5.80 to ensure $S_0 = \frac{2}{EPR}$.

1. Month-Specific Entrainment Model

Statistics from the general linear model analysis of entrainment counts based on the underlying zero-inflated Poisson distribution are listed in Table 4. Because the underlying parameter estimate for the zero-inflation portion of the distribution for May was not statistically significant, the analysis was re-run with a reduced (Poisson only) form of the model. Analysis of the reduced model produced the same parameter estimates for the Poisson portion for May as are listed in Table 4 for the full (zero-inflated Poisson) model. With a zero parameter estimate for the zero-inflation portion of the distribution, the full and reduced models are equivalent.

Parameter estimates for the parameters of the zero-inflated Poisson distribution are listed in Table 5.

2. Four-Month Seasonal Model

To account for the possibility that entrainment of Atlantic sturgeon occurred (but by chance was missed by entrainment sampling) in months adjacent to the month in which Atlantic sturgeon were collected in entrainment samples, the analysis was re-run with the data from April through July pooled into a single season. For this analysis a single seasonal zero-inflated Poisson distribution was used to model entrainment counts for each sample collected from April through July.

Statistics from the seasonal general linear model analysis of entrainment counts based on the underlying zero-inflated Poisson distribution are listed in Table 6. Because the underlying parameter estimate for the zero-inflation portion of the distribution was not statistically significant, the analysis was re-run with a reduced (Poisson only) form of the model. Analysis of the reduced model produced the same parameter estimates for the Poisson portion as are listed in Table 6 for the full (zero-inflated Poisson) model. With a zero parameter estimate for the zero-inflation portion of the distribution, the full and reduced models are equivalent.

Parameter estimates for the parameters of the zero-inflated Poisson distribution are listed in Table 7.

B. Estimated Annual Numbers Entrained

1. Month-Specific Entrainment Model

Estimated annual numbers of Atlantic sturgeon entrained at Eddystone based on historical monthly water withdrawal volumes from 2013 to 2017 are listed in Table 8. Estimated numbers entrained were calculated using the methods described in Section III.

The five-year (2013-2017) average of estimated numbers entrained was less than one (0.2) age-1 equivalent per year. The five-year average of Lower 95% confidence limits was 0, and the five-year average of Upper 95% confidence limits was less than one (0.8) age-1 equivalent per year.

2. Four-Month Seasonal Model

Estimated annual numbers of Atlantic sturgeon entrained at Eddystone based on historical seasonal (April through July) water withdrawal volumes from 2013 to 2017 are listed in Table 9. Estimated numbers entrained were calculated using the methods described in Section III.

The five-year (2013-2017) average of estimated numbers entrained was less than one (0.3) age-1 equivalent per year. The five-year average of Lower 95% confidence limits was 0, and the five-year average of Upper 95% confidence limits was 1.1 age-1 equivalents per year. These estimates were higher than the estimates from the month-specific model because historical water withdrawal rates from April through July were higher than in May.

VI. EVALUATION OF ALTERNATIVE LEVELS OF SAMPLING INTENSITY FOR FUTURE ENTRAINMENT SAMPLING

Alternative levels of sampling intensity for future entrainment sampling at Eddystone were evaluated by assessing the effect of sample size on confidence limits for estimates of annual number of Atlantic sturgeon entrained. Because future water withdrawal rates cannot be predicted, this assessment was conducted assuming the design water withdrawal rate (3.161 million m^3 per day) on all dates. Confidence limits were computed using Monte Carlo simulation as described in Section III with the following modification made to equation (7):

$$\tilde{X}_{D,k} = \sum_{j=4}^{5} \left(\frac{\sum_{i=1}^{n_j} \tilde{Y}_{i,j,k}}{\left(100 \times n*_j\right)} \times V_{D,j} \right) \qquad (19)$$

where,

$\tilde{X}_{D,k}$	=	simulated estimate of annual numbers entrained for random iteration, *k*, assuming design water withdrawal rates,
n^*_j	=	alternative number of entrainment samples collected during month, *j*, and
$V_{D,j}$	=	design water withdrawal rate for month, *j* (m^3 per month).

Parameter estimates for the zero-inflated Poisson distribution of counts for entrainment sampling as described above were used for this assessment. Also, for this assessment, it was assumed that on each day of sampling, four samples would be collected as had been done historically.

Estimates of annual numbers entrained and corresponding 95% confidence limits, assuming design water withdrawal rates, were computed for a range of sampling intensities from one day per month (i.e., 4 samples per month) to every day per month (i.e., 120 or 124 samples per month, depending on the month).

1. Month-Specific Entrainment Model

For the month-specific model, it was assumed that entrainment of Atlantic sturgeon only occurred in May. For this model, the calculated confidence intervals ranged from 0 to 18.92 times the estimated annual number entrained for one day of sampling per month to 0 to 2.52 times the estimated annual number entrained for sampling every day per month (i.e., 31 days) (Figure 1).

2. Four-Month Seasonal Model

For the four-month seasonal model, it was assumed that entrainment of Atlantic sturgeon could occur from April through July. For this model, the calculated confidence intervals ranged from 0 to 17.55 times the estimated annual number entrained for one day of sampling per month to 0.40 to 2.87 times the estimated annual number entrained for sampling every day per month (i.e., 122 days) (Figure 2).

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VIII. TABLES

Table 1. Historical water withdrawal rates at Eddystone (million m^3 per month) for May (the only month in which Atlantic sturgeon were collected in entrainment samples).

Year	Water Withdrawal Rate (million m^3/month)
2013	28.7
2014	13.0
2015	1.3
2016	51.4
2017	30.4

Table 2. Historical water withdrawal rates at Eddystone (million m^3) for the four-month season of April through July (the season when larval Atlantic sturgeon could be in the vicinity).

Year	Water Withdrawal Rate (million m^3/season)
2013	125.5
2014	86.3
2015	89.3
2016	199.5
2017	142.1

Table 3. Derived life history parameter estimates for age-0 Atlantic sturgeon.

Life Stage	Life Stage Duration (days)	Mortality Rate per Life Stage	Survival Fraction per Life Stage S_t
Egg	8	1.65	0.193
Yolk-sac larvae	24	2.79	0.062
Post yolk-sac larvae	73	3.91	0.020
Juvenile	260	4.22	0.015
Age-0	365	12.56	0.000004

Table 4. Statistics from the month-specific general linear model analysis of entrainment counts based on underlying zero-inflated Poisson distribution.

Month	Parameter	Estimate	Standard Error of Estimate	Chi-Square Value	Pr(Chi-Square)
May	β_j	-4.367	1	19.07	<0.0001
	γ_j	-20.763	387,274	0	1

Table 5. Parameter estimates for underlying month-specific zero-inflated Poisson distributions based on estimates of β_j and γ_j from Table 4.

Month	λ_j	ω_j
May	0.01269	0.00000

Table 6. Statistics from the four-month seasonal (April through July) general linear model analysis of entrainment counts based on underlying zero-inflated Poisson distribution.

Parameter	Estimate	Standard Error of Estimate	Chi-Square Value	Pr(Chi-Square)
β	-5.651	1	31.94	<0.0001
γ	-19.168	332,774	0	1

Table 7. Parameter estimates for underlying four-month seasonal (April through July) zero-inflated Poisson distribution based on estimates of β and γ from Table 6.

λ	ω
0.0035	0.000

Table 8. Estimates of annual numbers of Atlantic sturgeon entrained at Eddystone (2013-2017) and 95% confidence limits for the estimates based on the month-specific model (expressed in terms of age-1 equivalents).

Year	Estimate	Lower 95% Confidence Limit	Upper 95% Confidence Limit
2013	0.3	0.0	0.9
2014	0.1	0.0	0.4
2015	0.0	0.0	0.0
2016	0.5	0.0	1.6
2017	0.3	0.0	0.9
Average	0.2	0.0	0.8

Table 9. Estimates of annual numbers of Atlantic sturgeon entrained at Eddystone (2013-2017) and 95% confidence limits for the estimates based on the four-month (April through July) seasonal model (expressed in terms of age-1 equivalents).

Year	Estimate	Lower 95% Confidence Limit	Upper 95% Confidence Limit
2013	0.3	0.0	1.1
2014	0.2	0.0	0.7
2015	0.2	0.0	0.8
2016	0.5	0.0	1.7
2017	0.4	0.0	1.2
Average	0.3	0.0	1.1

IX. FIGURES

Figure 1. Confidence intervals from the assessment of the effect of sampling intensity on size of confidence limits for estimates of annual numbers of Atlantic sturgeon entrained, expressed in terms of age-1 equivalents, based on the month-specific zero-inflated Poisson model of entrainment counts. Confidence intervals are shown as a multiple of the entrainment estimate for age-1 equivalents. Confidence intervals were computed assuming design flow and four 100 m^3 samples per day.

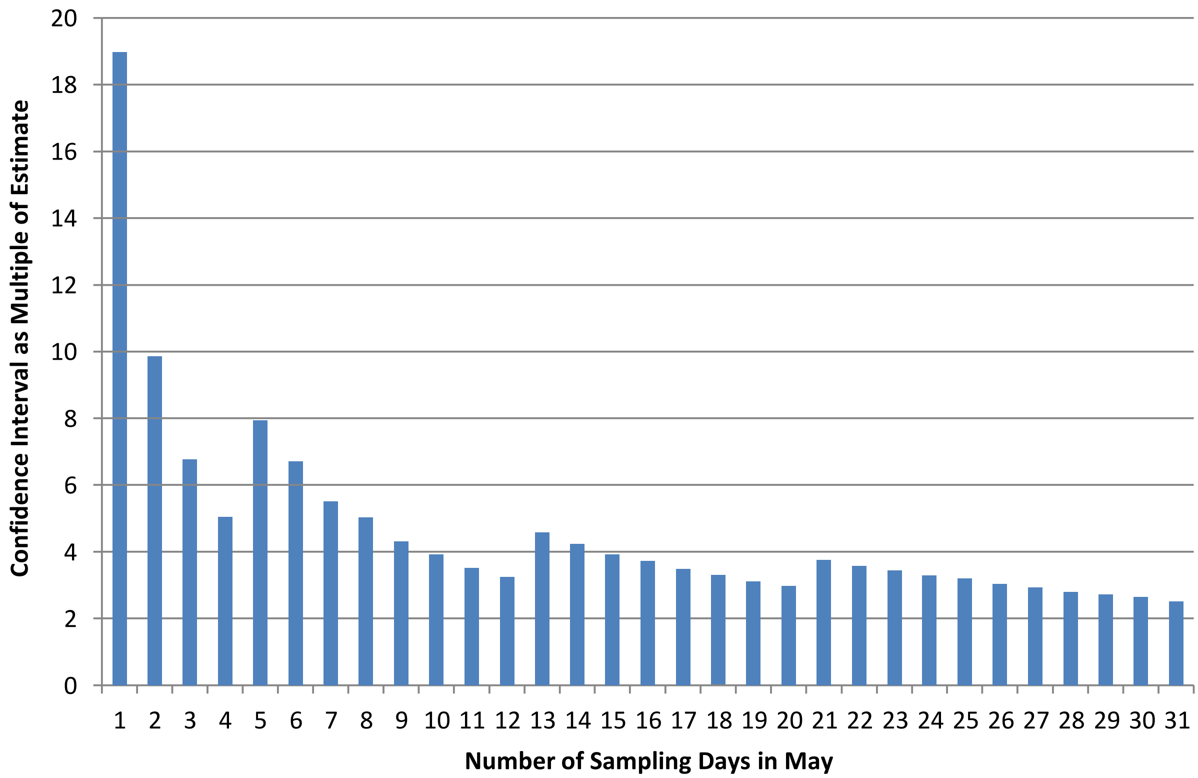
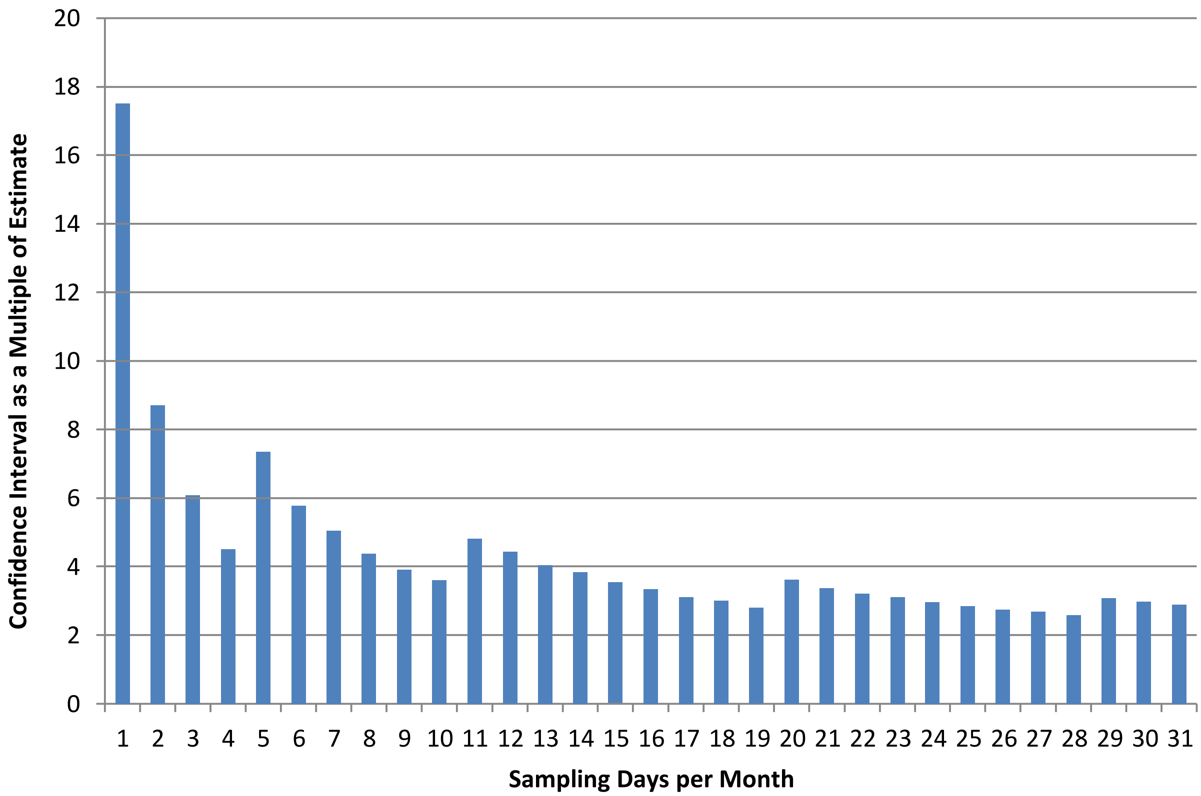


Figure 2. Confidence intervals from the assessment of the effect of sampling intensity on size of confidence limits for estimates of annual numbers of Atlantic sturgeon entrained, expressed in terms of age-1 equivalents, based on the four-month seasonal (April through July) zero-inflated Poisson model of entrainment counts. Confidence intervals are shown as a multiple of the entrainment estimate for age-1 equivalents. Confidence intervals were computed assuming design flow and four 100 m^3 samples per day.



Note: 31 sampling days represents sampling every day of the month throughout the season (i.e., 30 days in April and June, 31 days in May and July)

Appendix B

Eddystone Generating Station
Atlantic and Shortnose Sturgeon
Estimated Annual Numbers Impinged
Based on Historical Impingement Sampling Data

June 2019

Prepared for:

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Table of Contents

I. INTRODUCTION

A. Background

Eddystone Generating Station ("Eddystone") is located on the Delaware River ("Delaware" or "River") at river kilometer (RKM) 136 (river mile [RM] 84.5), south of Philadelphia, PA. Units 3 and 4, both steam electric units, are the only units that remain in operation. Non-contact, once-through cooling water for Eddystone is withdrawn from the River. The cooling water intake structure ("CWIS") for Units 3 and 4 is equipped with coarse-mesh traveling screens and was designed to be "fish-friendly." In order to reduce through-screen and approach velocities, each pump utilizes two traveling screens and the intake forebay has a greater depth. These two modifications result in a velocity under the curtain wall and through the trash racks of less than 0.55 feet per second at mean low water and a screen approach velocity of 0.44 feet per second at mean low water. Additionally, the CWIS is designed with fish escape slots between the trash racks and traveling screens to allow fish to escape from the forebay to the River.

Atlantic sturgeon and shortnose sturgeon occupy the Delaware for at least part of the year. Adult Atlantic sturgeon migrate from the ocean to freshwater spawning grounds between Cherry Island (RM 68) and Trenton, NJ (RM 131) in April and May. Spawning occurs through June, and females typically migrate back to coastal waters four to six weeks after spawning; males may remain in the River or lower estuary until the fall (Able and Fahay 2010). When present in the Delaware, the majority of adult Atlantic sturgeon are found within 30 km [18.6 mi]) of the salt front, typically between New Castle, Delaware (RKM 99 [RM 61]) and the Schuylkill River (RKM 148 [RM 92]) (Breece et al. 2013). However, adult shortnose sturgeon can occur throughout the Delaware from the lower bay as far upstream as Lambertville, New Jersey (RKM 239 [RM 149]) (Hastings et al. 1987; SSSRT 2010). These larger sturgeon may be susceptible to impingement.

This report provides estimates of potential numbers of Atlantic and shortnose sturgeon that could have been impinged at Eddystone over the past five years (2013-2017) based on seven years (1987-1992 and 2005-2006) of impingement sampling.

B. Report Organization

Section II of this report summarizes previous impingement sampling at Eddystone. Section III describes data analysis methods used to calculate estimates of numbers impinged; Section IV details the results of the analyses.

II. IMPINGEMENT SAMPLING AT EDDYSTONE GENERATING STATION

Impingement sampling was conducted at Eddystone during 1987-1992 and 2005-2006. All fish that were collected were taxonomically identified, and no Atlantic or shortnose sturgeon were collected during impingement sampling efforts at the Station. There was additional impingement sampling in 1976-1978, but Units 3 and 4, the units currently in operation, were only sampled for a portion of this study. Therefore, the 1976-1978 sampling data was excluded from these analyses. It should be noted that no sturgeon were collected during the 1976-1978 study.

The sampling design, including sampling intensity and months of sampling, and sampling methods for each year of impingement sampling are summarized in the following sections.

A. 1987-1992

From 1987 to 1992, a virtual impingement census was conducted with the goal of identifying periods of high impingement at Eddystone. The census was scheduled once per week in April and May and three times per week from June through November, when impingement was expected to be highest due to the presence of young of the year in the estuary (NAI 2008b).

Debris and impinged fish collected on Eddystone's traveling screens for Units 1, 2, 3, and 4[1] were transferred to dumpsters and the contents were inspected on each census date. Each fish was identified and counted. When the census occurred once per week, the dumpsters were emptied immediately following the impingement survey. When the censuses occurred more frequently, the dumpsters were only emptied after two of the three weekly surveys. On the day the dumpsters were not emptied, plastic sheeting was placed over the debris following the survey to ensure that previously impinged fish were not counted on the subsequent census date (NAI 2008b). The number of days surveyed per year varied based upon the dates of onset and cessation of surveying, ranging from 129 days in 1987 to 365 days in 1992 (Table 1). Over the entire sampling effort from 1987 to 1992, a total of 1,496 days were surveyed, and 638,017 fish were collected (NAI 2008b).

B. 2005-2006

In 2005-2006, impingement sampling was conducted weekly from April 18, 2005 through December 2005 and biweekly from January through March 2006 at Units 3 and 4[2]. Sampling events lasted for 24 hours, during which two consecutive 12-hour samples were collected (NAI 2008a).

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[1] In 1990 and 1991, cylindrical wedegewire screens were installed in the CWISs for Units 1 and 2, respectively. Following installation of the wedgewire screens, these units were removed from sampling.

[2] As noted in Section II.A, the CWIS for Units 1 and 2 had been retrofitted with cylindrical wedgewire screens and therefore were excluded from this study.

Prior to initiation of sampling, the traveling screens for Units 3 and 4 were operating continuously for one full rotation to clear the screens and sluiceway of fish and debris. A six foot by six foot net with a mesh size of 0.25 inches was installed at the end of the screen wash sluiceway to collect all debris and aquatic organisms washed from the screens during the sampling period. During each 12-hour sampling period, all fish and crabs were separated from the debris, identified to species, and counted. For the 2005-2006 study, a total of 43 days were sampled (Table 1), and 6,467 fish were collected (NAI 2008a).

III. DATA ANALYSIS METHODS

In 1,539 days of impingement sampling, no Atlantic or shortnose sturgeon were collected. Despite the fish-friendly design of the CWIS (See Section II.A.2 of the IITP Application) and the lack of sturgeon in impingement sampling, it is possible that sturgeon impingement at Eddystone is not truly zero. Two different approaches were utilized to estimate average annual number of sturgeon impinged at the Station: a likelihood function approach and a Bayesian approach.

A. Likelihood Function Approach

The annual number of sturgeon impinged at Eddystone was estimated using a likelihood function that modeled count data as coming from a Poisson probability distribution:

$$Pr(\textstyle\sum_{i=1}^{n} y_i = 0 \,|\Theta = \theta) = e^{-n\lambda_\theta} \approx L(\Theta = \theta | \textstyle\sum_{i=1}^{n} y_i = 0)$$

and

$$\lambda = \frac{\theta}{365}$$

where

y_i	=	Number of sturgeon observed day, *i*, in impingement sampling,
θ	=	Hypothetical average annual number of sturgeon impinged,
λ_θ	=	Average number of sturgeon impinged per day given that $\Theta = \theta$, and
$Pr(\sum_{i=1}^{n} y_i = 0 \,|\Theta = \theta)$	=	Poisson probability that the total number of sturgeon observed over *n* samples (*n* = 1539) was 0, given that the average annual number of sturgeon impinged was θ.

B. Bayesian Approach

The annual number of sturgeon impinged was also estimated using a Bayesian approach. This approach utilized a Bayesian posterior probability distribution with a non-informative prior:

$$h(\Theta = 0 | \sum_{i=1}^{n} y_i = 0) = \frac{Pr(\sum_{i=1}^{n} y_i = 0 \,|\Theta = \theta)\, f(\Theta = \theta)}{\int_0^\infty Pr(\sum_{i=1}^{n} y_i = 0 \,|\Theta = \theta)\, f(\Theta = \theta) d\theta}$$

where

$h(\Theta = \theta)$	=	Bayesian posterior probability that the annual number impinged is θ, given $\sum_{i=1}^{n} y_i = 0$, and
$f(\Theta = \theta)$	=	Prior (non-informative) probability that the annual number impinged is θ. $f(\Theta = \theta) = k$ for all values θ.

IV. RESULTS

A. Likelihood Function Approach

The results of the likelihood function analysis indicated that the maximum likelihood estimate for the annual number of sturgeon impinged was zero and that it is very unlikely that the annual number impinged is greater than one (Figure 1).

B. Bayesian Approach

The results of the Bayesian analysis indicated that there was a 99% probability that the annual number of sturgeon impinged is less than one (Figure 2).

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VI. TABLE

Table 1. Impingement sampling effort at Eddystone

Year	Days Sampled	Fish collected	Sturgeon collected
1987	129	23,250	0
1988	277	363,515	0
1989	241	117,157	0
1990	241	44,441	0
1991	243	56,531	0
1992	365	33,123	0
2005-2006	43	6,467	0
Total	**1,539**	**644,484**	**0**

VII. FIGURES

Figure 1. Estimate of annual numbers of sturgeon impinged at Eddystone, based on historical impingement data, from the likelihood function approach. The maximum likelihood estimate for annual number of sturgeon impinged is 0.

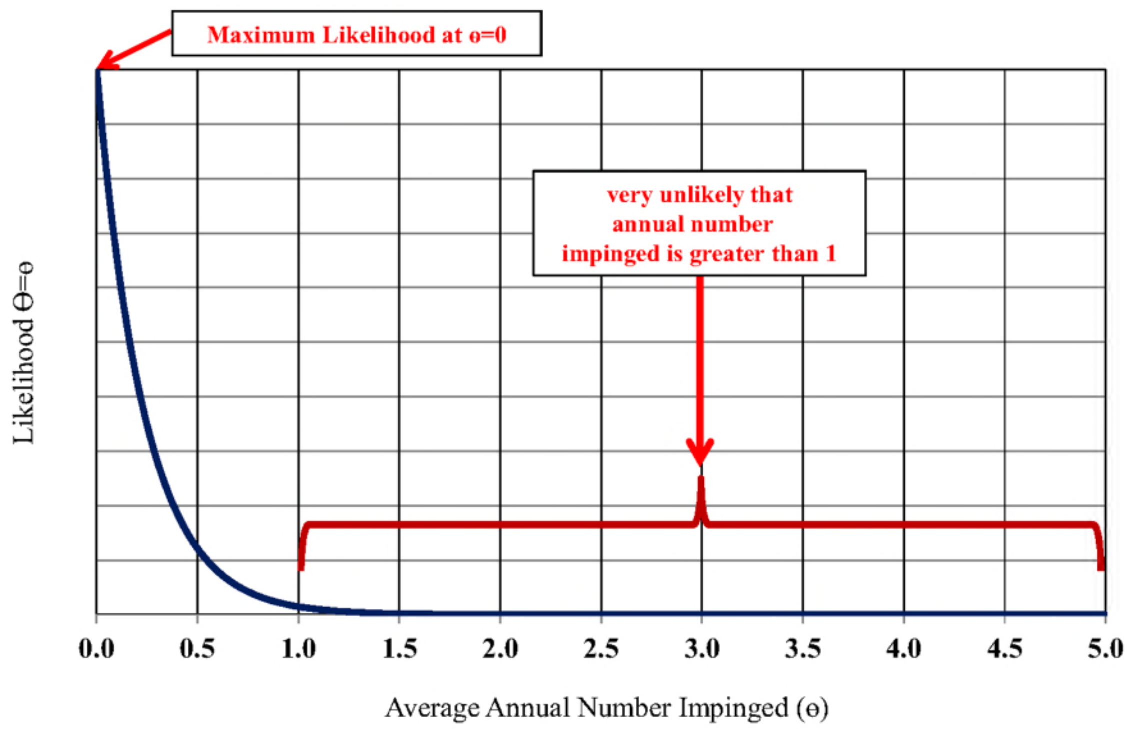
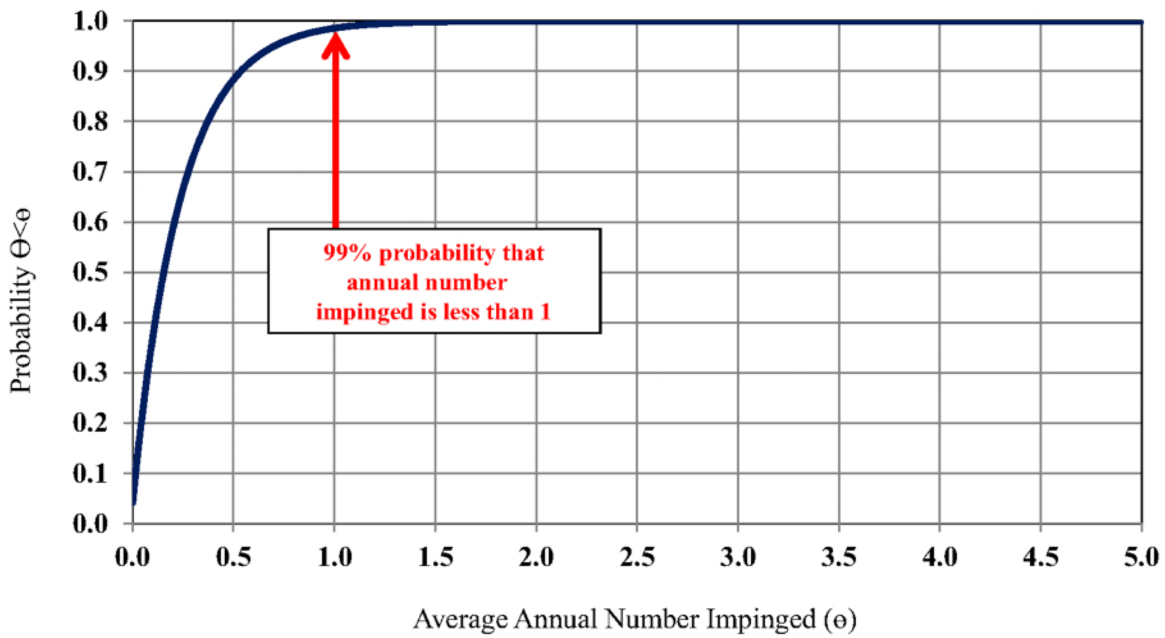


Figure 2. Estimate of annual numbers of sturgeon impinged at Eddystone, based on historical impingement data, from the Bayesian approach.



Appendix C

Eddystone Generating Station
Atlantic Sturgeon and Shortnose Sturgeon
Proposed Annual Take Limits and
Evaluation of Proposed Sampling Schedules

June 2019

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Table of Contents

I. INTRODUCTION

A. Background

1. Entrainment

As described in Appendix A of this Individual Incidental Take Permit ("IITP") application for sturgeon at Eddystone Generating Station ("Eddystone" or "Station"), in three years of entrainment sampling at Eddystone, one yolk-sac larva Atlantic sturgeon was collected. Based on the entrainment sampling data and data on the actual cooling water withdrawal volumes during the years of sampling, Exelon estimated the average annual rate of entrainment of Atlantic sturgeon over the four-month season (April through July) of potential entrainment. Based on these estimates, Exelon developed estimates and confidence limits for the annual number of age-1 equivalent Atlantic sturgeon may have been entrained at the Station under historical operating conditions (Appendix A).

Exelon and National Marine Fisheries Service ("NMFS") met on June 28, 2018 to review the draft IITP application for Eddystone. At the meeting NMFS requested additional information on monitoring that would be required to ensure compliance with Exelon's proposed take limit for entrainment of Atlantic sturgeon at the Station. In particular NMFS expressed an interest in seeing a potential sampling schedule based on historical days of operation.

Furthermore, NMFS noted that while age-1 equivalents were acceptable for the take estimate in the Habitat Conservation Plan ("HCP"), the Incidental Take Statement will have to address the number of larvae taken rather than age-1 equivalents. NMFS further clarified that the take limit in the IITP would be expressed in terms of the number of individuals collected during entrainment sampling.

2. Impingement

Appendix B of this IITP application provides a summary of historical impingement sampling at Eddystone. Over the seven years from 1987 through 2006, impingement sampling was conducted on 1,539 days during which over 600,000 fish were collected. However, no Atlantic or shortnose sturgeons were collected.

As described in this IITP application and discussed with NMFS at the June 28, 2018 meeting, Exelon is planning to submit to Pennsylvania Department of Environmental Protection ("PADEP") a request for §316(b) impingement mortality compliance at Eddystone through option (c)(12) – capacity utilization rate less than 8%. Under compliance option (c)(12), Exelon would commit to operating circulating water pumps only when the Station is generating electricity, during ramp-up and ramp-down periods prior to and after generating electricity, and as needed to conduct testing or to support other plant activities.

At the meeting between Exelon and NMFS on June 28, 2018, NMFS noted that one potential approach to addressing impingement in the IITP, given the (c)(12) selection, would be to remove impingement from the IITP. However, NMFS expressed that it would prefer the application addressed impingement and include a monitoring plan for impingement similar to that proposed for entrainment.

Exelon and NMFS discussed the question of how take limits could be determined for impingement since sturgeon have never been collected in impingement sampling at Eddystone. One option discussed was to set an initial limit based on the impingement risk analysis (Appendix B) and monitor the traveling screen wash water one or two days per week when the circulating water pumps were operating. The take limit and monitoring schedule would be re-evaluated after 3 years of impingement monitoring data had been collected.

B. Objectives and Organization

This appendix addresses the additional information requested by NMFS at the June 28, 2018 meeting, as described above:

- Evaluation of proposed entrainment and impingement sampling plans in terms of historical days of operation at Eddystone,
- Setting of take limits in terms of number of sturgeon collected during entrainment and impingement monitoring at Eddystone,
- Setting of initial take limits for impingement of Atlantic sturgeon and shortnose sturgeon at the Station, and
- Development of an impingement sampling plan.

An examination of historical (2013-2017) days of generation at Eddystone and projections of the corresponding number of days of circulating water pump operation consistent with planned pump operation protocols at the Station are described in Section II, below. Section II also contains summaries of Exelon’s proposed plans for monitoring entrainment and impingement of sturgeon.

Evaluations of the proposed entrainment and impingement sampling schedules are also presented in Section II. The evaluations characterized the number of days of entrainment and impingement sampling corresponding to:

- Projected circulating water pump operations (2013-2017), and
- Proposed entrainment and impingement sampling plans.

Proposed take limits expressed in terms of numbers of sturgeon collected during entrainment and impingement sampling are described in Sections III and IV, respectively.

II. EVALUTION OF SAMPLING PLANS IN TERMS OF HISTORICAL GENERATION DATA

A. Projected Circulating Pump Operation Based on Historical Generation Data

Because the circulating water pump operating protocol has changed since 2015, and because entrainment sampling required by PADEP in 2016 and 2017 caused circulating water pumps to run when Eddystone was not generating electricity, historical circulating water pump data from 2013 through 2017 are not representative of circulating water pump operations as planned under the Station's §316(b) impingement compliance option (c)(12). Therefore, historical generation data were used to project the circulating water pump operation that would have occurred historically if the planned (c)(12) pump operating protocols had been in effect.

Historical generation data from the Station for the years 2013 through 2017 were summarized to identify all days on which Eddystone generated electricity. Then all contiguous days of generation within each year were identified. The projected days of circulating water pump operation that would have occurred as planned under (c)(12) in each year were defined as:

- All days of generation, plus
- Two days for ramp-up operations on the days prior to each set of contiguous days of generation, which includes a contingency factor of 36 hours, plus
- Ten days for ramp-down operations on the days after each set of contiguous days of generation.

For each historical year (2013-2017), the data on generation and the projections for circulating water pump operation were summarized by week to be consistent with the proposed sampling plans for entrainment and impingement (Tables 1 through 5).

B. Evaluation of Proposed Sampling Plans

1. Overview of Proposed Sampling Plans

a. Entrainment

For entrainment, the IITP application for Eddystone proposes to collect entrainment samples during the 17-week period of potential entrainment of Atlantic sturgeon (April through July) for an initial period of three years. On each day of entrainment sampling, samples would be collected over a 24-hour period. The proposed schedule for entrainment sampling is:

- 2 days per week during each week in which Eddystone runs circulating water pumps for two or more days,

- 1 day per week during each week in which Eddystone runs circulating water pumps for one day only, and
- No sampling during each week in which Eddystone does not run circulating water pumps on any days.

b. Impingement

For impingement, Exelon proposes to collect impingement samples year-round at the Station for an initial period of three years. Impingement of Atlantic sturgeon and shortnose sturgeon would be recorded on each day of impingement sampling. Each day of impingement sampling would consist of enumeration all sturgeon collected in the traveling screen wash water collection basket over a 24-hour period. The proposed schedule for impingement sampling is:

- 1 day per week during each week in which Eddystone runs circulating water pumps for one or more days, and
- No sampling during each week in which Eddystone does not run circulating water pumps on any days.

2. Number of Samples per Year Based on Historical Generation Data

The proposed sampling plans for entrainment and impingement monitoring at Eddystone were overlaid on the annual summaries of projected days per week of circulating water pump operation as planned under (c)(12) for the years 2013 through 2017 (Tables 1 through 5). Note that for entrainment monitoring, entrainment samples were only scheduled during the 17-week season of potential entrainment of Atlantic sturgeon.

Those results were further summarized to show the total number of days of projected circulating water pump operation (annually for impingement and for the 17-week season of potential entrainment of Atlantic sturgeon). The corresponding number of days of impingement sampling and entrainment sampling were also computed (Table 6).

This assessment indicates that under historical generation conditions, the Station would have been expected to run the circulating water pumps between 89 and 177 days annually, during which time impingement samples would be collected on between 15 and 30 days per year. During the 17-week season of potential entrainment of Atlantic sturgeon, the circulating water pumps would have been expected to run between 35 and 80 days. Over that season, entrainment sampling would be conducted on between 12 and 27 days each year.

III. ENTRAINMENT ANNUAL TAKE LIMITS

As described in the IITP application for Eddystone and in Appendix A, the proposed take limit for entrainment of Atlantic sturgeon is 2 age-1 equivalents per year. To translate from age-1 equivalents to numbers of yolk-sac larval sturgeon collected by entrainment sampling, the entrainment sampling fraction (f_{ent}) and the survival fraction from the yolk-sac larvae life stage to age 1 (S) must be considered. Note that the entrainment sampling fraction depends on the number of sampling days and on the number of days of circulating water pump operation. Therefore, the number of larvae collected during entrainment sampling that is consistent with the proposed take limit of 2 age-1 equivalents varies depending on the number of sampling days and the number of days of circulating water pump operation.

Specifically, the number collected by entrainment sampling (X_{ent}) is related to age-1 equivalents (*A1E*) as follows:

$$X_{ent} = \frac{A1E \times f_{ent}}{S} \qquad (1)$$

The estimated survival fraction from yolk-sac larvae to age 1 is 0.0000747 (Appendix A). The entrainment sampling fraction depends on the total volume of water collected during entrainment sampling (v_{ent}) over the 17-week season and the total volume of water withdrawn by the circulating water pumps (V_{cwp}) during the 17-week season:

$$f_{ent} = \frac{v_{ent}}{V_{cwp}} \qquad (2)$$

On each day of entrainment sampling, the target volume of water to be collected is 400 m^3 (equivalent to 0.106 million gallons per day [“MGD”]). Therefore, the total volume of water collected during entrainment sampling in a year (expressed in terms of millions of gallons) is the number of days of entrainment sampling times 0.106 MGD.

For this assessment, the projected rate of water withdrawal by the circulating water pumps was set to the design intake flow of 835.2 MGD (which includes circulating water pumps and river water pumps) for all days of projected circulating water pump operation. Accordingly, the total volume of water (expressed in terms of millions of gallons) withdrawn by Eddystone during the 17-week season in a year is the number of days of circulating water pump operation during that season times 835.2 MGD. This assumption has the effect of setting the sampling fraction to a minimum value (per Equation 2), which causes the annual take limit (expressed in terms of numbers of larvae collected during entrainment sampling) to be at a minimum value as well (per Equation 1).

Annual take limits of yolk-sac larval sturgeon collected during entrainment sampling at Eddystone were calculated using Equations 1 and 2. The calculations were made for a range of days of sampling between 12 and 27 (see Section II.B.2, above), and for a range of days of circulating water pump operation between 24 and 39 (see Section II.B.2, above). Annual take limits corresponding to 2 age-1 equivalents are presented in Table 7. Note that for combinations of relatively few days of sampling and relatively many days of circulating water pump operation, the calculated take limit is less than 1 yolk-sac larval sturgeon collected. Since numbers collected must be integer, this result implies the take limit is zero which contradicts the purpose of the IITP.

To address this anomaly, annual take limits corresponding to 3 age-1 equivalents were calculated using the methods described above (Table 8). In this case, all calculated take limits of yolk-sac larval sturgeon collected during entrainment sampling were 1 or more. Based on these results, the annual take limits listed in Table 8 (i.e., a maximum of 3 Atlantic sturgeon yolk-sac larvae) are proposed for entrainment of Atlantic sturgeon at Eddystone. These annual take limits correspond to annual take estimates for entrainment of 3 age-1 equivalent Atlantic sturgeon for the HCP.

IV. IMPINGEMENT ANNUAL TAKE LIMITS

Based on impingement sampling results at Eddystone from 1987 through 2006 (see Section I.A.2), there was a 99% probability that the number of sturgeon impinged annually was less than 1. However, as noted by NMFS at the June 28, 2018 meeting, the abundance of juvenile Atlantic sturgeon in the Delaware River likely has increased dramatically since 2006. Therefore, the analysis results based on data through 2006 may understate the annual number of Atlantic sturgeon impinged at the Station. To address the possibility that the abundance of juvenile Atlantic sturgeon has increased since 2006, a range of potential take limits for annual impingement estimates of 1 to 10 sturgeon was evaluated.

As was the case for annual take limits for entrainment, the relationship between an annual take estimate for the number of sturgeon impinged at Eddystone (as stated in the HCP) and a take limit expressed in terms of the number of sturgeon collected during impingement sampling depends on the impingement sampling fraction. The impingement sampling fraction depends on the annual number of sampling days and on the annual number of days of circulating water pump operation. Therefore, the annual number of sturgeon *collected during impingement sampling* that is consistent with a take estimate for annual numbers of sturgeon *impinged* varies depending on the number of sampling days and the number of days of circulating water pump operation.

For the purpose of establishing an initial annual take limit for impingement, the sampling plan evaluation approach for entrainment (Section III) was modified as follows. The relationship between the number of sturgeon impinged annually (N_{imp}) and the number of sturgeon collected during impingement sampling (X_{imp}) is:

$$X_{imp} = N_{imp} \times f_{imp} \qquad (3)$$

where f_{imp} is the impingement sampling fraction. At Eddystone, all traveling screen wash water is transported via sluices to a debris collection basket that allows wash water to return to the river and retains debris and fish. Impingement sampling will consist of enumerating all sturgeon collected in the debris collection basket during each 24-hour impingement sampling period. Therefore, each day of impingement sampling would provide an enumeration of all sturgeon impinged on the traveling screens and removed by the screen wash water over a 24-hour period. Accordingly, the impingement sampling fraction depends only on the total number of impingement sampling days during the year (d_{imp}) and the total number of days of circulating water pump operation during the year (D_{CWP}):

$$f_{imp} = \frac{d_{imp}}{D_{CWP}} \qquad (4)$$

Annual take limits of sturgeon collected during impingement sampling at the Station were calculated using Equations 3 and 4. The calculations were made for a range of days of impingement sampling between 15 and 30 (see Section II.B.2, above), and for a range of days of circulating water pump operation between 89 and 177 (see Section II.B.2, above).

As observed for annual entrainment take expressed in terms of numbers of sturgeon collected during entrainment sampling, results from the assessment of impingement take included take limits (expressed in terms of numbers of sturgeon collected during sampling) of zero sturgeon. This was the case for some combinations of numbers of days of impingement sampling and numbers of days of pump operation when the potential annual take estimate for impingement was 6 sturgeon (Table 9) or less. When the annual take estimate for impingement was set to 7 sturgeon, the annual take limits expressed in terms of numbers collected during impingement sampling were 1 or more (Table 10).

Based on these results, the annual take limits listed in Table 10 (i.e., a maximum of 2 sturgeon per year) are proposed for impingement of Atlantic sturgeon at Eddystone. The annual take limits listed in Table 10 are proposed for impingement of shortnose sturgeon at the Station as well. These annual take limits correspond to annual take estimates for the HCP of 7 Atlantic sturgeon and 7 shortnose sturgeon impinged per year.

V. TABLES

Table 1 . EGS Historical Generation 2013

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
1	1	0	0	0	0	0
2	1	0	0	0	0	0
3	1	0	0	0	0	0
4	1	0	0	0	0	0
5	2	0	0	0	0	0
6	2	0	0	0	0	0
7	2	0	0	0	0	0
8	2	0	0	0	0	0
9	3	0	0	0	0	0
10	3	0	0	0	0	0
11	3	0	0	0	0	0
12	3	0	0	0	0	0
13	4	0	0	0	0	0
14	4	0	0	0	1	0
15	4	0	0	0	1	0
16	4	0	0	0	1	0
17	4	0	0	0	1	0
18	5	0	0	0	1	0
19	5	0	0	0	1	0
20	5	0	0	0	1	0
21	5	0	0	0	1	0
22	6	2	7	1	1	2
23	6	0	7	1	1	2
24	6	0	0	0	1	0
25	6	1	3	1	1	2
26	7	3	7	1	1	2
27	7	1	7	1	1	2

(Continued)

Table 1 . EGS Historical Generation 2013

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

		Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
Week	Month					
28	7	3	7	1	1	2
29	7	6	7	1	1	2
30	7	0	7	1	1	2
31	8	0	2	1	0	0
32	8	0	0	0	0	0
33	8	0	1	1	0	0
34	8	2	7	1	0	0
35	9	2	7	1	0	0
36	9	0	7	1	0	0
37	9	3	7	1	0	0
38	9	0	6	1	0	0
39	9	0	0	0	0	0
40	10	0	0	0	0	0
41	10	0	0	0	0	0
42	10	0	0	0	0	0
43	10	0	0	0	0	0
44	11	0	0	0	0	0
45	11	0	0	0	0	0
46	11	0	0	0	0	0
47	11	0	0	0	0	0
48	12	0	0	0	0	0
49	12	0	0	0	0	0
50	12	0	0	0	0	0
51	12	0	0	0	0	0
52	12	0	0	0	0	0
53	12	0	0	0	0	0

Table 2 . EGS Historical Generation 2014

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
1	1	2	4	1	0	0
2	1	1	7	1	0	0
3	1	1	7	1	0	0
4	1	5	7	1	0	0
5	2	3	7	1	0	0
6	2	0	6	1	0	0
7	2	0	0	0	0	0
8	2	0	0	0	0	0
9	3	0	0	0	0	0
10	3	0	0	0	0	0
11	3	0	0	0	0	0
12	3	0	0	0	0	0
13	4	0	0	0	0	0
14	4	0	0	0	1	0
15	4	0	0	0	1	0
16	4	0	0	0	1	0
17	4	0	0	0	1	0
18	5	0	0	0	1	0
19	5	3	5	1	1	2
20	5	0	7	1	1	2
21	5	0	3	1	1	2
22	6	0	0	0	1	0
23	6	0	0	0	1	0
24	6	2	4	1	1	2
25	6	1	7	1	1	2
26	7	1	7	1	1	2
27	7	4	7	1	1	2

(Continued)

Table 2 . EGS Historical Generation 2014

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
28	7	4	7	1	1	2
29	7	1	7	1	1	2
30	7	2	7	1	1	2
31	8	2	7	1	0	0
32	8	0	7	1	0	0
33	8	0	3	1	0	0
34	8	0	0	0	0	0
35	9	1	3	1	0	0
36	9	2	7	1	0	0
37	9	0	7	1	0	0
38	9	0	0	0	0	0
39	9	0	0	0	0	0
40	10	0	0	0	0	0
41	10	0	0	0	0	0
42	10	0	0	0	0	0
43	10	0	0	0	0	0
44	11	0	0	0	0	0
45	11	0	0	0	0	0
46	11	0	0	0	0	0
47	11	0	0	0	0	0
48	12	1	3	1	0	0
49	12	2	7	1	0	0
50	12	0	5	1	0	0
51	12	0	0	0	0	0
52	12	0	0	0	0	0
53	12	0	0	0	0	0

Table 3 . EGS Historical Generation 2015

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

		Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
Week	**Month**					
1	1	0	0	0	0	0
2	1	0	0	0	0	0
3	1	0	0	0	0	0
4	1	0	0	0	0	0
5	2	0	0	0	0	0
6	2	0	0	0	0	0
7	2	0	2	1	0	0
8	2	5	7	1	0	0
9	3	1	7	1	0	0
10	3	0	4	1	0	0
11	3	0	0	0	0	0
12	3	0	0	0	0	0
13	4	0	0	0	0	0
14	4	0	0	0	1	0
15	4	0	0	0	1	0
16	4	0	0	0	1	0
17	4	0	0	0	1	0
18	5	0	0	0	1	0
19	5	0	0	0	1	0
20	5	0	0	0	1	0
21	5	0	0	0	1	0
22	6	0	0	0	1	0
23	6	0	0	0	1	0
24	6	2	5	1	1	2
25	6	2	7	1	1	2
26	7	0	7	1	1	2
27	7	0	3	1	1	2

(Continued)

Table 3 . EGS Historical Generation 2015

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
28	7	0	0	0	1	0
29	7	4	6	1	1	2
30	7	7	7	1	1	2
31	8	6	7	1	0	0
32	8	6	7	1	0	0
33	8	7	7	1	0	0
34	8	6	7	1	0	0
35	9	7	7	1	0	0
36	9	6	7	1	0	0
37	9	2	7	1	0	0
38	9	2	7	1	0	0
39	9	1	7	1	0	0
40	10	0	7	1	0	0
41	10	0	3	1	0	0
42	10	0	0	0	0	0
43	10	0	0	0	0	0
44	11	0	0	0	0	0
45	11	0	1	1	0	0
46	11	1	7	1	0	0
47	11	1	7	1	0	0
48	12	0	5	1	0	0
49	12	0	0	0	0	0
50	12	0	0	0	0	0
51	12	0	0	0	0	0
52	12	0	0	0	0	0
53	12	0	0	0	0	0

Table 4 . EGS Historical Generation 2016

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
1	1	0	0	0	0	0
2	1	0	0	0	0	0
3	1	0	0	0	0	0
4	1	0	0	0	0	0
5	2	0	0	0	0	0
6	2	0	0	0	0	0
7	2	0	0	0	0	0
8	2	0	0	0	0	0
9	3	0	0	0	0	0
10	3	0	0	0	0	0
11	3	0	0	0	0	0
12	3	0	0	0	0	0
13	3	0	0	0	0	0
14	4	0	0	0	1	0
15	4	0	0	0	1	0
16	4	0	0	0	1	0
17	4	1	4	1	1	2
18	5	1	7	1	1	2
19	5	1	7	1	1	2
20	5	0	7	1	1	2
21	5	1	6	1	1	2
22	6	1	7	1	1	2
23	6	0	4	1	1	2
24	6	0	0	0	1	0
25	6	1	6	1	1	2
26	6	0	7	1	1	2
27	7	2	4	1	1	2

(Continued)

Table 4 . EGS Historical Generation 2016

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
28	7	2	7	1	1	2
29	7	7	7	1	1	2
30	7	7	7	1	1	2
31	8	5	7	1	0	0
32	8	2	7	1	0	0
33	8	6	7	1	0	0
34	8	4	7	1	0	0
35	9	5	7	1	0	0
36	9	2	7	1	0	0
37	9	3	7	1	0	0
38	9	3	7	1	0	0
39	9	1	7	1	0	0
40	10	0	4	1	0	0
41	10	0	0	0	0	0
42	10	0	0	0	0	0
43	10	1	3	1	0	0
44	11	0	7	1	0	0
45	11	0	3	1	0	0
46	11	0	0	0	0	0
47	11	0	0	0	0	0
48	12	0	0	0	0	0
49	12	0	0	0	0	0
50	12	0	2	1	0	0
51	12	3	7	1	0	0
52	12	0	7	1	0	0
53	12	0	1	1	0	0

Table 5 . EGS Historical Generation 2017

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
1	1	0	0	0	0	0
2	1	0	0	0	0	0
3	1	0	0	0	0	0
4	1	0	0	0	0	0
5	2	0	0	0	0	0
6	2	0	0	0	0	0
7	2	0	0	0	0	0
8	2	0	0	0	0	0
9	3	0	0	0	0	0
10	3	0	0	0	0	0
11	3	0	0	0	0	0
12	3	0	0	0	0	0
13	4	0	0	0	0	0
14	4	0	0	0	1	0
15	4	0	0	0	1	0
16	4	0	0	0	1	0
17	4	2	5	1	1	2
18	5	0	7	1	1	2
19	5	0	2	1	1	2
20	5	1	5	1	1	2
21	5	0	7	1	1	2
22	6	0	1	1	1	1
23	6	1	6	1	1	2
24	6	1	7	1	1	2
25	6	0	6	1	1	2
26	7	1	5	1	1	2
27	7	2	7	1	1	2

(Continued)

Table 5 . EGS Historical Generation 2017

Projected Circulating Water Pump Operation:
1 Day of Pump Operation for Each Day of Generation
2 Days Of Pump Operation for Ramp-up Added to Beginning of Each Set of Consecutive Days of Generation
10 Days Of Pump Operation for Ramp-down Added to End of Each Set of Consecutive Days of Generation

Projected Number of Days of Impingement and Entrainment Sampling
Based on Projected Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

Week	Month	Actual Number of Days of Generation	Projected Number of Days of Circulating Water Pump Operation	Projected Number of Days of Impingement Sampling	Week of Potential Entrainment (1=yes, 0=no)	Projected Number of Days of Entrainment Sampling
28	7	3	7	1	1	2
29	7	4	7	1	1	2
30	7	0	7	1	1	2
31	8	0	3	1	0	0
32	8	0	0	0	0	0
33	8	0	0	0	0	0
34	8	0	0	0	0	0
35	9	1	6	1	0	0
36	9	0	7	1	0	0
37	9	0	0	0	0	0
38	9	2	5	1	0	0
39	9	4	7	1	0	0
40	10	1	7	1	0	0
41	10	3	7	1	0	0
42	10	1	7	1	0	0
43	10	0	4	1	0	0
44	11	0	0	0	0	0
45	11	0	0	0	0	0
46	11	2	6	1	0	0
47	11	0	7	1	0	0
48	12	0	1	1	0	0
49	12	0	0	0	0	0
50	12	0	0	0	0	0
51	12	0	0	0	0	0
52	12	0	0	0	0	0
53	12	0	0	0	0	0

Table 6 . EGS Projected Annual Circulating Water Pump Operation

Projected Annual Number of Days of Impingement and Entrainment Sampling
Based on Projected Weekly Number of Days of Circulating Water Pump Operation and Proposed Sampling Schedules

	Projected Annual Number of Days of Circulating Water Pump Operation	Projected Annual Number of Days of Impingement Sampling	Projected Number of Days of Cirulating Water Pump Operation During Weeks of Potential Entrainment	Projected Annual Number of Days of Entrainment Sampling
Year				
2013	89	15	52	16
2014	148	25	61	20
2015	148	25	35	12
2016	177	30	80	26
2017	146	26	79	27

Table 7. EGS Entrainment Sampling
Annual Atlantic Sturgeon Take Limit
Expressed as Numbers of Yolk-Sac Larvae Collected
Corresponding to Annual Total of 2 Age-1 Equivalents *

Based on Number of Entrainment Sampling Days During the 17 Week Potential Entrainment Season, and Cooling Water Withdrawal Volume During that Season

		Entrainment Sampling Days per Year															
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Seasonal Number of Days of Circulating Water Pump Operation	Seasonal Cooling Water Withdrawal Volume ** (million gallons)																
35	29,232	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
38	31,737	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
41	34,243	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
44	36,748	.	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
47	39,254	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1
50	41,760	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1
53	44,265	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1
56	46,771	.	.	.	.	0	1	1	1	1	1	1	1	1	1	1	1
59	49,276	.	.	.	.	.	0	1	1	1	1	1	1	1	1	1	1
62	51,782	.	.	.	.	.	.	0	1	1	1	1	1	1	1	1	1
65	54,288	.	.	.	.	.	.	.	0	1	1	1	1	1	1	1	1
68	56,793	.	.	.	.	.	.	.	.	0	1	1	1	1	1	1	1
71	59,299	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1
74	61,804	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1
77	64,310	.	.	.	.	.	.	.	.	.	.	0	1	1	1	1	1
80	66,816	.	.	.	.	.	.	.	.	.	.	.	0	1	1	1	1

Missing table entries: number of sampling days lower than possible based on proposed sampling plan

**** Assuming sample volume of 400 m3 per day of entrainment sampling***
**** Assuming survival from YSL to Age-1 = 0.0000747***
***** Assuming Design Intake Flow (835.2 MGD) on every day of pump operation***

Table 8. EGS Entrainment Sampling
Annual Atlantic Sturgeon Take Limit
Expressed as Numbers of Yolk-Sac Larvae Collected
Corresponding to Annual Total of 3 Age-1 Equivalents *

Based on Number of Entrainment Sampling Days During the 17 Week Potential Entrainment Season, and Cooling Water Withdrawal Volume During that Season

		Entrainment Sampling Days per Year															
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Seasonal Number of Days of Circulating Water Pump Operation	**Seasonal Cooling Water Withdrawal Volume ** (million gallons)**																
35	**29,232**	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3
38	**31,737**	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3
41	**34,243**	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3
44	**36,748**	.	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3
47	**39,254**	.	.	1	1	1	1	1	2	2	2	2	2	2	2	2	2
50	**41,760**	.	.	.	1	1	1	1	1	2	2	2	2	2	2	2	2
53	**44,265**	.	.	.	.	1	1	1	1	1	2	2	2	2	2	2	2
56	**46,771**	.	.	.	.	1	1	1	1	1	1	1	2	2	2	2	2
59	**49,276**	.	.	.	.	.	1	1	1	1	1	1	1	2	2	2	2
62	**51,782**	.	.	.	.	.	.	1	1	1	1	1	1	1	2	2	2
65	**54,288**	.	.	.	.	.	.	.	1	1	1	1	1	1	1	2	2
68	**56,793**	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1	2
71	**59,299**	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1
74	**61,804**	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1
77	**64,310**	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1
80	**66,816**	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1

Missing table entries: number of sampling days lower than possible based on proposed sampling plan

**** Assuming sample volume of 400 m3 per day of entrainment sampling***
**** Assuming survival from YSL to Age-1 = 0.0000747***
***** Assuming Design Intake Flow (835.2 MGD) on every day of pump operation***

Table 9. EGS Impingement Sampling
Annual Atlantic (or Shortnose) Sturgeon Take Limit
Expressed as Numbers of Sturgeon Collected
*Corresponding to Annual Total of 6 Impinged **

Based on Number of Impingement Sampling Days During the Year, and
Annual Number of Days of Circulating Water Pump Operation

	Impingement Sampling Days per Year															
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Annual Number of Days of Circulating Water Pump Operation																
89	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
93	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
97	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
101	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
105	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
109	.	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
113	.	.	0	0	1	1	1	1	1	1	1	1	1	1	1	1
117	.	.	0	0	0	1	1	1	1	1	1	1	1	1	1	1
121	.	.	.	0	0	0	1	1	1	1	1	1	1	1	1	1
125	.	.	.	0	0	0	1	1	1	1	1	1	1	1	1	1
129	.	.	.	.	0	0	0	1	1	1	1	1	1	1	1	1
133	.	.	.	.	0	0	0	0	1	1	1	1	1	1	1	1
137	.	.	.	.	.	0	0	0	1	1	1	1	1	1	1	1
141	.	.	.	.	.	.	0	0	0	1	1	1	1	1	1	1

(Continued)

Missing table entries: number of sampling days lower than possible based on proposed sampling plan

**** Assuming all screen wash water is sampled on each day of impingement sampling***

Table 9. EGS Impingement Sampling
Annual Atlantic (or Shortnose) Sturgeon Take Limit
Expressed as Numbers of Sturgeon Collected
Corresponding to Annual Total of 6 Impinged *

Based on Number of Impingement Sampling Days During the Year, and
Annual Number of Days of Circulating Water Pump Operation

	Impingement Sampling Days per Year															
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Annual Number of Days of Circulating Water Pump Operation																
145	.	.	.	.	.	.	0	0	0	0	1	1	1	1	1	1
149	.	.	.	.	.	.	.	0	0	0	1	1	1	1	1	1
153	.	.	.	.	.	.	.	0	0	0	0	1	1	1	1	1
157	.	.	.	.	.	.	.	.	0	0	0	0	1	1	1	1
161	.	.	.	.	.	.	.	.	0	0	0	0	1	1	1	1
165	.	.	.	.	.	.	.	.	.	0	0	0	0	1	1	1
169	.	.	.	.	.	.	.	.	.	.	0	0	0	0	1	1
173	.	.	.	.	.	.	.	.	.	.	0	0	0	0	1	1
177	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	1

Missing table entries: number of sampling days lower than possible based on proposed sampling plan

**** Assuming all screen wash water is sampled on each day of impingement sampling***

Table 10 . EGS Impingement Sampling
Annual Atlantic (or Shortnose) Sturgeon Take Limit
Expressed as Numbers of Sturgeon Collected
Corresponding to Annual Total of 7 Impinged *

Based on Number of Impingement Sampling Days During the Year, and
Annual Number of Days of Circulating Water Pump Operation

	Impingement Sampling Days per Year															
	15	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Annual Number of Days of Circulating Water Pump Operation																
89	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
93	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
97	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2
101	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
105	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
109	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
113	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1
117	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	1
121	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1
125	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1
129	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1
133	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1
137	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1
141	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1

(Continued)

Missing table entries: number of sampling days lower than possible based on proposed sampling plan

**** Assuming all screen wash water is sampled on each day of impingement sampling***

Table 10 . EGS Impingement Sampling
Annual Atlantic (or Shortnose) Sturgeon Take Limit
Expressed as Numbers of Sturgeon Collected
Corresponding to Annual Total of 7 Impinged *

Based on Number of Impingement Sampling Days During the Year, and
Annual Number of Days of Circulating Water Pump Operation

	Impingement Sampling Days per Year															
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Annual Number of Days of Circulating Water Pump Operation																
145	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1
149	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1
153	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1	1
157	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1
161	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1	1
165	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1	1
169	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1
173	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1	1
177	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1

Missing table entries: number of sampling days lower than possible based on proposed sampling plan

**** Assuming all screen wash water is sampled on each day of impingement sampling***

IITP APPLICATION
ATTACHMENT 1

Eddystone Generating Station's
National Pollutant Discharge Elimination System
Permit No. PA0013714
September 11, 2014

June 2019

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF POINT AND NON-POINT SOURCE MANAGEMENT

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM DISCHARGE REQUIREMENTS FOR INDUSTRIAL WASTEWATER FACILITIES

NPDES PERMIT NO: PA0013714

In compliance with the provisions of the Clean Water Act, 33 U.S.C. Section 1251 *et seq.* ("the Act") and Pennsylvania's Clean Streams Law, as amended, 35 P.S. Section 691.1 *et seq.*,

Exelon Generation Co. LLC
300 Exelon Way
Kennett Square, PA 19348-2473

is authorized to discharge from a facility known as **Eddystone Generating Station**, located in **Eddystone Borough, Delaware County**, to **Delaware River Estuary Zone 4 and Crum Creek** in Watershed(s) **3-G** in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts A, B and C hereof.

THIS PERMIT SHALL BECOME EFFECTIVE ON OCTOBER 1, 2014

THIS PERMIT SHALL EXPIRE AT MIDNIGHT ON SEPTEMBER 30, 2019

The authority granted by this permit is subject to the following further qualifications:

1. If there is a conflict between the application, its supporting documents and/or amendments and the terms and conditions of this permit, the terms and conditions shall apply.

2. Failure to comply with the terms, conditions or effluent limitations of this permit is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. (40 CFR 122.41(a))

3. A complete application for renewal of this permit, or notice of intent to cease discharging by the expiration date, must be submitted to DEP at least 180 days prior to the above expiration date (unless permission has been granted by DEP for submission at a later date), using the appropriate NPDES permit application form. (40 CFR 122.41(b), 122.21(d)(2))

   In the event that a timely and complete application for renewal has been submitted and DEP is unable, through no fault of the permittee, to reissue the permit before the above expiration date, the terms and conditions of this permit, including submission of the Discharge Monitoring Reports (DMRs), will be automatically continued and will remain fully effective and enforceable against the discharger until DEP takes final action on the pending permit application. (25 Pa. Code 92a.7 (b), (c))

4. This NPDES permit does not constitute authorization to construct or make modifications to wastewater treatment facilities necessary to meet the terms and conditions of this permit.

DATE PERMIT ISSUED September 11, 2014 **ISSUED BY**

Jenifer L. Fields, P.E.
Clean Water Program Manager
Southeast Regional Office

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. A. For Outfall 001*, **Latitude** 39° 51' 41.00", **Longitude** 75° 19' 24.00", **River Mile Index** 0.26, **Stream Code** 00692

Receiving Waters: Crum Creek

Type of Effluent: stormwater

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly		Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
PCBs (Wet Weather) (pg/L)	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 001

*See Part C, Condition IV, applicable to Stormwater Outfalls.

I. B. For Outfall 002*, **Latitude** 39° 51' 41.00", **Longitude** 75° 19' 24.00", **River Mile Index** 0.17, **Stream Code** 00692

Receiving Waters: Crum Creek

Type of Effluent: stormwater

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.
2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 002 is not monitored

*See Part C, Condition IV, applicable to Stormwater Outfalls.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. C. For Outfall 004* , **Latitude** 39° 51' 34.00" , **Longitude** 75° 19' 20.00" , **River Mile Index** 0.132 , **Stream Code** 00692

Receiving Waters: Crum Creek

Type of Effluent: Stormwater, condensate storage tank overflow and city water tank overflow

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly		Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
pH (S.U.)	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
CBOD5	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Chemical Oxygen Demand	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Suspended Solids	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Oil and Grease	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Kjeldahl Nitrogen	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Phosphorus	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Iron	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 004

*See Part C, Condition IV, applicable to Stormwater Outfalls.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. D. For Outfall 005** , **Latitude** 39° 51' 32.00" , **Longitude** 75° 19' 19.00" , **River Mile Index** 0.095 , **Stream Code** 00692

Receiving Waters: Crum Creek

Type of Effluent: Stormwater

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Daily Maximum	Instant. Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
PCBs (Wet Weather) (pg/L)*	XXX	XXX	XXX	XXX	Report	XXX	1/year	24-Hr Composite

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 005

*See Other Requirement No. H. ** See Part C, Condition IV, applicable to Stormwater Outfalls.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. E. For Outfall 007*, **Latitude** 39° 51' 23.00", **Longitude** 75° 19' 27.00", **River Mile Index** 84.62, **Stream Code** 00002

Receiving Waters: Delaware River

Type of Effluent: Stormwater

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 007 is not monitored

*See Part C, Condition IV, applicable to Stormwater Outfalls.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. F. For Outfall 008, **Latitude** 39° 51' 23.00", **Longitude** 75° 19' 27.00", **River Mile Index** 84.65, **Stream Code** 00002

Receiving Waters: Delaware River

Type of Effluent: Once through cooling water, boiler blow down and river water from intake sump area

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Daily Maximum	Instant. Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
Flow (MGD)	Report	Report	XXX	XXX	XXX	XXX	****	Calculation
pH (S.U.)	XXX	XXX	6.0	XXX	XXX	9.0	****	Grab
Total Residual Chlorine	XXX	XXX	XXX	XXX	XXX	0.2	****	Grab
Temperature, Delta (°F)* (Discharge-Intake)	XXX	XXX	XXX	21	XXX	XXX	****	Calculation
Temperature (°F)* Intake	XXX	XXX	XXX	Report	XXX	XXX	****	I-S
Temperature (°F)*	XXX	XXX	XXX	Report	XXX	XXX	****	I-S
Total Suspended Solids Effluent Net	XXX	XXX	XXX	30	100	XXX	1/month	Calculation
Total Suspended Solids Intake	XXX	XXX	XXX	Report	Report	XXX	1/month	24-Hr Composite
Total Suspended Solids	XXX	XXX	XXX	Report	Report	XXX	1/month	24-Hr Composite
Spectrus CT1300**	XXX	XXX	XXX	XXX	0.05	XXX	1/day	Grab
Ammonia-Nitrogen	XXX	XXX	XXX	Report	XXX	XXX	*****	24-Hr Composite

Outfall 008, Continued (from Permit Effective Date through Permit Expiration Date)

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Daily Maximum	Instant. Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
Bromide	XXX	XXX	XXX	XXX	Report	XXX	1/quarter	24-Hr Composite

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 008
* Influent temperature at Intake No. 2 shall be taken concurrently with effluent temperature at Outfall 008. See Other Requirement Nos. F and G.
** Shall be sampled only during the use of Chemical additive. See Other Requirement No. M.
**** Sampling shall be daily when the facility is operating and weekly when the facility is not operating. Daily sampling shall continue the day after the operation is ceased.
***** Sampling shall be weekly during the use of ammonium hydroxide.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. G. For Outfall 010**, **Latitude** 39° 51' 23.00", **Longitude** 75° 19' 28.00", **River Mile Index** 84.7, **Stream Code** 00002

Receiving Waters: Delaware River

Type of Effluent: Noncontact cooling water, stormwater, groundwater and condensate storage tank overflow

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Daily Maximum	Instant. Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
Flow (MGD)	Report	Report	XXX	XXX	XXX	XXX	1/month	Estimate
pH (S.U.)	XXX	XXX	6.0	XXX	XXX	9.0	1/month	Grab
Temperature (°F)	XXX	XXX	XXX	XXX	XXX	110	1/month	I-S
Total Suspended Solids	XXX	XXX	XXX	30	60	75	1/month	Grab
Oil and Grease	XXX	XXX	XXX	15	20	30	1/month	Grab
Total Aluminum*	XXX	XXX	XXX	Report	Report	XXX	1/month	24-Hr Composite
Dissolved Iron*	XXX	XXX	XXX	Report	Report	XXX	1/month	24-Hr Composite
CBOD5	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Chemical Oxygen Demand	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab

Outfall 010, Continued (from Permit Effective Date through Permit Expiration Date)

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Daily Maximum	Instant. Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
Total Kjeldahl Nitrogen	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Phosphorus	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Iron	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 010

*See Other Requirement No.H . **See Part C, Condition IV, applicable to Stormwater Outfalls.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. H. For Outfall 013*, **Latitude** 39° 51' 26.00", **Longitude** 75° 19' 20.00", **River Mile Index** 84.9, **Stream Code** 00002

Receiving Waters: Delaware River

Type of Effluent: Stormwater

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly		Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
pH (S.U.)	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
CBOD5	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Chemical Oxygen Demand	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Suspended Solids	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Oil and Grease	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Kjeldahl Nitrogen	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Phosphorus	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Iron	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 013

* See Part C, Condition IV, applicable to Stormwater Outfalls.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. I. For Outfall 014* , **Latitude** 39° 51' 25.00" , **Longitude** 75° 19' 22.00" , **River Mile Index** 84.88 , **Stream Code** 00002

Receiving Waters: Delaware River

Type of Effluent: Stormwater

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly		Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
pH (S.U.)	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
CBOD5	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Chemical Oxygen Demand	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Suspended Solids	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Oil and Grease	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Kjeldahl Nitrogen	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Phosphorus	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Iron	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Outfall 014

*See Part C, Condition IV, applicable to Stormwater Outfalls.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. J. For Monitoring Point 108, **Latitude** 39° 51' 23.00", **Longitude** 75° 19' 27.00", **River Mile Index** 84.62, **Stream Code** 00002

Receiving Waters: Delaware River

Type of Effluent: Industrial wastewater treatment plant effluent

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Daily Maximum	Instant. Minimum	Average Monthly	Daily Maximum	Instant. Maximum		
Flow (MGD)	Report	Report	XXX	XXX	XXX	XXX	Continuous	Recorded
pH (S.U.)*	XXX	XXX	Report	XXX	XXX	Report	Daily when Discharging	Grab
Total Suspended Solids	XXX	XXX	XXX	30	100	XXX	2/month	24-Hr Composite
Total Dissolved Solids	XXX	XXX	XXX	1,000	2,000	2,500	2/month	24-Hr Composite
Oil and Grease	XXX	XXX	XXX	15	20	30	2/month	Grab
Total Copper*	XXX	XXX	XXX	Report	Report	XXX	1/month	24-Hr Composite
Total Iron*	XXX	XXX	XXX	Report	Report	XXX	1/month	24-Hr Composite
PCBs (Dry Weather) (pg/L)	XXX	XXX	XXX	XXX	Report	XXX	1/year	24-Hr Composite
CBOD20 (1/1/2018 to 12/31/2018)	Report	XXX	XXX	XXX	XXX	XXX	1/month	24-Hr Composite

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): Monitoring Point 108

*See Other Requirement No. L.

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS

I. K. For Monitoring Point 110 , **Latitude** 39° 51' 23.00" , **Longitude** 75° 19' 28.00" , **River Mile Index** 84.7 , **Stream Code** 00002

Receiving Waters: Delaware River

Type of Effluent: Stormwater from Eddyston Rail Company operations

1. The permittee is authorized to discharge during the period from Permit Effective Date through Permit Expiration Date.

2. Based on the anticipated wastewater characteristics and flows described in the permit application and its supporting documents and/or amendments, the following effluent limitations and monitoring requirements apply (see also Additional Requirements and Footnotes).

Parameter	Effluent Limitations						Monitoring Requirements	
	Mass Units (lbs/day) (1)		Concentrations (mg/L)				Minimum (2) Measurement Frequency	Required Sample Type
	Average Monthly	Daily Maximum	Instant. Minimum	Average	Daily Maximum	Instant. Maximum		
pH (S.U.)	XXX	XXX	6.0	XXX	XXX	9.0	1/quarter	Grab
Oil and Grease	XXX	XXX	XXX	15	XXX	30	1/quarter	Grab
Total Recoverable Petroleum Hydrocarbons	XXX	XXX	XXX	15	XXX	30	1/quarter	Grab
CBOD5	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Chemical Oxygen Demand	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Suspended Solids	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Kjeldahl Nitrogen	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Iron	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab
Total Phosphorus	XXX	XXX	XXX	XXX	Report	XXX	1/year	Grab

Samples taken in compliance with the monitoring requirements specified above shall be taken at the following location(s): MP 110, the sampling port located on the discharge end of the laminar flow oil/water separator (Hydrasep).

PART A - EFFLUENT LIMITATIONS, MONITORING, RECORDKEEPING AND REPORTING REQUIREMENTS (Continued)

Additional Requirements

The permittee may not discharge:

1. Floating solids, scum, sheen or substances that result in observed deposits in the receiving water. (25 Pa Code 92a.41(c))

2. Oil and grease in amounts that cause a film or sheen upon or discoloration of the waters of this Commonwealth or adjoining shoreline, or that exceed 15 mg/l as a daily average or 30 mg/l at any time (or lesser amounts if specified in this permit). (25 Pa. Code 92a.47(a)(7) and 95.2(2))

3. Substances in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life. (25 Pa Code 93.6(a))

4. Foam or substances that produce an observed change in the color, taste, odor or turbidity of the receiving water, unless those conditions are otherwise controlled through effluent limitations or other requirements in this permit. (25 Pa Code 92a.41(c))

Footnotes

(1) When sampling to determine compliance with mass effluent limitations, the discharge flow at the time of sampling must be measured and recorded.

(2) This is the minimum number of sampling events required. Permittees are encouraged, and it may be advantageous in demonstrating compliance, to perform more than the minimum number of sampling events.

Supplemental Information

(1) The effluent limitations for Outfalls 008, 010, MP108 were determined using effluent discharge rates of 835.08 MGD, 0.144 MGD, 3.045 MGD, respectively.
(2) The hydraulic design capacity of the industrial wastewater treatment plant is 3.7 mgd maximum. This will be used to determine whether a hydraulic overload exists.

II. DEFINITIONS

At Outfall (XXX) means a sampling location in outfall line XXX below the last point at which wastes are added to outfall line (XXX), or where otherwise specified.

Average refers to the use of an arithmetic mean, unless otherwise specified in this permit. (40 CFR 122.41(l)(4)(iii))

Best Management Practices (BMPs) means schedules of activities, prohibitions of practices, maintenance procedures and other management practices to prevent or reduce the pollution to surface waters of the Commonwealth. BMPs also include treatment requirements, operating procedures and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. (25 Pa. Code 92a.2)

Bypass means the intentional diversion of waste streams from any portion of a treatment facility. (40 CFR 122.41(m)(1)(i))

Calendar Week is defined as the seven consecutive days from Sunday through Saturday, unless the permittee has been given permission by DEP to provide weekly data as Monday through Friday based on showing excellent performance of the facility and a history of compliance. In cases when the week falls in two separate months, the month with the most days in that week shall be the month for reporting.

Clean Water Act means the Federal Water Pollution Control Act, as amended. (33 U.S.C.A. §§1251 to 1387).

Chemical Additive means a chemical product (including products of disassociation and degradation, collectively "products") introduced into a waste stream that is used for cleaning, disinfecting, or maintenance and which may be detected in effluent discharged to waters of the Commonwealth. The term generally excludes chemicals used for neutralization of waste streams, the production of goods, and treatment of wastewater, with the exception of wastewater treatment chemicals containing polyacrylamides.

Composite Sample (for all except GC/MS volatile organic analysis) means a combination of individual samples (at least eight for a 24-hour period or four for an 8-hour period) of at least 100 milliliters (mL) each obtained at spaced time intervals during the compositing period. The composite must be flow-proportional; either the volume of each individual sample is proportional to discharge flow rates, or the sampling interval is proportional to the flow rates over the time period used to produce the composite. (EPA Form 2C)

Composite Sample (for GC/MS volatile organic analysis) consists of at least four aliquots or grab samples collected during the sampling event (not necessarily flow proportioned). The samples must be combined in the laboratory immediately before analysis and then one analysis is performed. (EPA Form 2C)

Daily Average Temperature means the average of all temperature measurements made, or the mean value plot of the record of a continuous automated temperature recording instrument, either during a calendar day or during the operating day if flows are of a shorter duration.

Daily Discharge means the discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurement, the "daily discharge" is calculated as the average measurement of the pollutant over the day. (25 Pa. Code 92a.2 and 40 CFR 122.2)

Daily Maximum Discharge Limitation means the highest allowable "daily discharge."

Discharge Monitoring Report (DMR) means the DEP or EPA supplied form(s) for the reporting of self-monitoring results by the permittee. (25 Pa. Code 92a.2 and 40 CFR 122.2)

Estimated Flow means any method of liquid volume measurement based on a technical evaluation of the sources contributing to the discharge including, but not limited to, pump capabilities, water meters and batch discharge volumes.

Geometric Mean means the average of a set of n sample results given by the nth root of their product.

Grab Sample means an individual sample of at least 100 mL collected at a randomly selected time over a period not to exceed 15 minutes. (EPA Form 2C)

Hazardous Substance means any substance designated under 40 CFR Part 116 pursuant to Section 311 of the Clean Water Act. (40 CFR 122.2)

Hauled-In Wastes means any waste that is introduced into a treatment facility through any method other than a direct connection to the wastewater collection system. The term includes wastes transported to and disposed of within the treatment facility or other entry points within the collection system.

Immersion Stabilization (i-s) means a calibrated device is immersed in the wastewater until the reading is stabilized.

Instantaneous Maximum Effluent Limitation means the highest allowable discharge of a concentration or mass of a substance at any one time as measured by a grab sample. (25 Pa. Code 92a.2)

Measured Flow means any method of liquid volume measurement, the accuracy of which has been previously demonstrated in engineering practice, or for which a relationship to absolute volume has been obtained.

Monthly Average Discharge Limitation means the highest allowable average of "daily discharges" over a calendar month, calculated as the sum of all "daily discharges" measured during a calendar month divided by the number of "daily discharges" measured during that month. (25 Pa. Code 92a.2)

Non-contact Cooling Water means water used to reduce temperature which does not come in direct contact with any raw material, intermediate product, waste product (other than heat), or finished product.

Severe Property Damage means substantial physical damage to property, damage to the treatment facilities that causes them to become inoperable, or substantial and permanent loss of natural resources that can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production. (40 CFR 122.41(m)(1)(ii))

Stormwater means the runoff from precipitation, snow melt runoff, and surface runoff and drainage. (25 Pa. Code 92a.2)

Stormwater Associated With Industrial Activity means the discharge from any conveyance that is used for collecting and conveying stormwater and that is directly related to manufacturing, processing, or raw materials storage areas at an industrial plant, and as defined at 40 CFR 122.26(b)(14) (i) - (ix) & (xi) and 25 Pa. Code 92a.2.

Total Dissolved Solids means the total dissolved (filterable) solids as determined by use of the method specified in 40 CFR Part 136.

Toxic Pollutant means those pollutants, or combinations of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains may, on the basis of information available to DEP cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, including malfunctions in reproduction, or physical deformations in these organisms or their offspring. (25 Pa. Code 92a.2)

III. SELF-MONITORING, REPORTING AND RECORDKEEPING

A. Representative Sampling

1. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity (40 CFR 122.41(j)(1)). Representative sampling includes the collection of samples, where possible, during periods of adverse weather, changes in treatment plant performance and changes in treatment plant loading. If possible, effluent samples must be collected where the effluent is well mixed near the center of the discharge conveyance and at the approximate mid-depth point, where the turbulence is at a maximum and the settlement of solids is minimized. (40 CFR 122.48 and 25 Pa. Code § 92a.61)

2. Records Retention (40 CFR 122.41(j)(2))

   Except for records of monitoring information required by this permit related to the permittee's sludge use and disposal activities which shall be retained for a period of at least 5 years, all records of monitoring activities and results (including all original strip chart recordings for continuous monitoring instrumentation and calibration and maintenance records), copies of all reports required by this permit, and records of all data used to complete the application for this permit shall be retained by the permittee for 3 years from the date of the sample measurement, report or application, unless a longer retention period is required by the permit. The 3-year period shall be extended as requested by DEP or the EPA Regional Administrator.

3. Recording of Results (40 CFR 122.41(j)(3))

   For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

   a. The exact place, date and time of sampling or measurements.
   b. The person(s) who performed the sampling or measurements.
   c. The date(s) the analyses were performed.
   d. The person(s) who performed the analyses.
   e. The analytical techniques or methods used; and the associated detection level.
   f. The results of such analyses.

4. Test Procedures (40 CFR 122.41(j)(4))

   Facilities that test or analyze environmental samples used to demonstrate compliance with this permit shall be in compliance with laboratory accreditation requirements of Act 90 of 2002 (27 Pa. C.S. §§4101-4113) and 25 Pa. Code Chapter 252, relating to environmental laboratory accreditation. Unless otherwise specified in this permit, the test procedures for the analysis of pollutants shall be those approved under 40 CFR Part 136 (or in the case of sludge use or disposal, approved under 40 CFR Part 136, unless otherwise specified in 40 CFR Part 503 or Subpart J of 25 Pa. Code Chapter 271), or alternate test procedures approved pursuant to those parts, unless other test procedures have been specified in this permit.

5. Quality/Assurance/Control

   In an effort to assure accurate self-monitoring analyses results:

   a. The permittee, or its designated laboratory, shall participate in the periodic scheduled quality assurance inspections conducted by DEP and EPA. (40 CFR 122.41(e), 122.41(i)(3))

   b. The permittee, or its designated laboratory, shall develop and implement a program to assure the quality and accurateness of the analyses performed to satisfy the requirements of this permit, in accordance with 40 CFR Part 136. (40 CFR 122.41(j)(4))

B. Reporting of Monitoring Results

1. The permittee shall effectively monitor the operation and efficiency of all wastewater treatment and control facilities, and the quantity and quality of the discharge(s) as specified in this permit. (40 CFR 122.41(e),122.44(i)(1))

2. Discharge Monitoring Reports (DMRs) must be completed in accordance with DEP's published DMR Instructions (3800-BPNPSM-0463). DMRs are based on calendar reporting periods. DMR(s) must be received by the agency(ies) specified in paragraph 3 below in accordance with the following schedule:

   - Monthly DMRs must be received within 28 days following the end of each calendar month.

   - Quarterly DMRs must be received within 28 days following the end of each calendar quarter, i.e., January 28, April 28, July 28, and October 28.

   - Semiannual DMRs must be received within 28 days following the end of each calendar semiannual period, i.e., January 28 and July 28.

   - Annual DMRs must be received by January 28, unless Part C of this permit requires otherwise.

3. The permittee shall complete all Supplemental Reporting forms (Supplemental DMRs) provided by DEP in this permit (or an approved equivalent), and submit the signed, completed forms as an attachment to the DMR(s). If the permittee elects to use DEP's electronic DMR (eDMR) system, one electronic submission may be made for DMRs and Supplemental DMRs. If paper forms are used, the completed forms shall be mailed to:

   Department of Environmental Protection
   Clean Water Program
   2 East Main Street
   Norristown, PA 19401

   NPDES Enforcement Branch (3WP42)
   Office of Permits & Enforcement
   Water Protection Division
   U.S. EPA - Region III
   1650 Arch Street
   Philadelphia, PA 19103-2029

4. If the permittee elects to begin using DEP's eDMR system to submit DMRs required by the permit, the permittee shall, to assure continuity of business operations, continue using the eDMR system to submit all DMRs and Supplemental Reports required by the permit, unless the following steps are completed to discontinue use of eDMR:

   a. The permittee shall submit written notification to the regional office that issued the permit that it intends to discontinue use of eDMR. The notification shall be signed by a principal executive officer or authorized agent of the permittee.

   b. The permittee shall continue using eDMR until the permittee receives written notification from DEP's Central Office that the facility has been removed from the eDMR system, and electronic report submissions are no longer expected.

5. The completed DMR Form shall be signed and certified by either of the following applicable persons, as defined in 25 Pa. Code 92a.22:

   - For a corporation - by a principal executive officer of at least the level of vice president, or an authorized representative, if the representative is responsible for the overall operation of the facility from which the discharge described in the NPDES form originates.
   - For a partnership or sole proprietorship - by a general partner or the proprietor, respectively.

- For a municipality, state, federal or other public agency - by a principal executive officer or ranking elected official.

If signed by a person other than the above, written notification of delegation of DMR signatory authority must be submitted to DEP in advance of or along with the relevant DMR form. (40 CFR 122.22(b))

6. If the permittee monitors any pollutant at monitoring points as designated by this permit, using analytical methods described in Part A III.A.4. herein, more frequently than the permit requires, the results of this monitoring shall be incorporated, as appropriate, into the calculations used to report self-monitoring data on the DMR. (40 CFR 122.41(l)(4)(ii))

C. Reporting Requirements

1. Planned Changes to Physical Facilities – The permittee shall give notice to DEP as soon as possible but no later than 30 days prior to planned physical alterations or additions to the permitted facility. A permit under 25 Pa. Code Chapter 91 may be required for these situations prior to implementing the planned changes. A permit application, or other written submission to DEP, can be used to satisfy the notification requirements of this section.

   Notice is required when:

   a. The alteration or addition to a permitted facility may meet one of the criteria for determining whether a facility is a new source in 40 CFR §122.29(b). (40 CFR 122.41(l)(1)(i))

   b. The alteration or addition could significantly change the nature or increase the quantity of pollutants discharged. This notification applies to pollutants which are not subject to effluent limitations in this permit. (40 CFR 122.41(l)(1)(ii))

   c. The alteration or addition results in a significant change in the permittee's sludge use or disposal practices, and such alteration, addition, or change may justify the application of permit conditions that are different from or absent in the existing permit, including notification of additional use or disposal sites not reported during the permit application process or not reported pursuant to an approved land application plan. (40 CFR 122.41(l)(1)(iii))

   d. The planned change may result in noncompliance with permit requirements. (40 CFR 122.41(l)(2))

   e. The facility is proposing an expansion or modifications to its treatment processes.

2. Planned Changes to Waste Stream – Under the authority of 25 Pa. Code 92a.24(a), the permittee shall provide notice to DEP as soon as possible but no later than 45 days prior to any changes in the volume or pollutant concentration of its influent waste stream as a result of indirect discharges or hauled-in wastes, as specified in paragraphs 2.a. and 2.b., below. Notice shall be provided on the "Planned Changes to Waste Stream" Supplemental Report (3800-FM-BPNPSM0482), available on DEP's web site. The permittee shall provide information on the quality and quantity of waste introduced into the facility, and any anticipated impact of the change on the quantity or quality of effluent to be discharged from the facility. The Report shall be sent via Certified Mail or other means to confirm DEP's receipt of the notification. DEP will determine if the submission of a new application and receipt of a new or amended permit is required.

   a. Introduction of New Pollutants (25 Pa. Code 92a.24(a))

      New pollutants are defined as parameters that meet one or more of the following criteria:

      (i) Were not detected in the facilities' influent waste stream as reported in the permit application, or were otherwise not analyzed in the influent and reported to DEP prior to permit issuance;

      (ii) Have not been previously approved to be included in the permittee's influent waste stream by DEP in writing.

The permittee shall provide notification of the introduction of new pollutants in accordance with paragraph 2 above. The permittee may not authorize the introduction of new pollutants until the permittee receives DEP's written approval.

b. Increased Loading of Approved Pollutants (25 Pa. Code 92a.24(a))

Approved pollutants are defined as parameters that meet one or more of the following criteria:

(i) Were detected in the facilities' influent waste stream as reported in the permittee's permit application or were otherwise analyzed and reported to DEP prior to permit issuance;

(ii) Have an effluent limitation or monitoring requirement in this permit;

(iii) Have been previously approved for the permittee's influent waste stream by DEP in writing.

The permittee shall provide notification of the introduction of increased influent loading (lbs/day) of approved pollutants in accordance with paragraph 2 above when (1) the cumulative increase in influent loading (lbs/day) exceeds 10% of the maximum loading reported in the permit application, or a loading previously approved by DEP, or (2) may cause an exceedance in the effluent of Effluent Limitation Guidelines (ELGs) or limitations in Part A of this permit, or (3) may cause interference or pass through at the facility, or (4) may cause exceedances of the applicable water quality standards in the receiving stream. Unless specified otherwise in this permit, if DEP does not respond to the notification within 30 days of its receipt, the permittee may proceed with the increase in loading. The acceptance of increased loading of approved pollutants may not result in an exceedance of ELGs or effluent limitations and may not cause exceedances of the applicable water quality standards in the receiving stream.

3. Reporting Requirements for Hauled-In Wastes

a. Receipt of Residual Waste

(i) The permittee shall document the receipt of all hauled-in residual wastes (including but not limited to wastewater from oil and gas wells, food processing waste, and landfill leachate) received for processing at the treatment facility. The permittee shall report hauled-in residual wastes on a monthly basis to DEP on the "Hauled In Residual Wastes" Supplemental Report (3800-FM-BPNPSM0450) as an attachment to the DMR. If no residual wastes were received during a month, submission of the Supplemental Report is not required.

The following information is required by the Supplemental Report. The information used to develop the Report shall be retained by the permittee for five years from the date of receipt and must be made available to DEP or EPA upon request.

(1) The dates that residual wastes were received.

(2) The volume (gallons) of wastes received.

(3) The license plate number of the vehicle transporting the waste to the treatment facility.

(4) The permit number(s) of the well(s) where residual wastes were generated, if applicable.

(5) The name and address of the generator of the residual wastes.

(6) The type of wastewater.

(7) Documentation of whether or not a chemical analysis of the residual wastes were reported on a Residual Waste Form 26R, or a separate waste characterization using the parameters from Form 26R.

The transporter of residual waste must maintain these and other records as part of the daily operational record (25 Pa. Code 299.219). If the transporter is unable to provide this information, the residual wastes shall not be accepted by the permittee until such time as the transporter is able to provide the required information.

(ii) The following conditions apply to the characterization of residual wastes received by the permitted treatment facility:

(1) The permitted facility must receive and maintain on file a characterization of the residual wastes it receives from the generator, as required by 25 Pa. Code 287.54. The characterization shall conform to the Bureau of Waste Management's Form 26R except as noted in paragraph (2), below. Each load of residual waste received must be characterized accordingly.

(2) For wastewater generated from hydraulic fracturing operations ("frac wastewater") within the first 30 production days of a well site, the characterization may be a general frac wastewater characterization approved by DEP. Thereafter, the characterization must be waste-specific and reported on the Form 26R.

b. Receipt of Municipal Waste

(i) The permittee shall document the receipt of all hauled-in municipal wastes (including but not limited to septage and liquid sewage sludge) received for processing at the treatment facility. The permittee shall report hauled-in municipal wastes on a monthly basis to DEP on the "Hauled In Municipal Wastes" Supplemental Report (3800-FM-BPNPSM0437) as an attachment to the DMR. If no municipal wastes were received during a month, submission of the Supplemental Report is not required.

The following information is required by the Supplemental Report:

(1) The dates that municipal wastes were received.

(2) The volume (gallons) of wastes received.

(3) The BOD_5 concentration (mg/l) and load (lbs) for the wastes received.

(4) The location(s) where wastes were disposed of within the treatment facility.

(ii) Sampling and analysis of hauled-in municipal wastes must be completed to characterize the organic strength of the wastes, unless composite sampling of influent wastewater is performed at a location downstream of the point of entry for the wastes.

4. Unanticipated Noncompliance or Potential Pollution Reporting

a. Immediate Reporting - The permittee shall immediately report any incident causing or threatening pollution in accordance with the requirements of 25 Pa. Code Sections 91.33 and 92a.41(b).

(i) If, because of an accident, other activity or incident a toxic substance or another substance which would endanger users downstream from the discharge, or would otherwise result in pollution or create a danger of pollution or would damage property, the permittee shall immediately notify DEP by telephone of the location and nature of the danger. Oral notification to the Department is required as soon as possible, but no later than 4 hours after the permittee becomes aware of the incident causing or threatening pollution.

(ii) If reasonably possible to do so, the permittee shall immediately notify downstream users of the waters of the Commonwealth to which the substance was discharged. Such notice shall include the location and nature of the danger.

(iii) The permittee shall immediately take or cause to be taken steps necessary to prevent injury to property and downstream users of the waters from pollution or a danger of pollution and, in addition, within 15 days from the incident, shall remove the residual substances contained thereon or therein from the ground and from the affected waters of this Commonwealth to the extent required by applicable law.

b. The permittee shall report any noncompliance which may endanger health or the environment in accordance with the requirements of 40 CFR 122.41(l)(6). These requirements include the following obligations:

(i) 24 Hour Reporting - The permittee shall orally report any noncompliance with this permit which may endanger health or the environment within 24 hours from the time the permittee becomes aware of the circumstances. The following shall be included as information which must be reported within 24 hours under this paragraph:

(1) Any unanticipated bypass which exceeds any effluent limitation in the permit;

(2) Any upset which exceeds any effluent limitation in the permit; and

(3) Violation of the maximum daily discharge limitation for any of the pollutants listed in the permit as being subject to the 24-hour reporting requirement. (40 CFR 122.44(g))

(ii) Written Report - A written submission shall also be provided within 5 days of the time the permittee becomes aware of any noncompliance which may endanger health or the environment. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

(iii) Waiver of Written Report - DEP may waive the written report on a case-by-case basis if the associated oral report has been received within 24 hours from the time the permittee becomes aware of the circumstances which may endanger health or the environment. Unless such a waiver is expressly granted by DEP, the permittee shall submit a written report in accordance with this paragraph. (40 CFR 122.41(l)(6)(iii))

5. Other Noncompliance

The permittee shall report all instances of noncompliance not reported under paragraph C.4 of this section or specific requirements of compliance schedules, at the time DMRs are submitted, on the Non-Compliance Reporting Form (3800-FM-BPNPSM0440). The reports shall contain the information listed in paragraph C.4.b.(ii) of this section. (40 CFR 122.41(l)(7))

D. Specific Toxic Pollutant Notification Levels (for Manufacturing, Commercial, Mining, and Silvicultural Direct Dischargers) - The permittee shall notify DEP as soon as it knows or has reason to believe the following: (40 CFR 122.42(a))

1. That any activity has occurred, or will occur, which would result in the discharge of any toxic pollutant which is not limited in this permit, if that discharge on a routine or frequent basis will exceed the highest of the following "notification levels": (40 CFR 122.42(a)(1))

a. One hundred micrograms per liter.

b. Two hundred micrograms per liter for acrolein and acrylonitrile.

c. Five hundred micrograms per liter for 2,4-dinitrophenol and 2-methyl-4,6-dinitrophenol.

d. One milligram per liter for antimony.

   e. Five times the maximum concentration value reported for that pollutant in this permit application.

   f. Any other notification level established by DEP.

2. That any activity has occurred or will occur which would result in any discharge, on a nonroutine or infrequent basis, of a toxic pollutant which is not limited in this permit, if that discharge will exceed the highest of the following "notification levels": (40 CFR 122.42(a)(2))

   a. Five hundred micrograms per liter.

   b. One milligram per liter for antimony.

   c. Ten times the maximum concentration value reported for that pollutant in the permit application.

   d. Any other notification level established by DEP.

PART B

I. MANAGEMENT REQUIREMENTS

A. Compliance Schedules (25 Pa. Code 92a.51 and 40 CFR 122.47(a))

1. The permittee shall achieve compliance with the terms and conditions of this permit within the time frames specified in this permit.

2. The permittee shall submit reports of compliance or noncompliance, or progress reports as applicable, for any interim and final requirements contained in this permit. Such reports shall be submitted no later than 14 days following the applicable schedule date or compliance deadline. (40 CFR 122.47(a)(4))

B. Permit Modification, Termination, or Revocation and Reissuance

1. This permit may be modified, terminated, or revoked and reissued during its term in accordance with 25 Pa. Code 92a.72 and 40 CFR 122.41(f).

2. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition. (40 CFR 122.41(f))

3. In the absence of DEP action to modify or revoke and reissue this permit, the permittee shall comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time specified in the regulations that establish those standards or prohibitions. (40 CFR 122.41(a)(1))

C. Duty to Provide Information

1. The permittee shall furnish to DEP, within a reasonable time, any information which DEP may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. (40 CFR 122.41(h))

2. The permittee shall furnish to DEP, upon request, copies of records required to be kept by this permit. (40 CFR 122.41(h))

3. Other Information - Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to DEP, it shall promptly submit the correct and complete facts or information. (40 CFR 122.41(l)(8))

D. Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance includes, but is not limited to, adequate laboratory controls including appropriate quality assurance procedures. This provision also includes the operation of backup or auxiliary facilities or similar systems that are installed by the permittee, only when necessary to achieve compliance with the terms and conditions of this permit. (40 CFR 122.41(e))

E. Duty to Mitigate

The permittee shall take all reasonable steps to minimize or prevent any discharge, sludge use or disposal in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment. (40 CFR 122.41(d))

F. Bypassing

1. Bypassing Not Exceeding Permit Limitations - The permittee may allow a bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions in paragraphs two, three and four of this section. (40 CFR 122.41(m)(2))

2. Other Bypassing - In all other situations, bypassing is prohibited and DEP may take enforcement action against the permittee for bypass unless:

   a. A bypass is unavoidable to prevent loss of life, personal injury or "severe property damage." (40 CFR 122.41(m)(4)(i)(A))

   b. There are no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance. (40 CFR 122.41(m)(4)(i)(B))

   c. The permittee submitted the necessary notice required in F.4.a. and b. below. (40 CFR 122.41(m)(4)(i)(C))

3. DEP may approve an anticipated bypass, after considering its adverse effects, if DEP determines that it will meet the conditions listed in F.2. above. (40 CFR 122.41(m)(4)(ii))

4. Notice

   a. Anticipated Bypass – If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible, at least 10 days before the bypass. (40 CFR 122.41(m)(3)(i))

   b. Unanticipated Bypass

      (i) The permittee shall submit immediate notice of an unanticipated bypass causing or threatening pollution. The notice shall be in accordance with Part A III.C.4.a.

      (ii) The permittee shall submit oral notice of any other unanticipated bypass within 24 hours, regardless of whether the bypass may endanger health or the environment or whether the bypass exceeds effluent limitations. The notice shall be in accordance with Part A III.C.4.b.

II. PENALTIES AND LIABILITY

A. Violations of Permit Conditions

Any person violating Sections 301, 302, 306, 307, 308, 318 or 405 of the Clean Water Act or any permit condition or limitation implementing such sections in a permit issued under Section 402 of the Act is subject to civil, administrative and/or criminal penalties as set forth in 40 CFR §122.4l(a)(2).

Any person or municipality, who violates any provision of this permit; any rule, regulation or order of DEP; or any condition or limitation of any permit issued pursuant to the Clean Streams Law, is subject to criminal and/or civil penalties as set forth in Sections 602, 603 and 605 of the Clean Streams Law.

B. Falsifying Information

Any person who does any of the following:

- Falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit, or

- Knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit (including monitoring reports or reports of compliance or noncompliance)

Shall, upon conviction, be punished by a fine and/or imprisonment as set forth in *18 Pa.C.S.A § 4904* and 40 CFR §122.41(j)(5) and (k)(2).

C. Liability

Nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance pursuant to Section 309 of the Clean Water Act or Sections 602, 603 or 605 of the Clean Streams Law.

Nothing in this permit shall be construed to preclude the institution of any legal action or to relieve the permittee from any responsibilities, liabilities or penalties to which the permittee is or may be subject to under the Clean Water Act and the Clean Streams Law.

D. Need to Halt or Reduce Activity Not a Defense

It shall not be a defense for the permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit. (40 CFR 122.41(c))

III. OTHER RESPONSIBILITIES

A. Right of Entry

Pursuant to Sections 5(b) and 305 of Pennsylvania's Clean Streams Law, and Title 25 Pa. Code Chapter 92 and 40 CFR §122.41(i), the permittee shall allow authorized representatives of DEP and EPA, upon the presentation of credentials and other documents as may be required by law:

1. To enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit; (40 CFR 122.41(i)(1))

2. To have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit; (40 CFR 122.41(i)(2))

3. To inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices or operations regulated or required under this permit; and (40 CFR 122.41(i)(3))

4. To sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act or the Clean Streams Law, any substances or parameters at any location. (40 CFR 122.41(i)(4))

B. Transfer of Permits

1. Transfers by modification. Except as provided in paragraph 2 of this section, a permit may be transferred by the permittee to a new owner or operator only if this permit has been modified or revoked and reissued, or a minor modification made to identify the new permittee and incorporate such other requirements as may be necessary under the Clean Water Act. (40 CFR 122.61(a))

2. Automatic transfers. As an alternative to transfers under paragraph 1 of this section, any NPDES permit may be automatically transferred to a new permittee if:

    a. The current permittee notifies DEP at least 30 days in advance of the proposed transfer date in paragraph 2.b. of this section; (40 CFR 122.61(b)(1))

b. The notice includes the appropriate DEP transfer form signed by the existing and new permittees containing a specific date for transfer of permit responsibility, coverage and liability between them; (40 CFR 122.61(b)(2))

c. DEP does not notify the existing permittee and the proposed new permittee of its intent to modify or revoke and reissue this permit, the transfer is effective on the date specified in the agreement mentioned in paragraph 2.b. of this section; and (40 CFR 122.61(b)(3))

d. The new permittee is in compliance with existing DEP issued permits, regulations, orders and schedules of compliance, or has demonstrated that any noncompliance with the existing permits has been resolved by an appropriate compliance action or by the terms and conditions of the permit (including compliance schedules set forth in the permit), consistent with 25 Pa. Code 92a.51 (relating to schedules of compliance) and other appropriate DEP regulations. (25 Pa. Code 92a.71)

3. In the event DEP does not approve transfer of this permit, the new owner or controller must submit a new permit application.

C. Property Rights

The issuance of this permit does not convey any property rights of any sort, or any exclusive privilege. (40 CFR 122.41(g))

D. Duty to Reapply

If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for a new permit. (40 CFR 122.41(b))

E. Other Laws

The issuance of this permit does not authorize any injury to persons or property or invasion of other private rights, or any infringement of state or local law or regulations.

IV. ANNUAL FEES

Permittees shall pay an annual fee in accordance with 25 Pa. Code § 92a.62. Annual fee amounts are specified in the following schedule and are due on each anniversary of the effective date of the most recent new or reissued permit. All flows identified in the schedule are annual average design flows. (25 Pa. Code 92a. 62)

Minor IW Facility without ELG (Effluent Limitation Guideline)	$500
Minor IW Facility with ELG	$1,500
Major IW Facility < 250 MGD (million gallons per day)	$5,000
Major IW Facility ≥ 250 MGD	$25,000
IW Stormwater Individual Permit	$1,000
CAAP (Concentrated Aquatic Animal Production Facility)	$0

As of the effective date of this permit, the facility covered by the permit is classified in the following fee category: **Major IW Facility >=250 MGD**.

Invoices for annual fees will be mailed to permittees approximately three months prior to the due date. In the event that an invoice is not received, the permittee is nonetheless responsible for payment. Throughout a five year permit term, permittees will pay four annual fees followed by a permit renewal application fee in the last year of permit coverage. Permittees may contact DEP at 717-787-6744 with questions related to annual fees. The fees identified above are subject to change in accordance with 25 Pa. Code 92a.62(e).

Payment for annual fees shall be remitted to DEP at the address below by the anniversary date. Checks should be made payable to the Commonwealth of Pennsylvania.

PA Department of Environmental Protection
Bureau of Point and Non-Point Source Management
Re: Chapter 92a Annual Fee
P.O. Box 8466
Harrisburg, PA 17105-8466

PART C

I. OTHER REQUIREMENTS

A. The approval herein given is specifically made contingent upon the permittee acquiring all necessary property rights by easement or otherwise, providing for the satisfactory construction, operation, maintenance or replacement of all structures associated with the herein approved discharge in, along, or across private property, with full rights of ingress, egress and regress.

B. Collected screenings, slurries, sludges, and other solids shall be handled, recycled and/or disposed of in compliance with the Solid Waste Management Act (35 P.S. §§ 6018.101 – 6018.1003), 25 Pa. Code Chapters 287, 288, 289, 291, 295, 297, and 299 (relating to requirements for landfilling, impoundments, land application, composting, processing, and storage of residual waste), Chapters 261a, 262a, 263a, and 270a (related to identification of hazardous waste, requirements for generators and transporters, and hazardous waste, requirements for generators and transporters, and hazardous waste permit programs), federal regulation 40 CFR Part 257, The Clean Streams Law, and the Federal Clean Water Act and its amendments. Screenings collected at intake structures shall be collected and managed and not be returned to the receiving waters.

The permittee is responsible to obtain or assure that contracted agents have all necessary permits and approvals for the handling, storage, transport and disposal of solid waste materials generated as a result of wastewater treatment.

C. The terms and conditions of Water Quality Management (WQM) permits that may have been issued to the permittee relating to discharge requirements are superseded by this NPDES permit unless otherwise stated herein.

D. If the applicable standard or effluent guideline limitation relating to the application for Best Available Technology (BAT) Economically Achievable or to Best Conventional Technology (BCT) is developed by DEP or EPA for this type of industry, and if such standard or limitation is more stringent than the corresponding limitations of this permit (or if it controls pollutants not covered by this permit), DEP may modify or revoke and reissue the permit to conform with that standard or limitation.

E. Chlorine or other approved biocides may not be discharged from any single generating unit for more than two hours per day unless the discharger demonstrates to the permitting authority that discharges for more than two hours are required for macro invertebrate control. Simultaneous multi-unit chlorination/biocide application is permitted.

F. The following requirements apply with respect to the thermal impact of the discharge from Outfall 008 upon Zone 4 of the Delaware Estuary:

Temperature increase shall not exceed 5 °F above the average 24-hour temperature gradient displayed during the 1961-1966 period which may be interpolated from the table below, or exceed a maximum of 86 °F, whichever is less. Temperatures shall be measured outside of designated heat dissipation areas (See Other Requirement G).

Date	DRBC Zone 4 Average 24-hour Temp. (°F)
January 1	42
February 1	36
March 1	40
April 1	47
May 1	58
June 1	72
July 1	80
August 1	81
September 1	78
September 15	76
October 1	70
November 1	60
December 1	50
December 15	45

G. The assigned thermal mixing zone for Outfall 008 wherein the stream temperature criteria may be exceeded shall consist of an area in the Delaware River defined as 210 feet both upstream and downstream (420 feet total) and 400 feet laterally away from Outfall 008.

H. Sampling for total aluminum and dissolved iron at Outfall 010 and sampling for PCB, wet weather, at Outfall 005 shall be performed as follows: two grab samples shall be collected during Ebb Tide (one shortly after high tide and one shortly before low tide). The two samples shall be composited and the analysis shall be performed on this composited sample.

I. Analysis for the following pollutant(s) shall be performed using the following test method(s) contained in 40 C.F.R. Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants, or any approved test method(s) of equal or greater sensitivity:

Parameter	Test Method
Copper, Total	3113 B (AA, Furnace)
Iron, Total	3113 B (AA, Furnace)
Aluminum, Total	3113 B (AA, Furnace)

J. This permit shall be amended or alternatively revoked and reissued to incorporate effluent limitations developed as part of the Delaware Estuary-wide permitting process.

K. Debris collected on the intake trash racks shall not be returned to the waterway.

L. During any period involving treatment of chemical metal cleaning wastewater, the permittee shall do the following:

a. After commencement of the release of chemical metal cleaning wastewater from the boiler units, a series of 24-hour composite samples shall be collected at MP 108 during the period where chemical metal cleaning wastewater is expected to be present in the discharge from the industrial wastewater treatment plant. The 24-hour composite samples shall be analyzed for Copper, Total and Iron, Total. The start and completion of the series of 24-hour composite samples shall be adjusted to take into account the time period for the chemical metal cleaning wastewater to pass through the industrial wastewater treatment plant and reach MP 108.

b. During the period when chemical metal cleaning wastewater is being treated in the industrial wastewater treatment plant, the pH of the treated discharge shall be monitored on an hourly basis.

c. The allowable maximum daily effluent concentration of Copper, Total shall not exceed a value determined by the mean plus one standard deviation for all data (exclude data obtained during chemical metal cleaning operations) obtained during the previous year to which will be added an adjustment of 0.02 mg/l.

d. The allowable maximum daily effluent concentration of Iron, Total shall not exceed a value determined by the mean plus one standard deviation of all data (exclude data obtained during chemical metal cleaning operations) obtained during the previous year.

e. The individual results of the 24-hour composite samples for Copper, Total and Iron, Total along with the pH monitoring data shall be included as a supplement to the DMR. The calculations related to Items (c) and (d) above shall also be submitted as a supplement to the DMR. This will be used in determining the compliance status of Copper, Total and Iron, Total with effluent limits.

M. Analysis for Spectrus CT1300 shall be performed using Methyl Orange Method. The effluent limit is based on the current available minimum method detection limit.

N. The DEP may identify and require certain discharge specific data to be submitted before the expiration date of this permit. Upon notification by the DEP, the permittee will have 12 months from the date of the notice to provide the required data. These data, along with any other data available to the DEP, will be used in completing the Watershed TMDL/WLA Analysis and in establishing discharge effluent limits. In the event that DEP requires the submission of data pursuant to this condition, the permittee shall have the right to appeal or otherwise contest the requirement.

O. (a) The following non-stormwater discharges may be authorized through the permitted stormwater outfalls, provided the discharge is in compliance with part (b) of this requirement: discharges from fire fighting activities, fire hydrant flushings, potable water sources, including waterline flushings, irrigation drainage, lawn watering, routine external building washdown which does not use detergents or other compounds, pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used, air conditioning condensate, springs, uncontaminated groundwater, and foundation or footing drains where flows are not contaminated with process materials such as solvents.

(b) Except for flows from fire fighting activities, sources of non-stormwater listed in part (a) (authorized non-stormwater discharges) that are combined with stormwater discharges must be identified in the PPC Plan. The Plan shall identify and ensure the implementation of appropriate pollution prevention measures for the non-stormwater component(s) of the discharge.

II. CHEMICAL ADDITIVES

A. Approved Chemical Additives List

1. The permittee is authorized to use chemical additives that are published on DEP's Approved Chemical Additives List (Approved List) (see www.depweb.state.pa.us/chemicaladditives) subject to paragraphs A.2 and A.3, below.

2. The permittee may not discharge a chemical additive at a concentration that is greater than the water quality-based effluent limitation (WQBEL) for the chemical additive or, if applicable, a technology-based effluent limitation. If effluent limitations are not specified in Part A of this permit for the chemical additive, the permittee is responsible for determining the WQBEL and ensuring the WQBEL is not exceeded by restricting usage to an amount that will not cause an excursion above in-stream water quality standards.

3. If the permittee decides to use a chemical additive that is on DEP's Approved List and the use would either (1) constitute an increase in the usage rate specified in the NPDES permit application or previous notification to DEP or (2) constitute a new use, not identified in the NPDES permit application

or otherwise no previous notification occurred, the permittee shall complete and submit the "Chemical Additives Notification Form" to the DEP regional office that issued the permit. The permittee may proceed to use the chemical additive as reported on the Form upon receipt by the DEP regional office.

B. New Chemical Additives, Not on Approved Chemical Additives List

1. In the event the permittee wishes to use a chemical additive that is not listed on DEP's Approved List, the permittee shall submit the "New Chemical Additives Request Form" (3800-FM-BPNPSM0486) to DEP's Central Office, Bureau of Point and Non-Point Source Management (BPNPSM), Division of Water Quality Standards, Rachel Carson State Office Building, PO Box 8774, Harrisburg, PA 17105-8774, prior to use. A copy shall be submitted to the DEP regional office that issued the permit. The form must be completed in whole in order for BPNPSM to approve the chemical additive, and a Material Safety Data Sheet (MSDS) that meets the minimum requirements of 29 CFR 1910.1200(g) must be attached.

2. Following placement of the chemical additive on the Approved List, the permittee may submit the "Chemical Additive Notification Form" (3800-FM-BPNPSM0487) in accordance with paragraph A.3, above, to notify DEP of the intent to use the approved chemical additive. The permittee may proceed with usage when the new chemical has been identified on DEP's Approved List and following DEP's receipt of the Chemical Additives Notification Form.

3. The permittee shall restrict usage of chemical additives to the maximum usage rates determined and reported to DEP on Chemical Additives Notification Forms.

C. Chemical Additives Usage Reporting Requirements

The "Chemical Additives Usage Form" (3800-FM-BPNPSM0439) shall be used to report the usage of chemical additives and shall be submitted as an attachment to the Discharge Monitoring Report (DMR) at the time the DMR is submitted.

D. DEP may amend this permit to include WQBELs or otherwise control usage rates of chemical additives if there is evidence that usage is adversely affecting receiving waters, producing Whole Effluent Toxicity test failures, or is causing excursions of in-stream water quality standards.

III. COOLING WATER INTAKE STRUCTURE(S)

The purpose of Section 316(b) of the Clean Water Act (CWA) is to establish the best technology available (BTA) for minimizing adverse environmental impacts associated with the use of cooling water intake structures.

As the operator of a facility with an existing cooling water intake structure, the following conditions apply:

A. The cooling water intake structures must meet BTA standards for impingement mortality by employing one of the alternatives in 40 CFR §§ 125.94(c)(1) – (c)(7). Additional measures may be required to protect federal or state threatened and endangered species and fragile species.

B. The cooling water intake structures must meet BTA standards for entrainment which will be established by DEP on a site-specific basis after consideration of relevant factors in 40 CFR § 125.98 and information in the subsequent permit application as required in §§ 122.21(r)(9), (10), (11), (12) and (13), if applicable.

C. The permittee must submit applicable information in §§ 122.21(r)(2) – (r)(8) with the subsequent permit application.

D. If the facility covered by this permit withdraws 125 MGD or more, on average, over the past five years of operation, the permittee must submit applicable information in §§ 122.21(r)(9) – (r)(13) with the subsequent permit application.

E. If the facility covered by this permit withdraws 125 MGD or more, on average, over the past five years of operation, the permittee must notify DEP of external peer reviewers for submissions required in §§ 122.21(r)(10) – (r)(12) and gain DEP approval in advance of peer review.

F. If DEP requests additional information to make a BTA determination, the permittee shall submit information as soon as practicable.

G. The permittee must retain data and other records for any information developed pursuant to Section 316(b) for a minimum of ten years.

H. The location, design, construction or capacity of the intake structure(s) may not be altered without prior approval of DEP.

I. Nothing in this permit authorizes the take for the purposes of the permittee's compliance with the Endangered Species Act.

IV. REQUIREMENTS APPLICABLE TO STORMWATER OUTFALLS

A. The permittee is authorized to discharge non-polluting stormwater from its site, alone or in combination with other wastewaters, through the following outfalls: 001, 002, 004, 005, 007, 010, 013 and 014.

Monitoring requirements and effluent limitations for these outfalls are specified in Part A of this permit, if applicable.

B. Preparedness, Prevention and Contingency (PPC) Plan

The permittee must develop and implement a PPC Plan in accordance with 25 Pa. Code § 91.34 following the guidance contained in DEP's "Guidelines for the Development and Implementation of Environmental Emergency Response Plans" (DEP ID 400-2200-001), its NPDES-specific addendum and the minimum requirements below. For existing facilities, the PPC Plan must be developed prior to permit issuance. For new facilities, the PPC Plan must be submitted to DEP no later than prior to startup of facility operation.

1. The PPC Plan must identify all potential sources of pollutants that may reasonably be expected to affect the quality of stormwater discharges from the facility.

2. The PPC Plan must describe preventative measures and best management practices (BMPs) that will be implemented to reduce or eliminate pollutants from coming into contact with stormwater resulting from routine site activities and spills.

3. The PPC Plan must address actions that will be taken in response to on-site spills or other pollution incidents.

4. The PPC Plan must identify areas which, due to topography or other factors, have a high potential for soil erosion, and identify measures to limit erosion. Where necessary, erosion and sediment control measures must be developed and implemented in accordance with 25 Pa. Code Chapter 102 and DEP's "Erosion and Sediment Pollution Control Manual" (DEP ID 363-2134-008).

5. The PPC Plan must address security measures to prevent accidental or intentional entry which could result in an unintentional discharge of pollutants.

6. The PPC Plan must include a plan for training employees and contractors on pollution prevention, BMPs, and emergency response measures.

7. If the facility is subject to SARA Title III, Section 313, the PPC Plan must identify releases of "Water Priority Chemicals" within the previous three years. Water Priority Chemicals are those identified in EPA's "Guidance for the Determination of Appropriate Methods for the Detection of Section 313 Water Priority Chemicals" (EPA 833-B-94-001, April 1994). The Plan must include an evaluation of all activities that may result in the stormwater discharge of Water Priority Chemicals.

Spill Prevention Control and Countermeasure (SPCC) plans may be used to meet the requirements of this section if the minimum requirements are addressed.

The PPC Plan shall be evaluated and if necessary updated on an annual basis, at a minimum, and when one or more of the following occur:

- Applicable DEP or federal regulations are revised, or this permit is revised;
- The Plan fails in an emergency;
- There is a change in design, industrial process, operation, maintenance, or other circumstances, in a manner that materially increases the potential for fires, explosions or releases of toxic or hazardous constituents; or which changes the response necessary in an emergency;
- The list of emergency coordinators or equipment changes; or
- When notified in writing by DEP.

All updates must be kept on-site and be made available to DEP upon request.

C. Minimum Required BMPs

In addition to BMPs identified in the PPC Plan, the permittee shall implement the following minimum BMPs relating to stormwater pollution prevention:

1. If applicable, post-construction stormwater BMPs that are required under 25 Pa. Code Chapter 102 must be maintained.
2. For industrial facilities, the BMPs in the applicable Appendix to the NPDES PAG-03 General Permit for Discharges of Stormwater Associated with Industrial Activities that is currently in effect.
3. For POTWs, all of the following:
   a. Manage sludge in accordance with all applicable permit requirements.
   b. Store chemicals in secure and covered areas on impervious surfaces away from storm drains.
   c. For new facilities and upgrades, design wastewater treatment facilities to avoid, to the maximum extent practicable, stormwater commingling with sanitary wastewater, sewage sludge, and biosolids.
   d. Efficiently use herbicides for weed control. Where practicable, use the least toxic herbicide that will achieve pest management objectives. Do not apply during windy conditions.
   e. Do not wash parts or equipment over impervious surfaces that wash into storm drains.
   f. Implement infiltration techniques, including infiltration basins, trenches, dry wells, porous pavement, etc., wherever practicable.

D. Annual Inspection and Compliance Evaluation

On an annual basis, the permittee shall conduct an annual inspection of each outfall identified in paragraph A and record the results on the "Annual Inspection Form for NPDES Permits for Discharges of Stormwater Associated with Industrial Activities" (3800-PM-WSFR0083v). The form shall be retained on-site and be made available to DEP upon request.

Areas contributing to a stormwater discharge associated with industrial activity shall be visually inspected for evidence of, or the potential for, pollutants entering the drainage system. BMPs in the PPC Plan and required by this permit shall be evaluated to determine whether they are adequate and properly implemented in accordance with the terms of this permit or whether additional control measures are needed.

E. Stormwater Sampling Requirements
If stormwater sampling is required in Part A of this permit, the following requirements apply:

1. The permittee shall record stormwater sampling event information on the "Additional Information for the Reporting of Stormwater Discharge Monitoring" form (3800-PM-WSFR0083t) and submit the form as an attachment to the DMR.

2. All samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. The 72-hour storm interval is waived when the preceding storm did not yield a measurable discharge, or if the permittee is able to document that a less than 72-hour interval is representative for local storm events during the sample period.

3. Grab samples shall be taken during the first 30 minutes of the discharge. If the collection of a grab sample during the first 30 minutes is not possible, a grab sample can be taken during the first hour of the discharge, in which case the discharger shall provide an explanation of why a grab sample during the first 30 minutes was not possible.

V. PCB MINIMIZATION PLAN AND MONITORING

A. On December 15, 2003, the U.S. Environmental Protection Agency (EPA), Regions 2 and 3, adopted a Total Maximum Daily Load (TMDL) for Polychlorinated Biphenyls (PCBs) for Zones 2, 3, 4, and 5 of the tidal Delaware River. The TMDLs require the facilities identified as discharging PCBs to these zones of the Delaware River or to the tidal portions of tributaries to these zones to conduct monitoring for 209 PCB congeners, and prepare and implement a PCB Pollutant Minimization Plan (PMP). Subsequent monitoring required by DRBC in 2005 confirmed the presence of PCBs, and indicates that this facility does not contribute to 99 percent of the cumulative loadings from all point sources.

B. The permittee shall collect one sample annually during a wet weather flow from Outfalls 001 and 005 and one sample annually during a dry weather flow from Monitoring Point 108.

C. All sample analyses shall be performed using EPA Method 1668A, Revision A: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS. EPA-821-R-00-002, December 1999 as supplemented or amended, and results for all 209 PCB congeners shall be reported. Project-specific, sample collection protocols, analytical procedures, and reporting requirements at http://www.state.nj.us/drbc/ quality/toxics/pcbs/monitoring.html shall be followed. Monitoring information, sample data, and reports associated with PCB monitoring shall be submitted to the DEP and the Delaware River Basin Commission (DRBC) in the form of two compact discs in the format referenced at http://www.state.nj.us/ drbc/library/documents/PCB-EDD011309.pdf.

In accordance with the U.S. EPA, Regions 2 and 3, TMDLs for PCBs for Zones 2–5 of the Tidal Delaware River, the permittee submitted a PMP for PCBs to the DRBC on April 7, 2006, which was approved on May 17, 2006. The permittee shall continue to comply with the requirements of Section 4.30.9 of DRBC's Water Quality Regulations. Therefore, the permittee shall:

1. Continue to implement the PMP to achieve PCB loading reduction goals.

2. Submit an Annual Report on the yearly anniversary of the commencement of the PMP to DRBC and DEP consistent with the guidance specified at http://www.state.nj.us/drbc/programs/quality/pmp.html.

The PMP Annual Report and PCB data shall be submitted to the DEP and DRBC at the following addresses:

PA Department of Environmental Protection
Southeast Regional Office
Clean Water Program
2 East Main Street
Norristown, PA 19401

Delaware River Basin Commission
Modeling, Monitoring & Assessment Branch
P.O. Box 7360
West Trenton, NJ 08628

IITP APPLICATION
ATTACHMENT 2

CORMIX Modeling of Eddystone Generating
Station's Thermal Plume

June 2019

CORMIX Modeling of Eddystone Generating Station's Thermal Plume

Prepared for Exelon

29 August 2014

Environmental Resources Management
75 Valley Stream Parkway
Suite 200
Malvern, PA 19355

The world's leading sustainability consultancy.

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BACKGROUND

Exelon's Eddystone Generating Station (Eddystone) is located along the Delaware River southwest of Philadelphia, PA (Figure 1 and Figure 2). Two units at Eddystone, Units Three and Four, operate intermittently with a combined maximum generating capacity of 790 MWe. The discharge of heated cooling water from Outfall 008 is regulated by the Pennsylvania Department of Environmental Protection (PADEP) under National Pollutant Discharge Elimination System (NPDES) Permit No. PA0013714 and by the Delaware River Basin Commission (DRBC) under DRBC docket No. D-92-66. PADEP has agreed that DRBC would take the lead in reviewing the thermal discharge in preparation for renewing both the NPDES permit and the DRBC docket. ERM is providing surfacewater modeling to support the renewal process.

The primary purpose of this study is to determine the size and configuration of the thermal plume at Eddystone using CORMIX in accordance DRBC requirements. CORMIX has been applied to many cases (http://www.cormix.info/) and is recognized by the USEPA and other national regulatory agencies, including the DRBC, as an appropriate model for computing trajectories, dilution rates and mixing zone dimensions. This report summarizes the model input data and the results of the simulations and analyses.

An Environmental Impact Statement (EIS) was completed for the site in 1971 and included a physical model of thermal discharges into the Delaware River. The 1971 EIS modeled discharges from Units One, Two, Three, and Four through two adjacent outfalls with a temperature rise of 15°F at the end of pipe. Under these conditions, the 1971 EIS found the size of a 3°F isotherm would be limited to 400 ft in width and 1,200 ft in length. The present study modeled the thermal plume with only Units Three and Four operating.

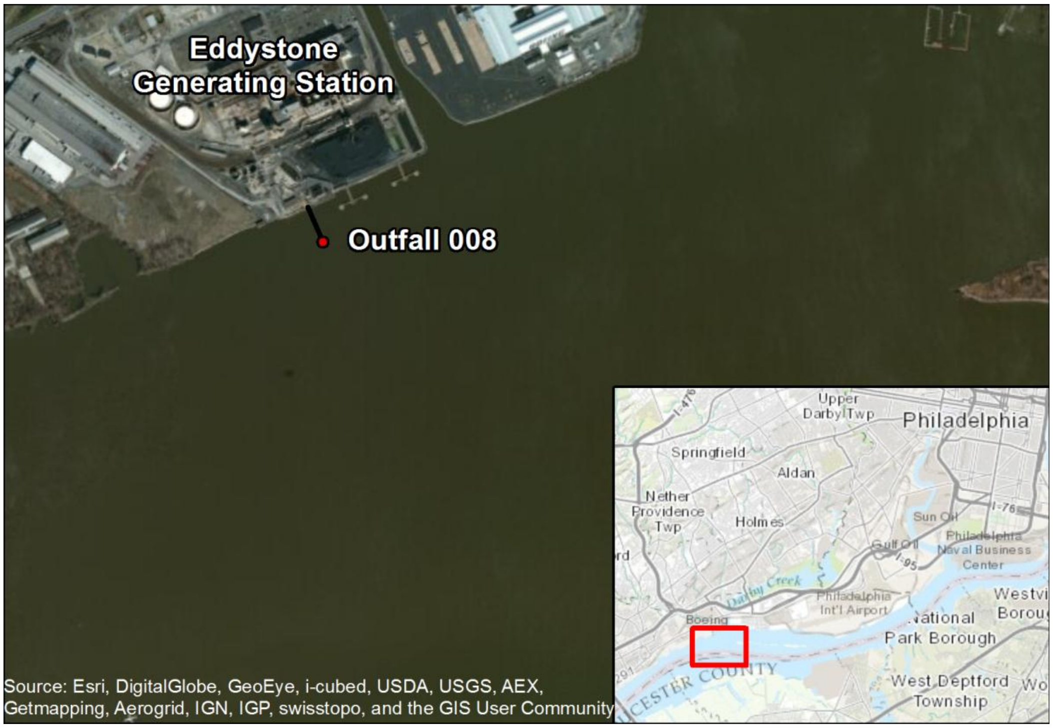

Figure 1 Eddystone Site

Figure 2 Delaware River

DRBC HEAT DISSIPATION AREA REQUIREMENTS

The DRBC sets water temperature limits for non-contact cooling and service water by dividing the Delaware River into zones, with a set of temperatures by month or half-month for each zone. Eddystone discharges into Zone 4. The previous DRBC docket No. D-92-66 specified the dimensions of a heat dissipation area (HDA) as 400 feet in width, 1,200 feet upstream, and 1,200 feet downstream of Outfalls 007 and 008. At the edge of the HDA, the water temperature cannot exceed 5°F above the daily average established from the 1961-1966 observed temperature dataset (Table 1), or a maximum of 86°F. The previous docket was based on modeling performed for Units One, Two, Three, and Four. In 2012, Units One and Two were retired, and updated modeling was requested by the DRBC for docket renewal.

Table 1 1961-1966 Daily Average Temperatures

Date	DRBC Zone 4 Average 24-hour Temp. (°F)
January 1	42
February 1	36
March 1	40
April 1	47
May 1	58
June 1	72
July 1	80
August 1	81
September 1	78
September 15	76
October 1	70
November 1	60
December 1	50
December 15	45

CORMIX APPLICATION

The plan to model Eddystone's thermal discharge with regard to compliance with DRBC regulations was developed in coordination with DRBC staff and uses DRBC's CORMIX modeling procedure.

MODEL INPUT

The data used to set up the CORMIX simulations were supplied by the DRBC, United States Geological Survey (USGS), National Oceanographic and Atmospheric Administration (NOAA), and Exelon in the form of reports, drawings, electronic files, and website-accessible data files. ERM reviewed these documents with respect to CORMIX requirements. Data sources for use as input to the model are summarized in the sections below.

AMBIENT TEMPERATURE AND SALINITY

In accordance with DRBC methods and as approved by DRBC staff, the model was set up for two temperature conditions representing August and February. The ambient water temperature for these three scenarios was 81°F in August and 36°F in February, the DRBC Zone 4 average daily temperature listed for these months.

Salinity was calculated from conductance records at the USGS Chester, PA station from 1964 to 2012. The mean salinities were 0.3 ppt in August and 0.2 ppt in February. These temperatures and salinities resulted in ambient densities of 996.7 kg/m^3 in August and 1000.1 kg/m^3 in February as computed by CORMIX using the UNESCO equation.

EFFLUENT PROPERTIES AND DISCHARGE CONFIGURATION

At full capacity, once-through cooling and other services for Units Three and Four require a total of 580,000 gallons per minute (gpm). This effluent discharge rate was used in the CORMIX simulations. The effluent temperature rise of 21.0°F is primarily the result of heat rejection through Units Three and Four condensers. The discharge rate and temperature rise values were provided by Exelon.

Given ambient temperatures of 81°F in August and 36°F in February, and a 21.0°F temperature rise above ambient, the effluent temperature was calculated to be 102°F in August and 57°F in February. The effluent salinity is assumed to be equal to the ambient salinity. These temperature and salinity values resulted in effluent densities of 992.9 kg/m^3 in August and 999.3 kg/m^3 in February.

The discharge structure is a 12.0 ft diameter pipe extending 300 ft from the nearest bank. The orientation of the discharge port is horizontal, perpendicular to the shoreline, and towards the southeast. The bottom of the port, assumed to be at the bottom of the channel, is 37.2 ft below the National Geodetic Vertical Datum of 1929 (NGVD). The dimensions used in the model are based on the schematics provided by Exelon (Appendix A).

AMBIENT DEPTHS AND CURRENTS

Ambient gage heights and velocities over the tidal cycle at Eddystone were provided by the DRBC. A total of 25 depths and currents in half-hour intervals were used to represent a 12 hour tidal cycle. The combination of two seasonal conditions and 25 time-steps resulted in 50 discrete simulations.

Water surface elevations at the discharge structure vary with the tide, from 2.38 ft below to 3.38 ft above NGVD. The 25 model depths are shown in Figure 3.

The current velocity values range between -1.77 ft/s and +2.60 ft/s and include flow direction reversals due to the tidal cycle. Positive values represent flood tide. The 25 current velocities are shown in Figure 4. The slack tide during flow reversal produces an environment where dilution is based solely on the effluent flow rate and discharge structure configurations. Because CORMIX requires a velocity greater than zero, a nominal current velocity between 0.033 ft/s and 0.15 ft/s to represent this slack condition was assumed.

A summary of all of the input data used in the CORMIX simulations is provided in Table 2 below.

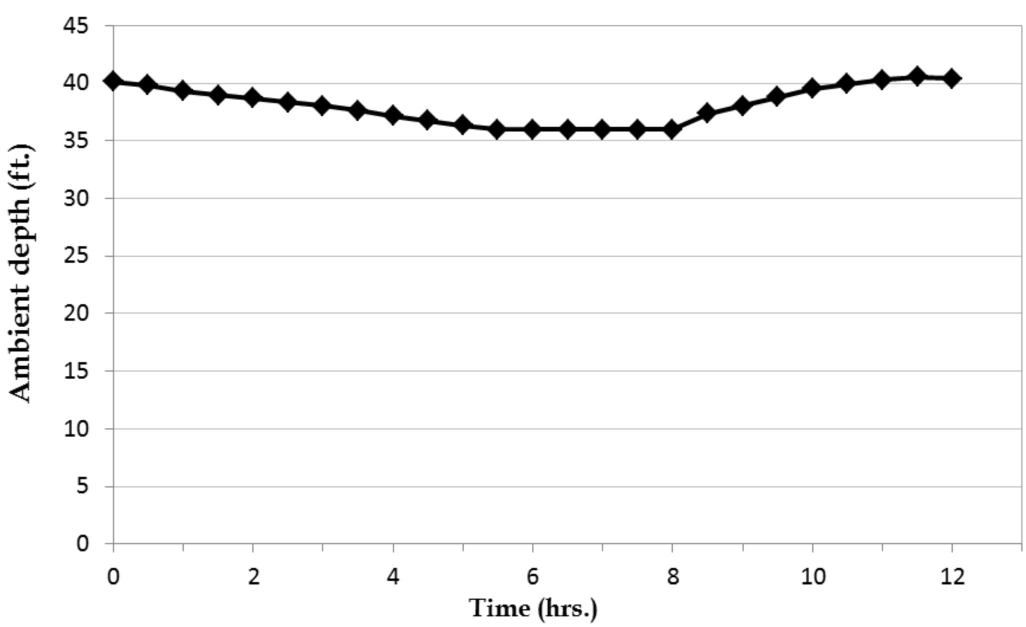

Figure 3 Modeled Water Depth at Eddystone

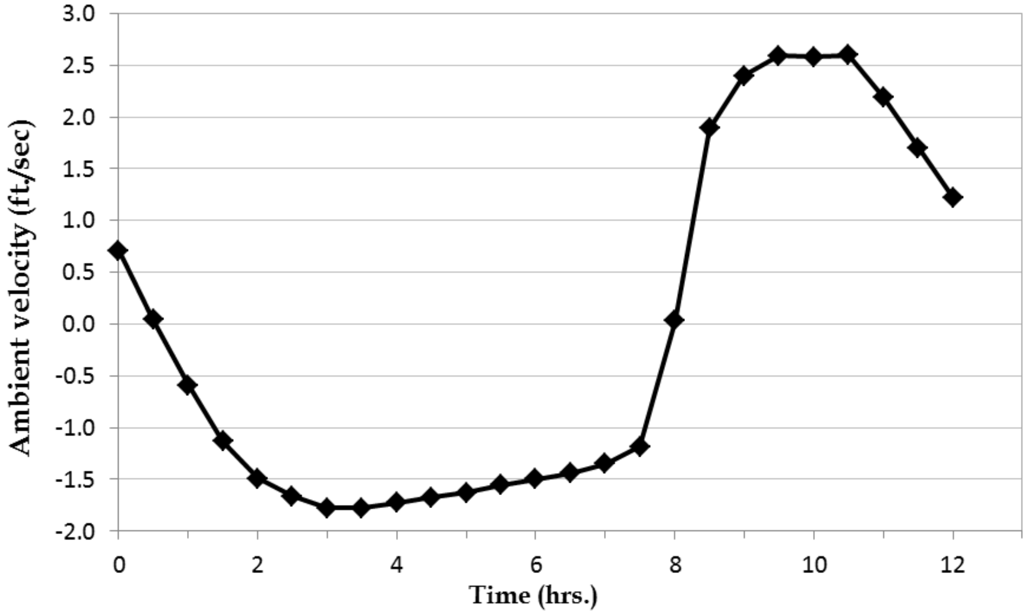

Figure 4 Modeled Current Velocities at Eddystone

Table 2 CORMIX Input Data

Parameter	Value
Number of ports	1
Port type (surface/subsurface)	Subsurface
Port diameter	12 ft
Port center height above waterbody bottom	6 ft
Port orientation (vertical/horizontal angles)	Horizontal, 270° at flood tide, 90° at ebb tide
Port distance from the shoreline	300 ft
Flow rate	580,000 gpm
Effluent density	August: 992.88 kg/m^3, February: 999.34 kg/m^3
Concentration	100 mg/L
Properties: conservative/non-conservative	Conservative
Waterbody type (bounded/unbounded)	Bounded: tidal navigation channel (Delaware River)
Bounded width	3000 ft
Bed roughness (Manning or Chezy coefficient)	0.025
Water depth at discharge structure	36.1 ft to 40.5 ft
Ambient current velocity	0.033 ft/s to 2.60 ft/s
Ambient density: uniform profile	August: 996.70 kg/m^3 February: 1000.11 kg/m^3
Wind speed	13 ft/s

RESULTS

Excess temperature at Exelon's Eddystone site has been modeled as a 580,000 gpm effluent discharge rate through a 12 ft diameter pipe with a 21.0°F temperature rise.

The 5°F requirement was met within the present docket's specified HDA for all 25 simulations in February. In August, the 5°F requirement was met within the HDA for all 25 simulations except the two slack tide conditions.

In February, the maximum downstream extent of the 5°F isotherm is 71.5 ft, at ebb tide; the maximum upstream extent is 76.8 ft, at flood tide; and the maximum lateral extent is 346.7 ft across the river, at slack tide.

In August, excluding the outliers, the maximum downstream extent of the 5°F isotherm is 189.9 ft, at ebb tide; the maximum upstream extent is 160.8 ft, at flood tide; and the maximum lateral extent is 267.8 ft across the river, at ebb tide. A dilution factor of 4.2 is required to reduce the effluent temperature rise from 21.0°F to 5.0°F. Longitudinal and lateral distances to achieve 5.0°F are presented in Appendix B and shown in Figure 5 and Figure 6.

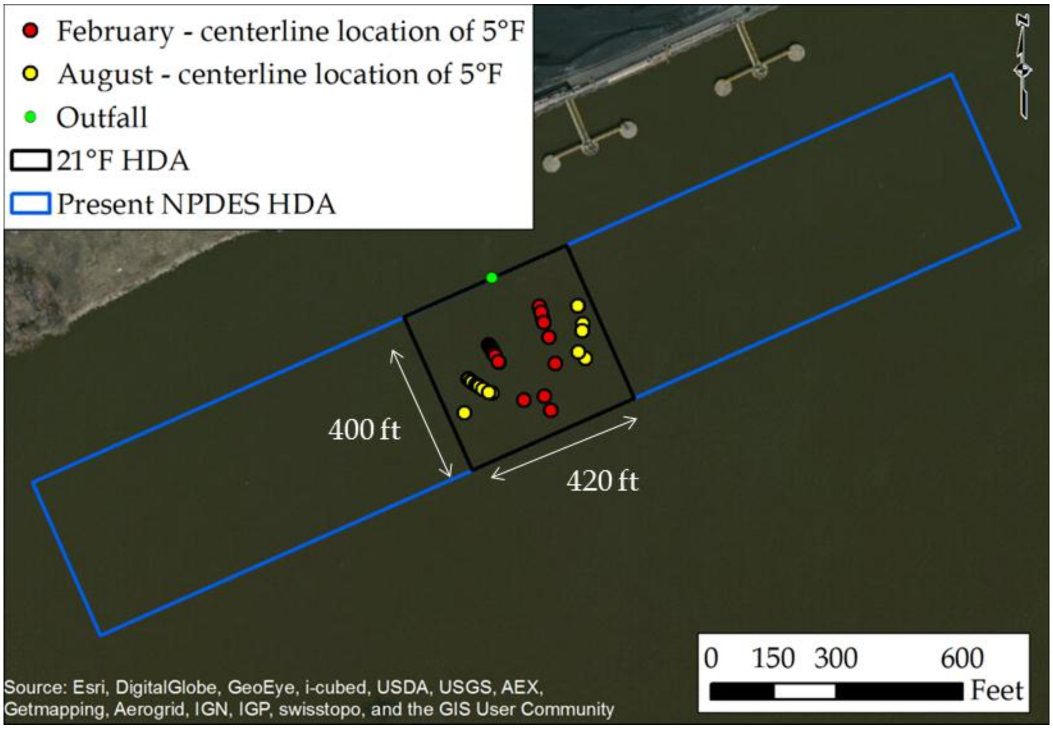

Figure 5 HDA developed from all February CORMIX results and all August results except the two slack tide values.

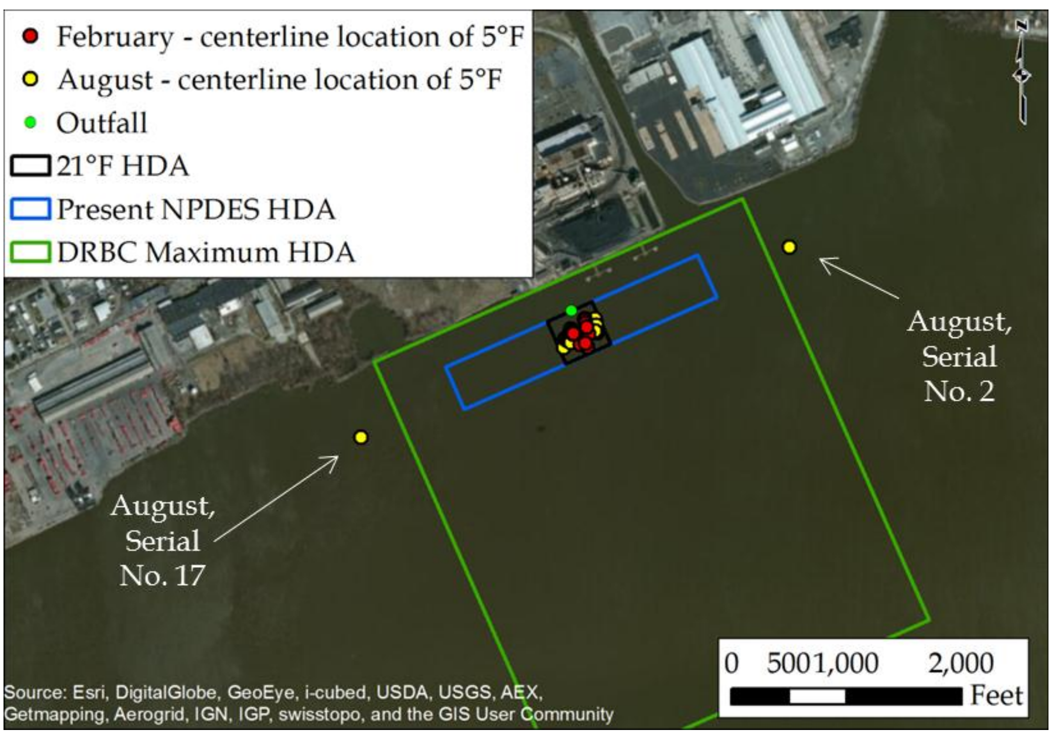

Figure 6 Diagram showing August slack before flood and slack before ebb outliers

DISCUSSION

According to the present docket, the edge of the heat dissipation area is defined as 400 ft in width across the river, 1,200 ft downstream, and 1,200 ft upstream of the outfall. Results of CORMIX modeling show that an excess temperature of 5°F will be achieved within this area. Excluding the August slack tide simulations, and accounting for a 15-20% safety factor, the thermal plume meets the 5°F requirement within a heat dissipation area 400 ft in width, 228 ft upstream, and 193 ft downstream.

There are two slack tide outliers in the August CORMIX results that were not included in calculating HDA dimensions. These outliers represent slack before ebb and slack before flood. Slack tide is a brief event; DRBC CORMIX protocol shows that slack tide lasts no more than 30 minutes. CORMIX's time of travel information shows that the thermal plume represented by the outliers would require four hours to develop. Because slack tide conditions exist, at most, for about 30 minutes, these outliers are not realistic estimates of the thermal plume dimensions. CORMIX is known to have difficulty in very low velocity situations (slack tide velocities for August and February are less than 0.15 ft/s).

Results of the current thermal modeling study are consistent with results of the 1971 EIS. The heat dissipation area required for Units Three and Four is similar in size and shape to the previously modeled heat dissipation area for all four units, although it is smaller due to the decrease in heat load.

In conclusion, the thermal discharge at Outfall 008 was modeled using realistic ambient conditions as input to CORMIX and conservative (highest possible flow rate and maximum temperature rise) effluent conditions for the combination of temperature rise and flow rate. A heat dissipation area was determined based on results of the distance to achieve 5°F.

REFERENCES

CORMIX1 Technical Report: "Expert Systems for Hydrodynamic Mixing Zone Analysis of Conventional and Toxic Single Port Discharges (CORMIX1)", by R. L. Doneker and G. H. Jirka, EPA /600/3-90/012, 1990.

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Exelon Drawing AB-210452

NOAA charts at http://www.charts.noaa.gov/OnLineViewer/12312.shtml

United States Geological Survey (USGS). Station 01477050 Delaware River at Chester, PA.
http://waterdata.usgs.gov/nwis/uv/?site_no=01477050&agency_cd=USGS&amp. Accessed 01/2014

CORMIX RESULTS AND FIGURES

Figure 7 through Figure 16 are CORMIX generated output for five simulations plotted up to 400 m (1312 ft). Plan views illustrate the effluent plume from above. Isometric views illustrate the shape and position of the plume in the channel, outlined in grey. The x-axis is the downstream direction during ebb tide and upstream during flood tide, parallel to shore, and the y-axis is perpendicular to shore. Axis units are in meters.

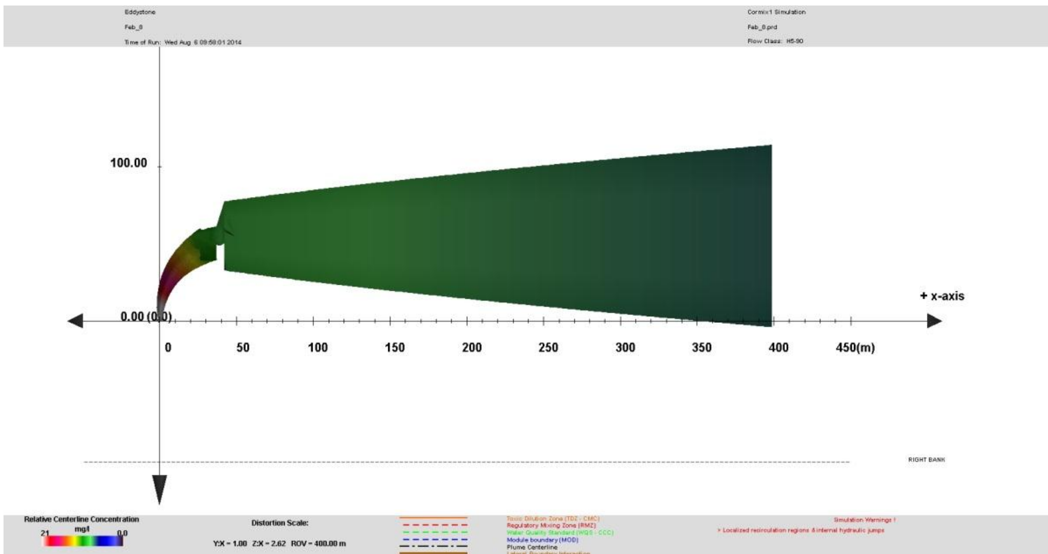


Figure 7 February ebb tide, serial no. 8, plan view

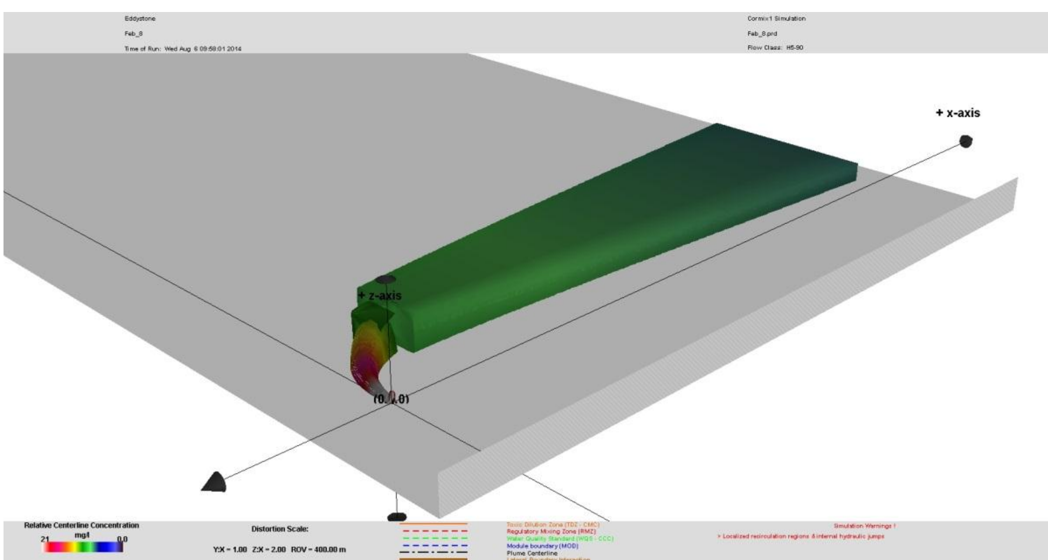


Figure 8 February ebb tide, serial no. 8, isometric view

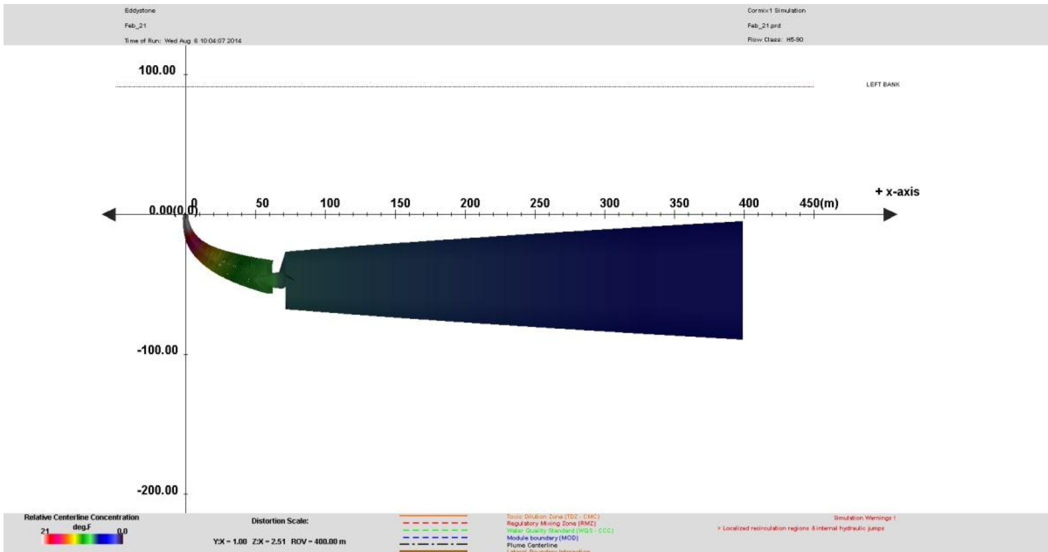


Figure 9 February flood tide, serial no. 21, plan view

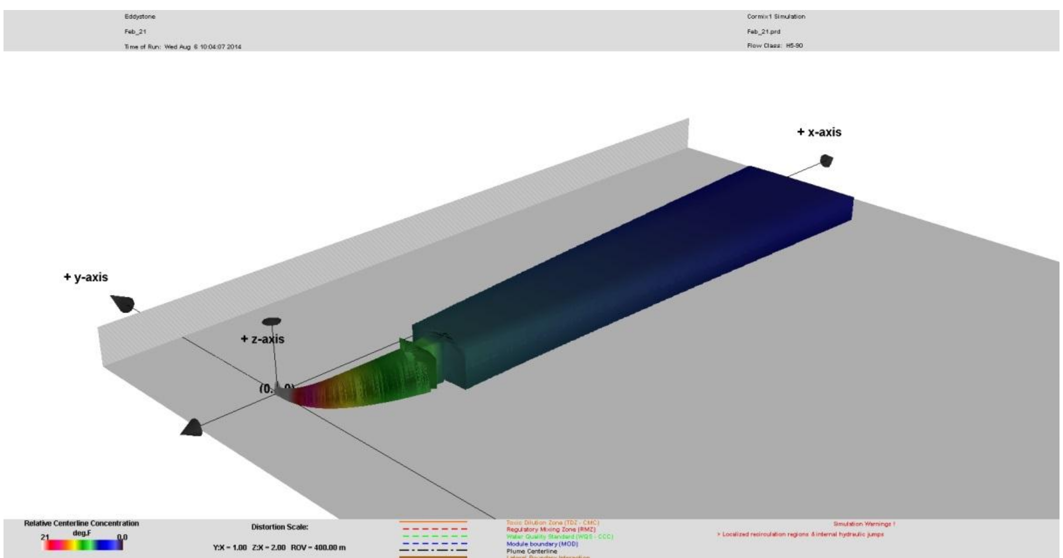


Figure 10 February flood tide, serial no. 21, isometric view

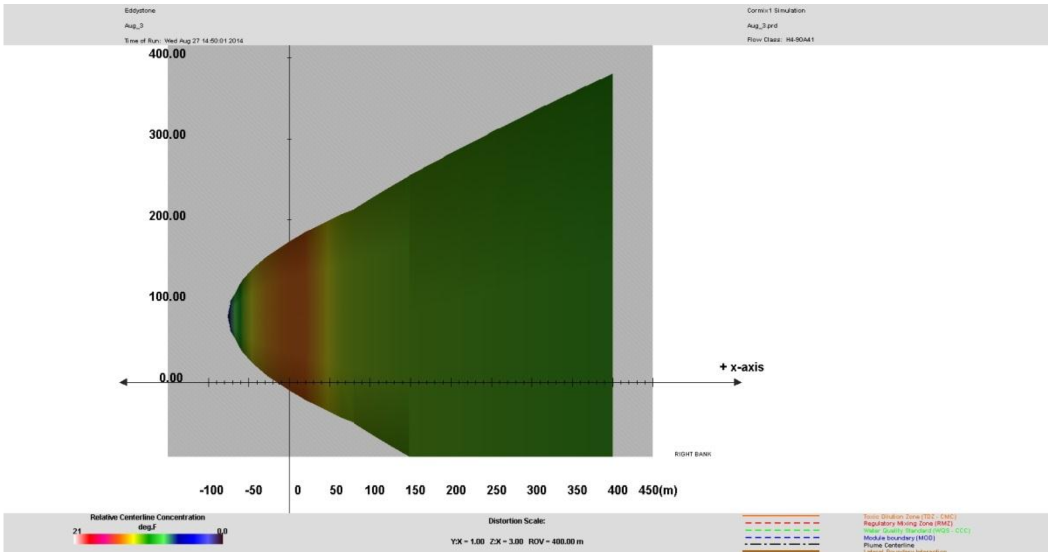


Figure 11 August ebb tide, serial no. 3, plan view

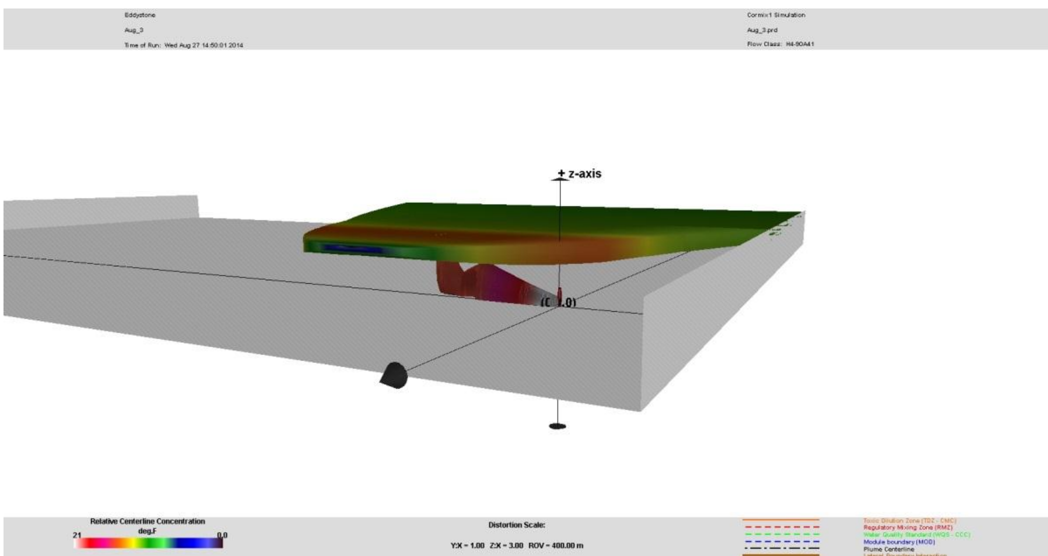


Figure 12 August ebb tide, serial no. 3, isometric view

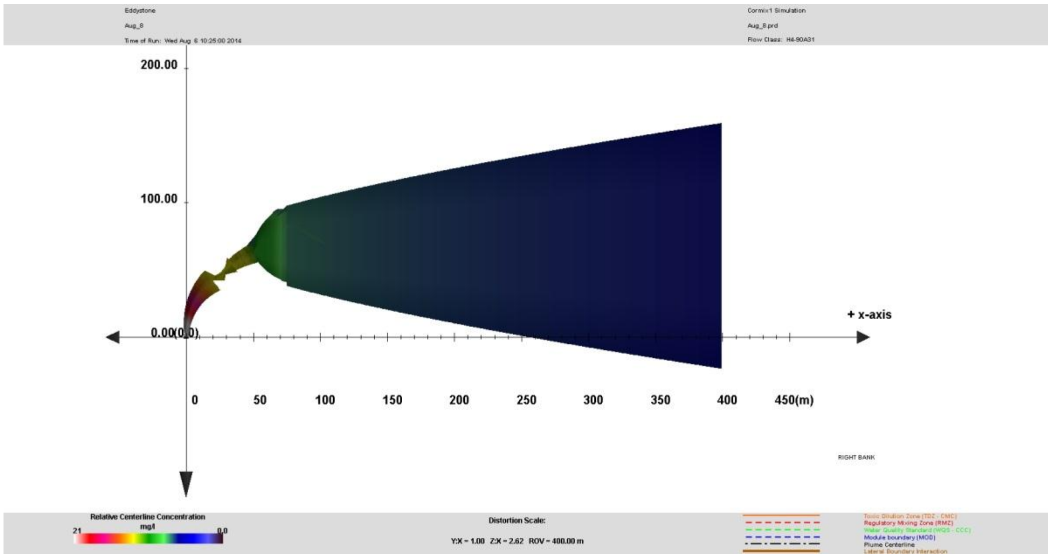


Figure 13 August ebb tide, serial no. 8, isometric view

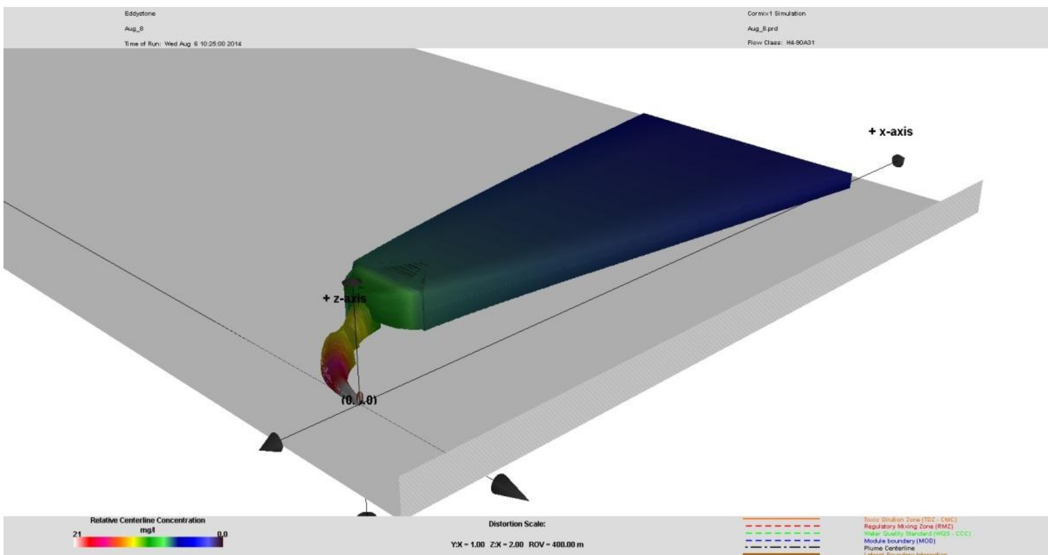


Figure 14 August ebb tide, serial no. 8, isometric view

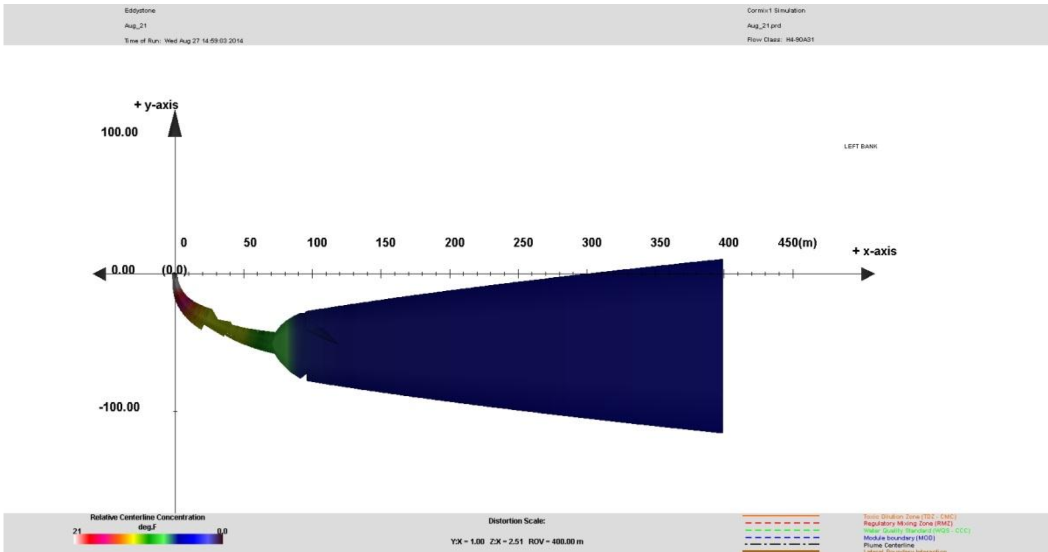


Figure 15 August flood tide, serial no. 21, plan view

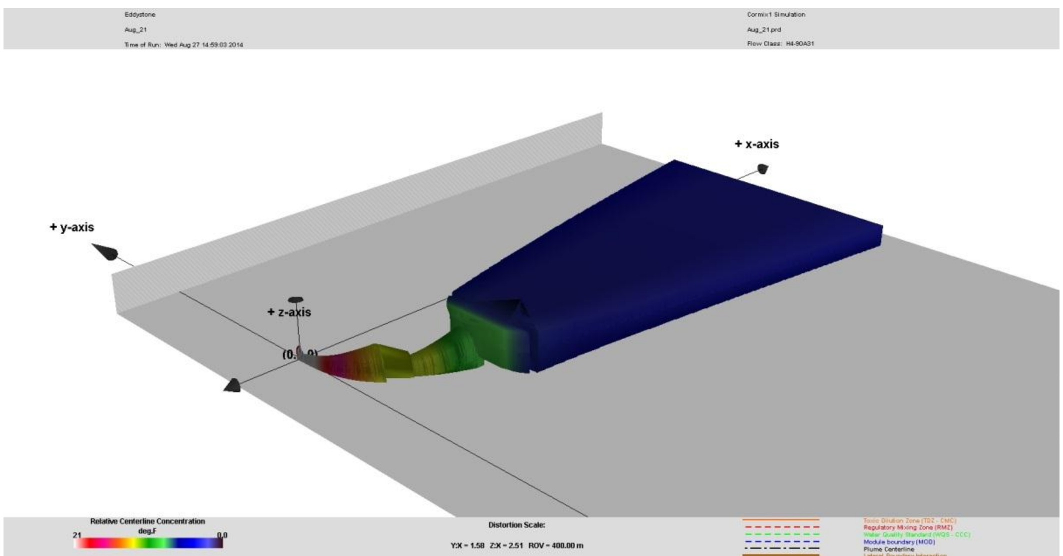
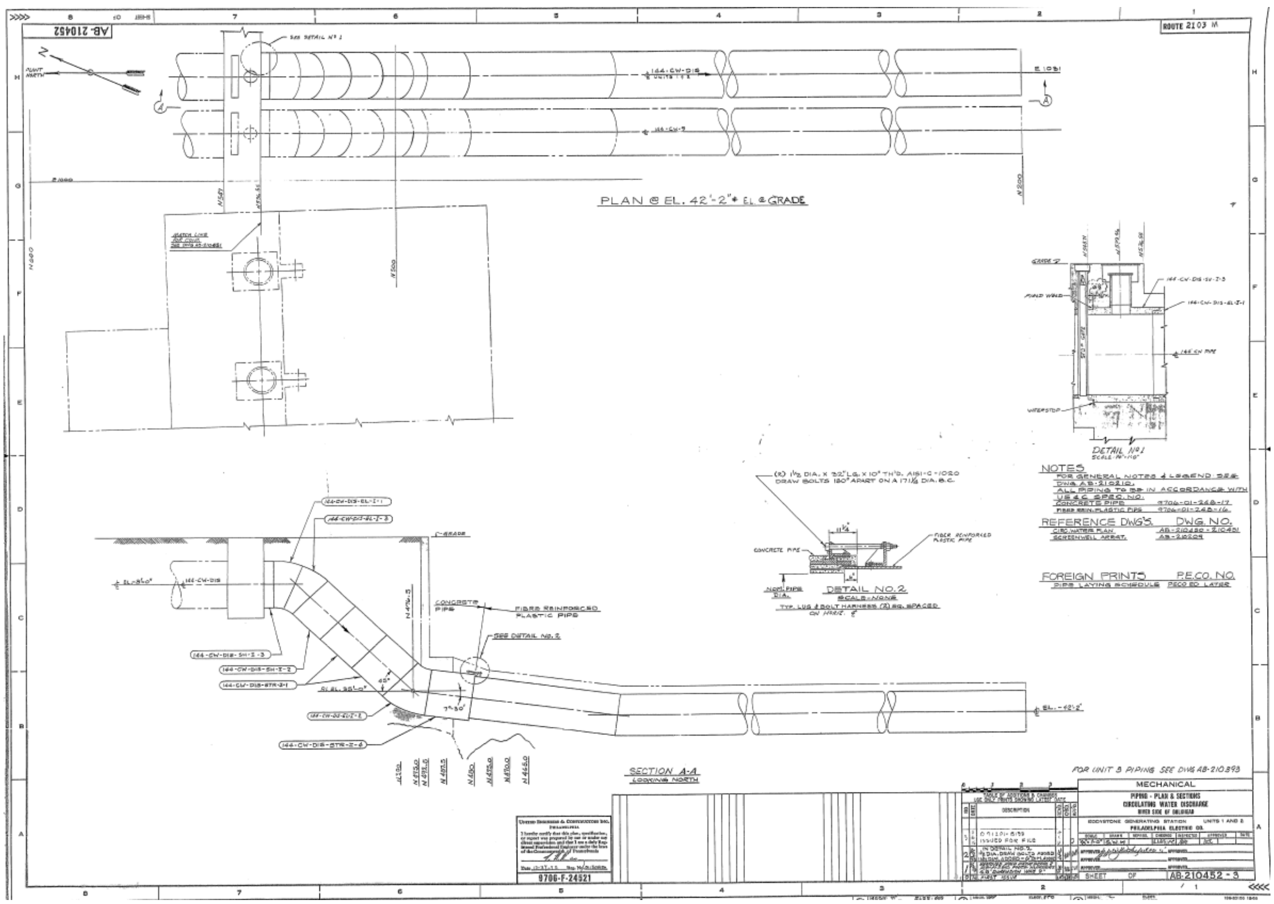


Figure 16 August flood tide, serial no. 21, isometric view

APPENDIX A EXELON DESIGN DRAWING AB-210452



APPENDIX B LONGITUDINAL AND LATERAL DISTANCES TO 5°F, FEBRUARY

Serial No.	Time step (hr.)	Ambient current velocity* (ft/s)	Ambient water depth (ft)	Required dilution factor	Longitudinal distance† (ft)	Lateral distance (ft)
1	0	0.709	40.2	4.2	55.3	248
2	0.5	0.043	39.8	4.2	1.1	346
3	1.0	-0.59	39.3	4.2	-48.0	298
4	1.5	-1.13	38.9	4.2	-65.6	192
5	2.0	-1.49	38.7	4.2	-69.4	163
6	2.5	-1.66	38.4	4.2	-70.8	150
7	3.0	-1.77	38.0	4.2	-71.4	144
8	3.5	-1.77	37.6	4.2	-71.5	144
9	4.0	-1.72	37.2	4.2	-71.2	146
10	4.5	-1.68	36.7	4.2	-70.8	150
11	5.0	-1.63	36.3	4.2	-70.6	152
12	5.5	-1.55	36.1	4.2	-69.8	158
13	6.0	-1.50	36.1	4.2	-69.7	161
14	6.5	-1.44	36.1	4.2	-69.0	166
15	7.0	-1.35	36.1	4.2	-68.2	174
16	7.5	-1.18	36.1	4.2	-66.2	189
17	8.0	0.033	36.1	4.2	-0.5	309
18	8.5	1.89	37.3	4.2	72.4	137
19	9.0	2.40	38.0	4.2	75.5	115
20	9.5	2.59	38.8	4.2	76.7	108
21	10.0	2.58	39.5	4.2	76.8	108
22	10.5	2.60	39.9	4.2	76.7	108
23	11.0	2.19	40.3	4.2	74.0	123
24	11.5	1.70	40.5	4.2	70.9	148
25	12.0	1.22	40.4	4.2	66.5	186

* Positive values represent flood tide

† Positive values represent distance upstream

APPENDIX B LONGITUDINAL AND LATERAL DISTANCES TO 5°F, AUGUST

Serial No.	Time step (hr.)	Ambient current velocity* (ft/s)	Ambient water depth (ft)	Required dilution factor	Longitudinal distance† (ft)	Lateral distance (ft)
1	0	0.709	40.2	4.2	126.8	267.1
2	0.5	0.15	39.8	4.2	1955.2	265.4
3	1.0	-0.59	39.3	4.2	-189.9	267.8
4	1.5	-1.13	38.9	4.2	-111.3	252.0
5	2.0	-1.49	38.7	4.2	-134.1	222.6
6	2.5	-1.66	38.4	4.2	-144.6	205.9
7	3.0	-1.77	38.0	4.2	-149.5	198.1
8	3.5	-1.77	37.6	4.2	-149.2	198.0
9	4.0	-1.72	37.2	4.2	-147.9	200.7
10	4.5	-1.68	36.7	4.2	-144.8	205.9
11	5.0	-1.63	36.3	4.2	-143.3	208.7
12	5.5	-1.55	36.1	4.2	-138.0	216.9
13	6.0	-1.50	36.1	4.2	-136.0	219.8
14	6.5	-1.44	36.1	4.2	-132.2	225.5
15	7.0	-1.35	36.1	4.2	-126.2	234.3
16	7.5	-1.18	36.1	4.2	-117.0	246.9
17	8.0	0.15	36.1	4.2	2115.4	261.2
18	8.5	1.89	37.3	4.2	154.8	188.1
19	9.0	2.40	38.0	4.2	75.5	115.1
20	9.5	2.59	38.8	4.2	160.8	145.5
21	10.0	2.58	39.5	4.2	160.8	145.5
22	10.5	2.60	39.9	4.2	160.6	145.4
23	11.0	2.19	40.3	4.2	74.2	122.8
24	11.5	1.70	40.5	4.2	146.3	203.3
25	12.0	1.22	40.4	4.2	117.5	246.1

* Positive values represent flood tide

† Positive values represent distance upstream

IITP APPLICATION
ATTACHMENT 3

Bottom Contact Area for the
Eddystone Thermal Plume

June 2019

Memorandum

Date: 9 May 2018

To: Maureen Heimbuch; Rachael Blevins-Manhard, Gwendolyn Sivirichi (AKRF)

From: Edward M. Buchak, Shwet Prakash (ERM)

Subject: Bottom contact area for the Eddystone thermal plume

This memo describes the results of an examination of CORMIX simulations performed in 2014 for Exelon Generation Company, LLC's Eddystone Generating Station (Eddystone). The 2014 simulations were made to calculate the size of the thermal plume's surface area. In contrast, the purpose of this examination is to calculate the area of contact of the thermal plume with the bottom of the Delaware River Estuary.

BACKGROUND

In 2014 ERM applied the CORMIX model to Eddystone's thermal discharge to estimate mixing zone dimensions at the surface for inclusion in Eddystone's DRBC docket. ERM's 2014 report (ERM 2014) describes the model application and results.

Briefly, the CORMIX simulations were done using DRBC's protocol for modeling mixing zones[1]. The protocol, as used at Eddystone, called for 25 separate simulations for February ambient conditions and 25 simulations for August ambient conditions. The 25 simulations represent tidal conditions every half-hour of the 12 h 28 minute semidiurnal tidal cycle. Ambient conditions consisted of temperatures, salinities, depths, currents, and freshwater inflow rates. The DRBC provided the depths and currents for each half-hour interval, which were plotted by ERM and are shown in Figure 1 and Figure 2. The ambient conditions were chosen to be representative of conditions that favor the formation of large thermal plumes (e.g., minimum freshwater inflow rates).

[1] DRBC uses the term "Heat Dissipation Area" for a mixing zone from a thermal discharge.

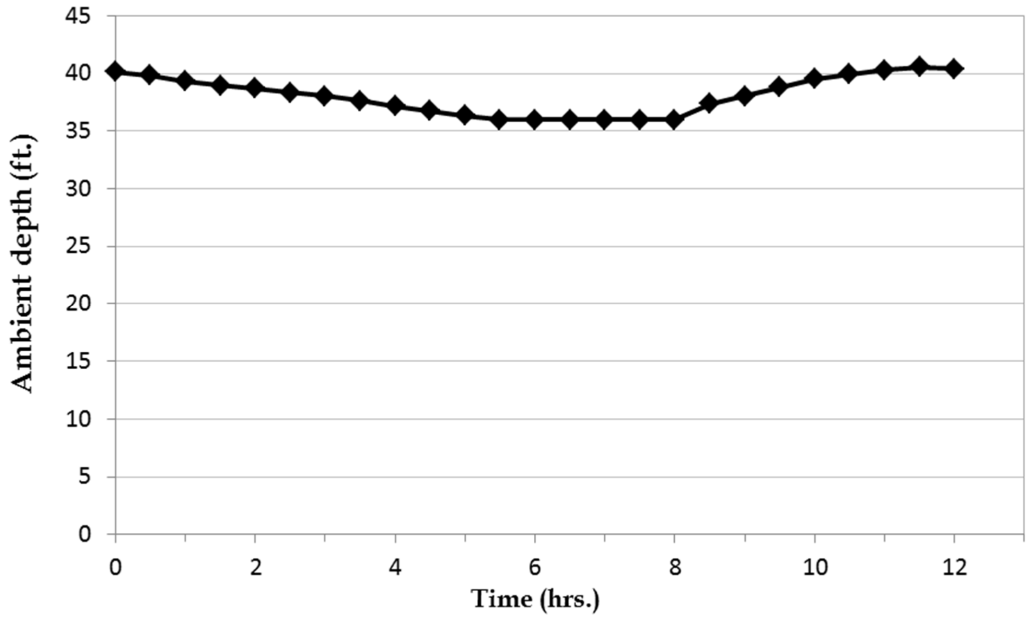


Figure 1 Water depths at Eddystone over a tidal cycle; data provided by the DRBC

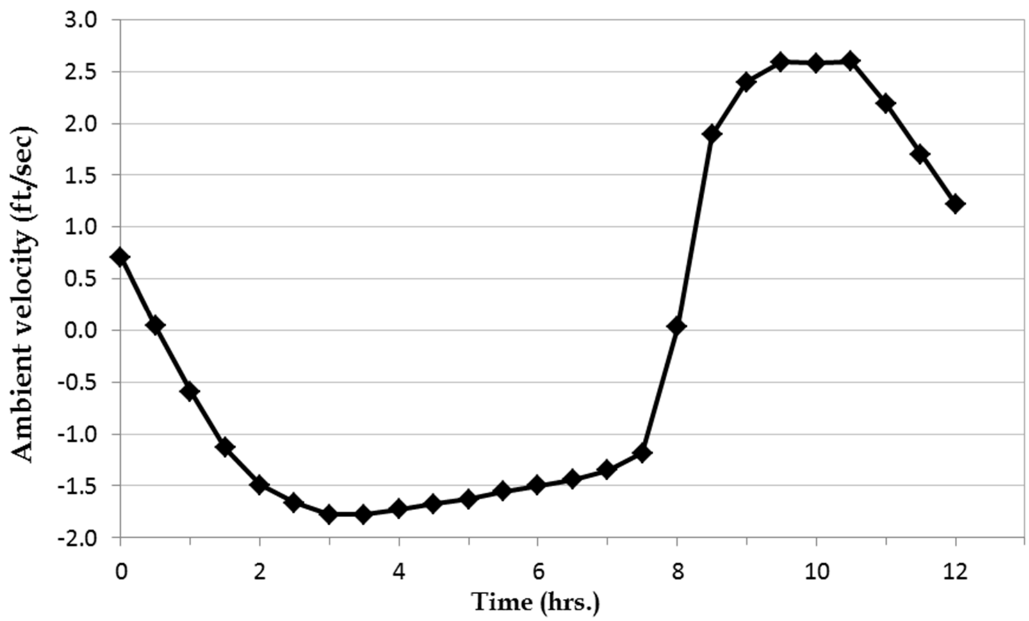


Figure 2 Currents at Eddystone over a tidal cycle; data provided by the DRBC

For each simulation, the Eddystone discharge rate was 580,000 gpm, which is the maximum capacity of Eddystone's circulating water pumps, and the condenser temperature rise was 21°F, which is the maximum value authorized under Eddystone's National Pollutant Discharge Elimination System (NPDES) permit.

The Eddystone discharge structure (Outfall 008) lies on the bottom of the Delaware River Estuary, extending 300 ft into the Delaware and oriented perpendicular to the shoreline. The outfall is 12 ft in diameter with a nominal exit velocity of about 1 ft s^{-1}. The outfall's exit velocity, orientation relative to Delaware River Estuary currents, strength and direction of the ambient currents, and effluent density relative to the ambient density determine the thermal plume's initial rate of mixing as well as its trajectory.

BOTTOM AREA CALCULATIONS

For Eddystone, CORMIX conceptualizes the thermal plume's cross section as a circle and calculates the plume's centerline trajectory as x, y, and z coordinates with the discharge structure as the origin. At each of the centerline positions along the trajectory, the dilution rate, centerline temperature (defined as the increase above ambient), Gaussian half-width, centerline velocity, and time-of-travel are also calculated and sent to the simulation's prediction file (the prd file).

The centerline temperature and Gaussian half-width at each point along the trajectory can be used to calculate the changing diameter and temperature distribution across the diameter using the following relationship:

$$C(n) = C_c \, ex \left(\frac{n}{b}\right)^{2} \qquad \text{(Equation 1)}$$

where

$C(n)$	=	centerline temperature increase, °F
C_c	=	initial temperature increase, 21°F
n	=	distance from the centerline, m
b	=	Gaussian 1/e (37%) half-width, m

Because Outfall 008 rests on the bottom, the lower half of the plume is initially intercepted by the bottom of the Delaware River Estuary – see Figure 3 – and the height of the centerline above the bottom is zero. In this case, the width of the 5°F isotherm in contact with the bottom is easily calculated as twice the distance from the centerline to the 5°F isotherm[2].

[2] For the bottom contact area calculation, the plume boundary is defined by the 5°F isotherm. This choice is consistent with the DRBC's definition of the mixing zone.

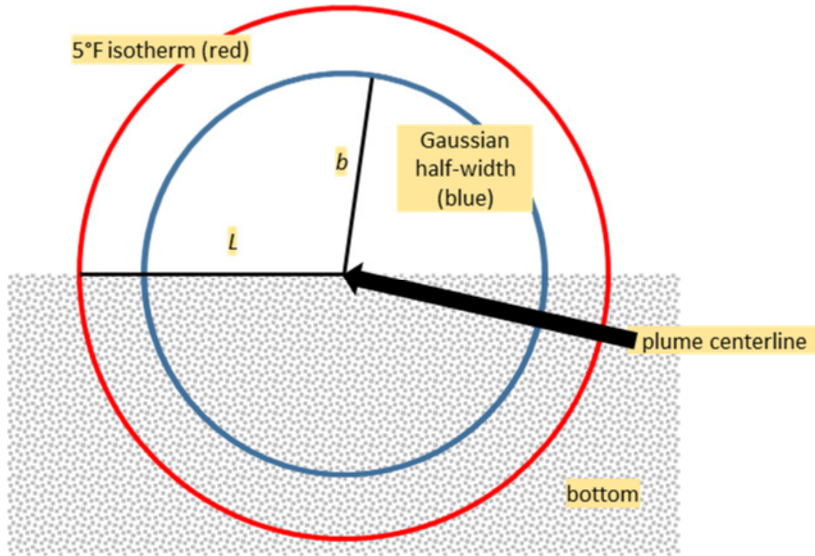


Figure 3 Variables used to calculate the bottom contact area when the plume centerline is on the bottom

Variables are defined in Equations 1 through 3 (below); in this example, the centerline temperature is large enough that the 5°F isotherm lies outside the Gaussian half width.

As the plume rises due to buoyancy, less of the cross-section is intercepted by the bottom (Figure 4). To calculate *L*, the distance from the plume centerline to the 5°F isotherm is first calculated from a rearrangement of Equation 1:

$$n_{5\text{x}} = \text{x}b\sqrt{-\ln(5) + \ln(C(n))}\text{x} \qquad \text{(Equation 2)}$$

The edge of the plume is defined as the Gaussian half-width, at which point the concentration is 0.37 C(n). The 5°F isotherm will lie inside the Gaussian half-width when the centerline temperature increase is greater than 13.5°F (5°F/0.37), or outside the Gaussian half-width if the centerline temperature increase is less than 13.5°F.

The bottom contact half-width can be calculated as follows:

$$L\text{x} = \text{x}\sqrt{n_5^{2\text{x}} - \text{x}z^{2\text{x}}} \qquad \text{(Equation 3)}$$

where

zx = height of the centerline above the bottom, m

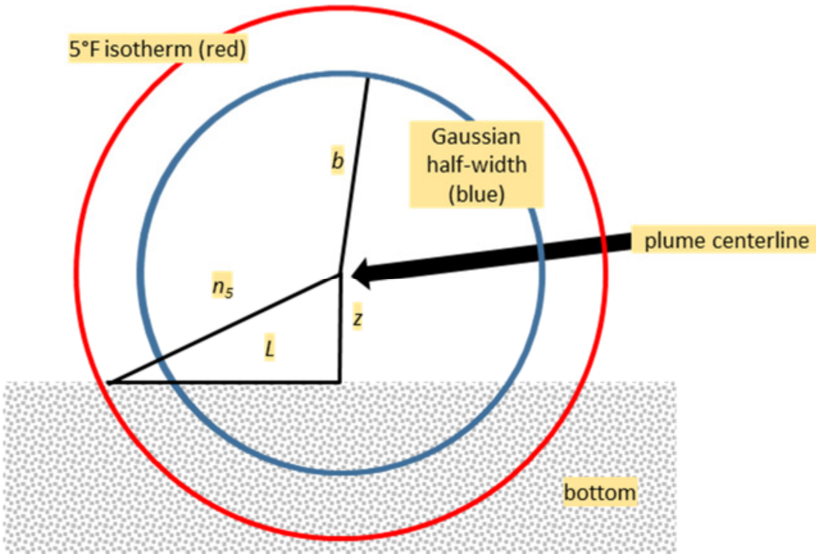


Figure 4 Variables used to calculate the bottom contact area when the plume centerline has risen from the bottom

In this example, the centerline temperature is large enough that the 5°F isotherm lies outside the Gaussian half width.

When the 5°F isotherm no longer touches the bottom, the calculation can be completed by determining the total bottom contact area as the sum of the increments, *Δx,* along the trajectory multiplied by the corresponding half-widths, *L*, also along the trajectory:

$$A = \sum_{x=0}^{D} 2L_x \Delta x \qquad \text{(Equation 4)}$$

where

D = the distance at which the bottom temperature increase is less than 5°F.

Equations 1 through 4 were applied to each of the 25 CORMX simulations for February and to each of the 25 CORMX simulations for August to obtain the bottom contact area. The results are shown in Table 1 and Table 2, which report both the length (D in Equation 4) and the average width (the area divided by the length).

Table 1 Bottom contact dimensions based on 5°F isotherm for February ambient conditions

Tidal hour	*D*, the length of bottom contact plume, ft	Average width of bottom contact plume, ft	Area of bottom contact plume, ft²
0.5	55	29	1612
1	3	32	106
1.5	48	30	1445
2	66	28	1853
2.5	69	27	1885

Tidal hour	*D*, the length of bottom contact plume, ft	Average width of bottom contact plume, ft	Area of bottom contact plume, ft^2
3	71	27	1883
3.5	71	26	1880
4	71	26	1879
4.5	71	26	1880
5	71	27	1883
5.5	71	27	1885
6	70	27	1886
6.5	70	27	1886
7	69	27	1885
7.5	68	28	1880
8	66	28	1860
8.5	2	34	68
9	72	26	1872
9.5	75	24	1843
10	77	24	1832
10.5	77	24	1832
11	77	24	1832
11.5	74	25	1854
12	71	27	1881
12.5	67	28	1864

Table 2 Bottom contact dimensions based on 5°F isotherm for August ambient conditions

Tidal hour	*D*, the length of bottom contact plume, ft	Average width of bottom contact plume, ft	Area of bottom contact plume, ft^2
0.5	55	25	1365
1	8	26	204
1.5	43	25	1076
2	102	23	2357
2.5	130	21	2686
3	142	19	2638
3.5	148	18	2694
4	148	17	2544
4.5	146	18	2587
5	143	18	2642
5.5	141	19	2665
6	135	20	2693
6.5	133	20	2692
7	128	21	2677
7.5	120	22	2612

Tidal hour	*D*, the length of bottom contact plume, ft	Average width of bottom contact plume, ft	Area of bottom contact plume, ft^2
8	106	23	2415
8.5	8	26	205
9	154	15	2309
9.5	160	13	2088
10	75	24	1843
10.5	160	13	2087
11	160	13	2087
11.5	74	25	1854
12	144	18	2617
12.5	109	23	2460

DISCUSSION

The bottom contact areas are small with the largest (about 2700 ft^2) occurring in August. A comparison of the example February plume visualizations (Figure 5 and Figure 6) with those of August (Figure 7 and Figure 8), shows that the February thermal plumes are less buoyant than the August plumes. The reason is that density differences due to an increase in temperature are greater at higher ambient temperatures. For example, an increase in temperature from 75 F to 79 F produces a larger density difference that an increase in temperature from 35 to 39 F.

The bottom plumes show the same variations in size relative to the set of the tide as the surface plumes (Appendix B of the 2014 report), with smaller values at slack before ebb and slack before flood. During slack tides, currents have begun reversing and the plumes are "doubled up" and do not extend in either the upstream or downstream directions. In another consequence of the higher buoyancy of the August plumes, the August bottom plumes are only 9% the size of the August surface plumes but the February bottom plumes are 19% of the February surface plume areas.

REFERENCES

Doneker, R.L. and G.H. Jirka. 2007. CORMIX User Manual, "A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Water". EPA-823-K-07-001. December.

Environmental Resources Management 2014. "CORMIX Modeling of Eddystone Generating Station's Thermal Plume." Prepared for Exelon. 29 August.

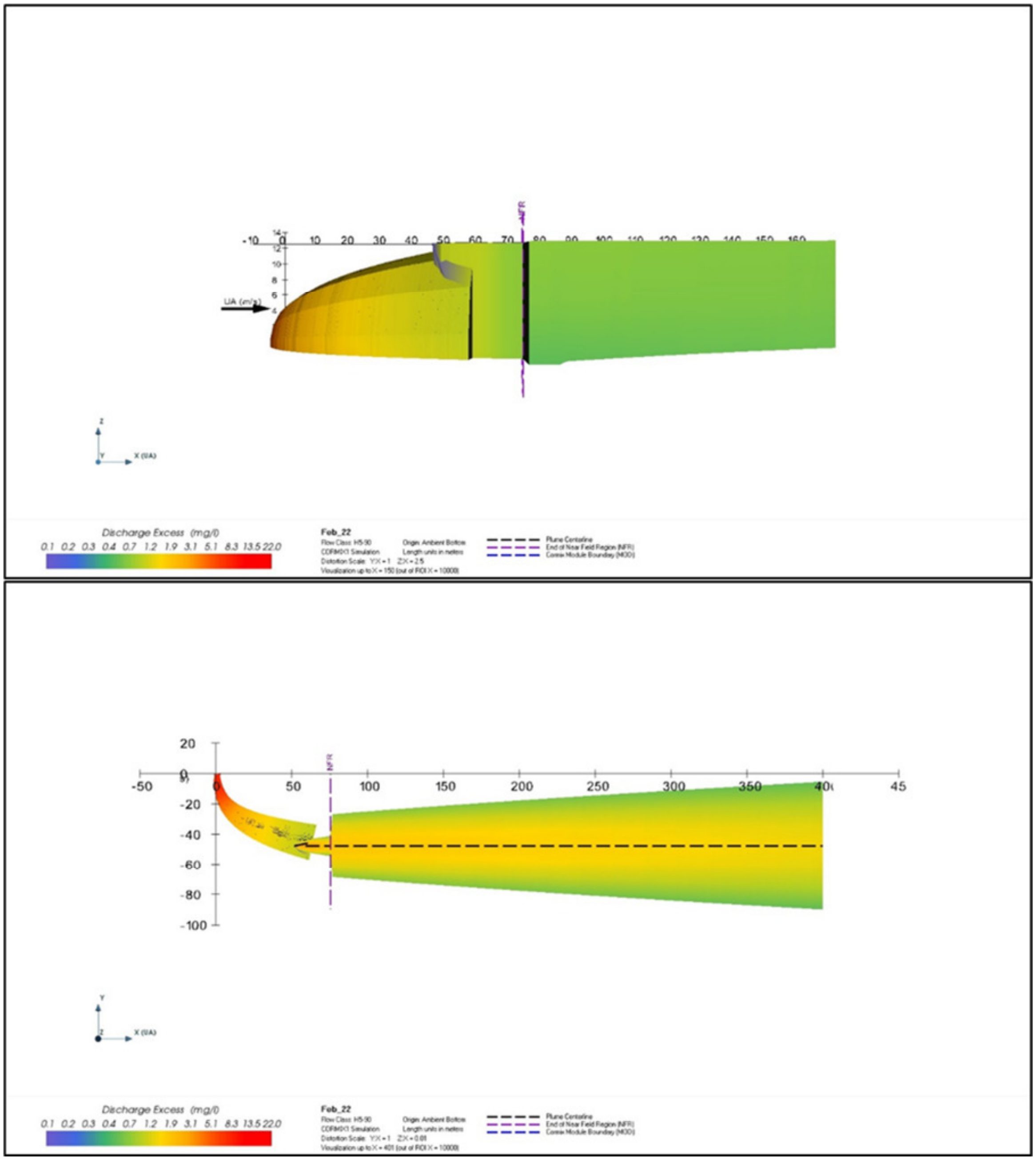


Figure 5 February thermal plume at hour 11; top panel– side view, bottom panel – plan view

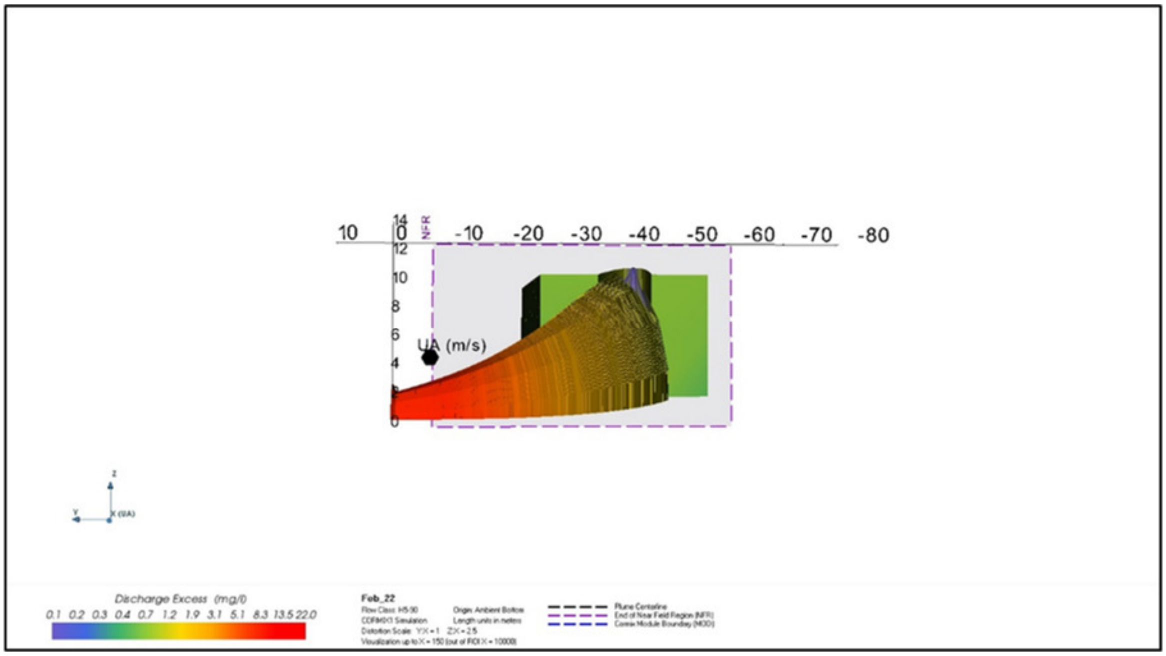


Figure 6 February thermal plume at hour 11; view from upstream in the direction of the currents

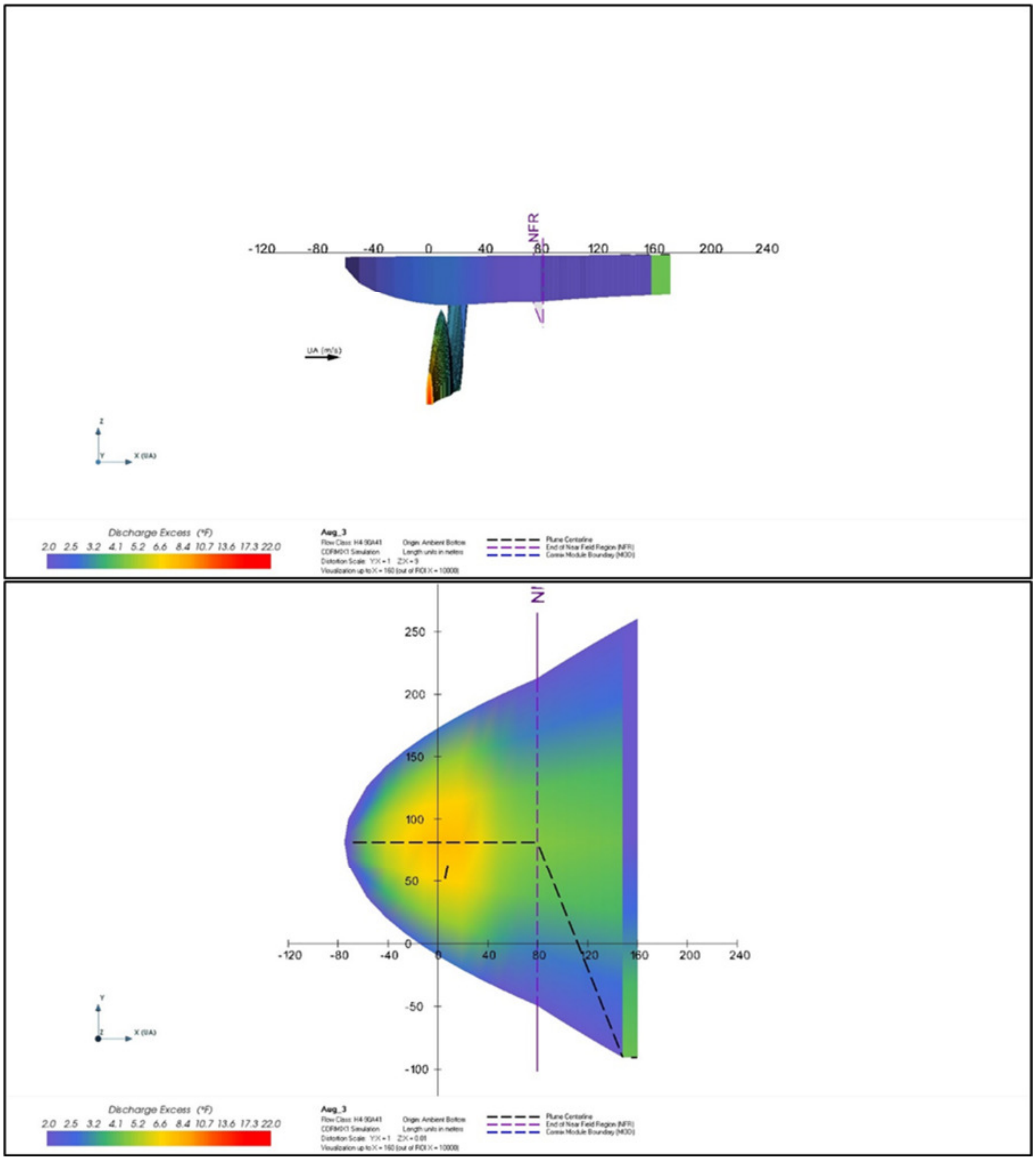


Figure 7 August thermal plume at hour 3; top panel – side view, bottom panel – plan view

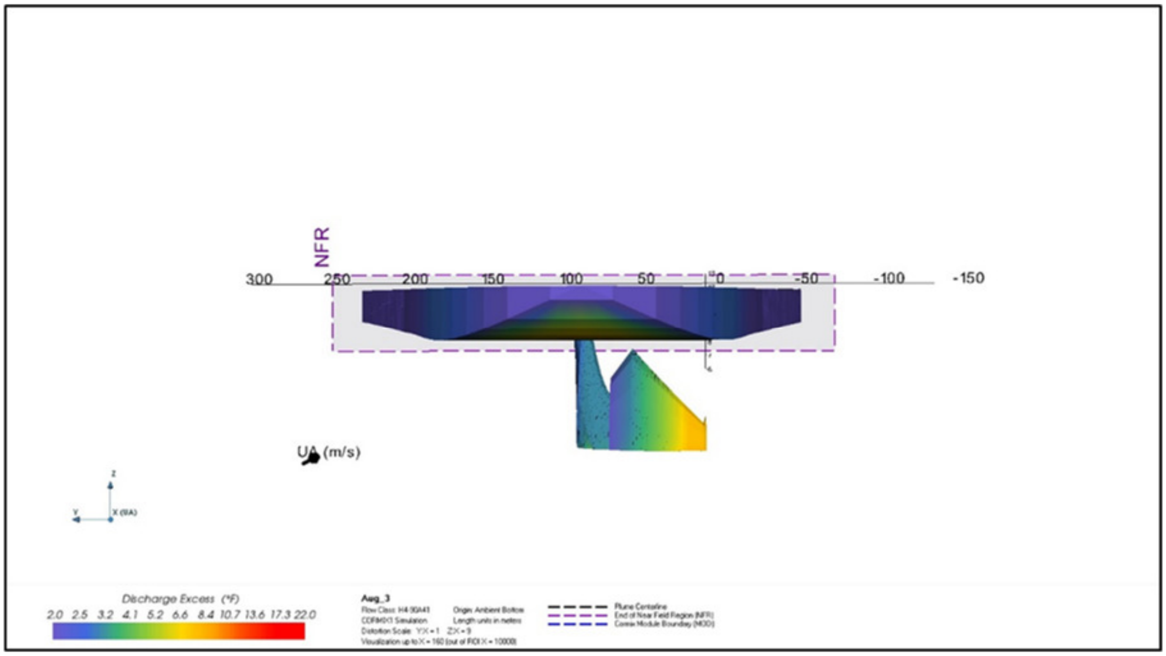


Figure 8 August thermal plume at hour 3; view from upstream in the direction of the currents

IITP APPLICATION

ATTACHMENT 4

PCB Pollutant Minimization Plan –
Eddystone Generating Station

June 2019

PCB POLLUTANT MINIMIZATION PLAN

EDDYSTONE GENERATING STATION
NO. 1 INDUSTRIAL HIGHWAY
EDDYSTONE, PA 19022-1585

April 7, 2006
REVISION 1

1. **Good Faith Commitment**
Rule Section 4.30.9.E.1

Exelon Power makes a good faith commitment to reduce the discharges of Polychlorinated Biphenyls (PCB's) from the Eddystone Generating Station to the Delaware Estuary through the Pollutant Minimization Plan (PMP) process in accordance with the Delaware River Basin Commission PMP Rule 4.30.

Name: ______________________________ Date: ______________________________
General Manager
Eddystone Generating Station
Exelon Power

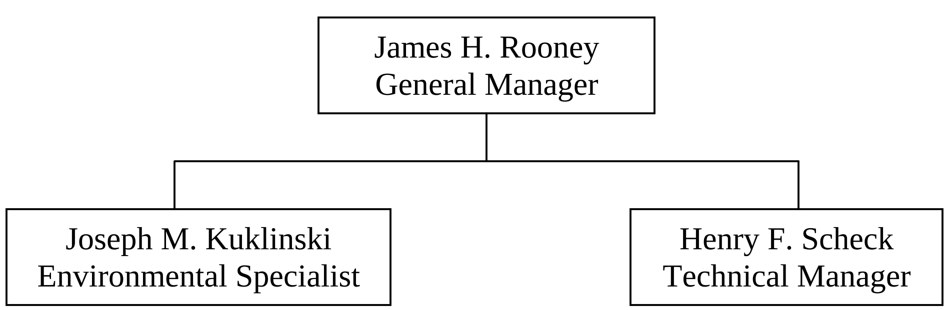
2. **Discharger/Facility Contact**
Rule Section 4.30.9.E.2

Eddystone Generating Station provides the following individuals who serve as the facility contacts to ensure that the provisions of this Pollution Minimization Plan are properly addressed and implemented.

Name: James H. Rooney
General Manager Eddystone Generating Station
610-595-8108

Name: Henry F. Scheck
Technical Manager Eddystone Generating Station
610-595-8469

Name: Joseph M. Kuklinski
Environmental Specialist Eddystone Generating Station
610-595-8113



3. Facility Description

Rule Section 4.30.9.E.3

Site Location

The Eddystone Generating Station is located at No. 1 Industrial Highway, Eddystone, Delaware County, Pennsylvania. The latitude of the facility is 39° 51' 35" and longitude is 75° 19' 20". The facility is located on the Delaware River (mile 84.5) at the confluence of the Delaware River and Crum Creek.

Description of Generation Process

The plant has a mix of coal-fired, oil/gas-fired, and combustion turbines that supply both base load and cycling generation. There are also three auxiliary boilers located onsite to provide start-up steam and in-house heat. The facility has a nominal gross capacity of 1,500 megawatts.

Units 1 and 2 are Combustion Engineering twin-furnace, balanced-draft, tangentially fired, radiant-type boilers that fire bituminous coal. These units are rated at 315 MW and 325 MW, respectively. Units 3 and 4 are Combustion Engineering single-furnace, balanced-draft, tangentially fired, radiant-type boilers that fire natural gas, No. 6 fuel oil, or a combination of the two fuels. These units are both rated at 395 MW. The three auxiliary boilers are identical Combustion Engineering 'D'-tube, single-pass package boilers with superheaters. There are also four Pratt & Whitney combustion turbines rated at 15 to 18 MW each located at the Eddystone Generating Station.

The facility average daily throughput is 3,820 tons/day of coal, 144,060 gallons/day of No. 6 oil, and 13,900 gallons/day of No. 2 oil.

Site History and Expansions

Units #1 and #2 became operational in 1960. Unit #3 became operational in 1974. Unit #4 became operational in 1976.

Site Layout

A Site map is provided in Figure 2. This map provides the location of storage tanks, storm drains, and outfalls. The map also shows how the storm drains and outfalls are connected.

Water and wastewater from the Eddystone Generating Station is collected via three (3) separate collection systems:

- Plant Drainage System
- Stormwater Drainage System
- Sewage Collection

The plant drainage system collects all of the wastewater at the facility for treatment at the wastewater treatment plant. Following treatment, the effluent is discharged to the Delaware River via Outfall 107 and Outfall 108. Non-contact cooling water is discharged via Outfall 007 and Outfall 008. The stormwater drainage collects surface runoff from uncontaminated areas and discharges directly into the Delaware River via Outfalls 010, 013, and 014 and into Crum Creek via Outfalls 001, 002, 004, and 005. National Pollutant Discharge Elimination System (NPDES) permit number PA0013714 regulates the outfalls. All stormwater that is collected in diked areas is inspected before being pumped into the stormwater drainage system and then discharged directly to the Delaware River or Crum Creek. The sewage collection serves all sanitary systems within the facility. This system drains to the municipal system.

Description of Stormwater Outfalls and Stream Mapping

Outfall 001 – Location noted on Site map provided in Figure 2. Discharge consists of stormwater from the parking lot.

Outfall 002 – Location noted on Site map provided in Figure 2. Discharge consists of stormwater runoff.

Outfall 004 – Location noted on Site map provided in Figure 2. Discharge consists of stormwater runoff and demineralized water supply tank effluent.

Outfall 005 – Location noted on Site map provided in Figure 2. Discharge consists of non-contact cooling water and stormwater runoff. Runoff from the SO2 plant area, which includes four transformers, enters this outfall.

Outfall 007 – Location noted on Site map provided in Figure 2. Discharge consists of non-contact cooling water.

Outfall 107 – Location noted on Site map provided in Figure 2. Discharge consists of water from the wastewater treatment plant.

Outfall 008 – Location noted on Site map provided in Figure 2. Discharge consists of non-contact cooling water.

Outfall 108 – Location noted on Site map provided in Figure 2. Discharge consists of water from the wastewater treatment plant.

Outfall 010 – Location noted on Site map provided in Figure 2. Discharge consists of non-contact cooling water and groundwater. Runoff from the electrical yards and fuel oil storage area.

Outfall 013 – Location noted on Site map provided in Figure 2. Discharge consists of stormwater runoff.

Outfall 014 – Location noted on Site map provided in Figure 2. Discharge consists of stormwater runoff from the roof drains.

Incident History

Eddystone Generating Station has had the following incidents related to oil or coal ash from 1975 through 2003. No incidents were related to the release of PCB's.

- On August 29, 1975 a truck delivery overfilled a storage tank spilling 3,000 gallons of lubricating oil. There was no environmental damage.
- On August 12, 1982 an oil sheen was noticed on the Delaware River (a navigable waterway) in the forebay area. The Waste Water Treatment Plant (WWTP) holding tank overflow and entering a nearby yard drain was the suspected cause. Booms were used to contain the sheen and there was no environmental damage.
- On December 11, 1984 and March 13, 1985 coal ash-laden water was discharged into the Delaware River from the ash house area. There was no environmental damage.
- On June 4, 1985, October 18, 1985, November 27, 1985, and February 21, 1986 oil spills of ½ gallon, 1 gallon, 1 gallon, and less than 1 gallon respectively occurred from outfall 003. The spills were caused by coke located in a settling pit associated with outfall 003 becoming saturated with oil and then carrying over into outfall 003. There was no environmental damage.
- On September 1, 1988 approximately 2 gallons of oily water overflowed the 1/2B settling pit resulting in a sheen on Crum Creek. No oil reached navigable waters and there was no environmental damage.
- On October 2, 1989 approximately 10 gallons of oily water escaped the1/2 oily water pits. This was caused by torrential rains flooding the area the same morning. Most of the material drained back to the oily water pits resulting in no environmental damage.
- On January 22, 1991, 1 gallon of #2 fuel oil entered a storm drain catch basin due to a faulty pressure regulator on the #2 oil system. No oil was observed in the discharge of the drain system. No oil reached navigable waters. There was no environmental damage.
- On June 18, 1992, 10 to 20 gallons of #6 fuel oil spilled into the Delaware River when the chicksan-unloading arm was lowered into the Delaware River due to a failure in the hydraulics, which controls the arm. This happened while attempting to connect a fuel barge to the unloading boom at the #2 dolphin. Ninety percent of the oil was captured by containment boom. The oil sheen on the Delaware River was removed by dragging an adsorbent boom through the water with workboats.
- On April 13, 1993 an oily sheen 0.5-2 feet wide by 100-200 yards long was observed on Crum Creek. The source of the sheen was outfall 005. The sheen did not reach navigable waters. The entire sheen was remediated by deploying containment and absorbent booms at outfall 005 and in the creek.

An inspection of all areas, which feed outfall 005, identified no abnormal conditions.

- On April 26, 1993 a small oil sheen was observed exiting outfall 005 and lasted approximately one hour. The sheen was cleaned up. The exact cause could not be found, however, it is suspected that the station water truck inadvertently washed road oil into a drain.
- On July 14, 1994 a failed sensing gauge at the #3/4 oil transfer pad resulted in a spill of approximately 12,000 gallons of #6 oil. An estimated 1,000 gallons entered the Delaware River. Secondary containment was effective until a severe rainfall flooded the area and carried the spilled oil into the storm drain system. Vendor assistance was employed to clean up the spilled oil and remediate all contaminated boats, docks, and piers at nearby marinas.
- On August 24, 1994 a small rainbow sheen on the Delaware River was created by oily water in outfall 010. The cause of the sheen was a faulty sump pump check-valve. Station personnel immediately cleaned up the sheen.
- On November 2, 1994 outfall 010 contained approximately 1 gallon of #2 fuel oil. The fuel oil spilled while draining a fuel oil pipe. There was no environmental damage.
- On October 25, 1995, a small oil sheen approximately 10 feet by 50 feet was observed on the Delaware River. The sheen was cleaned up using absorbent booms and vendor assistance was used to remediate 148 cubic yards of soil around the fuel oil pump house (FOPH). The spill was caused by a clogged discharge pipe in the FOPH sump resulting in the release of approximately 25-50 gallons of #2 fuel oil. A small amount of the oil entered a nearby yard drain which discharges to the Delaware River.
- On February 2, 1996, approximately 1000 gallons of turbine lube oil was released from the 22B lube oil cooler. The cooler is a non-contact heat exchanger that uses river water to cool the turbine lube oil. As a result of the leak, oil was released with the cooling water into the Delaware River, resulting in a large sheen. Vendor assistance was employed during clean-up operations. No environmental damage was observed.
- On January 27, 1997 approximately 500 gallons of Sulzer oil was released from the 1B Sulzer oil cool (SOC). The cooler is a non-contact heat exchanger that uses river water to cool the Sulzer oil. The leak allowed oil to pass into the cooling water and discharge into the Delaware River via outfall 007. No sheening was observed, as the Sulzer oil is heavier than water. The United States Coast Guard (USCG) concluded that no clean up could be carried out. No environmental damage or impact was observed.
- On February 6, 1997 the Unit 1&2 wash down sump overflowed, carrying river water with coal ash into two stormdrains affecting NPDES outfalls 004 and 005. The cause of the overflow was a failed sump pump. No environmental damage was observed.

- On February 27, 1997 the Unit 1&2 wash down sump overflowed, carrying river water and coal ash into one storm drain affecting NPDES outfall 005. The cause of the overflow was a diversion of process water to perform maintenance on the wash down sump pumps. No environmental damage was observed.
- On July 25, 1997 approximately 100 gallons of #6 fuel oil leaked from the #2 dolphin unloading pipe on-land near the A storage tank. An oil spill removal organization (OSRO) cleaned-up the spill and all impacted soil. None of the oil reached the storm drains or waterways.
- On August 19, 1997 approximately 100 gallons of lubricating oil was released over a ten-day period into the Delaware River through outfall 008. The cause of the release was a leak in the unit #4 main boiler feed pump oil cooler. There was no visible sheen on the river at any time. No environmental damage was observed during the incident.
- On March 23, 1998 approximately 500 gallons of #6 oil was spilled onto the roadway near the WWTP when the #2 dolphin transfer pipe burst. No oil entered the storm drains or the Delaware River. No environmental damage was observed.
- On May 20, 1998 approximately 50 gallons of #6 oil spilled onto the ground from the #2 dolphin unloading pipe during repairs. The repair vendor performed all clean-up duties. No environmental damage was observed during the incident.
- On January 25, 2005 a #2 fuel oil leak was discovered in the area of the coal pile. The supply line was isolated, tested and removed from service. Remediation is being performed in the area of the release under current regulations.

4. Known Sources

Rule Section 4.30.9.E.4

The facility currently has 24-precipitator transformers and 13 circuit breakers owned by Exelon Power. The #1 and #2 electrostatic precipitators contain the 24-precipitator transformers. These transformers are installed in a steel housing capable of containing the oil contents of each of the transformers it houses. Four transformers are located near the SO2 plant. These transformers are located on a paved area near a storm drain. The remaining equipment is located in the electrical yard areas. These areas are covered in stone and there are no drains near any of the transformers. One of the transformers has a dike surrounding it to help contain spills. The other units have no secondary containment. Table 1 contains a list of the equipment that contains PCBs and the latest concentrations of PCBs.

The transformers and circuit breakers have been tested for PCBs, and are known to contain varying amounts. The oil in each of the electrical units is mineral oil containing low levels of PCBs. However, in the past the units had been filled with oils containing much higher concentrations of PCBs. Units that contained high levels of PCBs were drained and refilled with non-PCB oils. There has been continued sampling done on the units to ascertain the current PCB levels of the mineral oil inside the units. The most recent results for each of the transformers and circuit breakers can be found in Table 1.

5.0 Potential Sources

Rule Section 4.30.9.E.5 and 4.30.9.E.6

There is other equipment onsite that could possibly contain fluids that contain PCBs. Oil filled cables run within the substations before traveling underground. The oil within these cables has never been tested for PCBs. There is also a storage shed located in the electrical yard that encloses a 5,000-gallon storage tank that holds dielectric fluid. This equipment has been tested and does not contain PCB's.

Historical onsite activities may have caused impact to the soil. A list of incidents that occurred onsite that resulted in the spilling of oils can be found in Section 2.5 Incident History. Other historic activities that may have resulted in PCBs being released to the river are old process units that have been removed, the improper disposal of chemicals onsite, using oils for dust suppression prior to the site being used for electrical generation, waste storage, and leaking electrical equipment. Areas that may have been affected by this are the soils surrounding old process equipment, waste storage areas, transformers, circuit breakers, old dirt roads, parking lots, and areas impacted by spills. Some other affected areas could be stormwater retention areas and areas of high solids loading.

Other uses of PCBs include paints, lubrication oils, hydraulic oils, and light ballasts. Any areas at the facility that may have been impacted by paint over spray or spilling, hydraulic fluid leaks, lubricating oil leaks, or leaking light ballasts are also possible sources. These are known possible sources that should be investigated and a determination made as to whether PCB contamination could occur from any of these sources. This can be verified by past analysis, closure or removal reports, remediation reports, or a lack of physical evidence such as staining.

Offsite Sources

Offsite sources may also contribute to an increase in PCBs discharged from the facility to the river. Deposition (both wet and dry) may occur at the site. These PCBs can be transported to the drainage system during rain events. Water that is brought onsite and used in the processes or buildings may also contain PCBs. Upstream facilities that use or have used PCBs are possible contributors to the PCB levels in the river. This water is brought into the facility through the intake at the river. Currently, water that is taken from the river is analyzed. However, municipal water that is used is not currently analyzed. The Maximum Contaminant Level for PCBs in drinking water allowed by the EPA is 0.5 parts per billion. Any groundwater used may also contain PCBs. Spills that have occurred offsite may also affect the amount of PCBs discharged by the facility. Any chemicals that have been spilled at nearby facilities could migrate onto the facility property soil or water system and cause impacts to the outfall PCB levels.

If a net increase of PCBs discharged to the river is shown in the initial review and additional source characterization is needed, then a statistical analysis and/or an analysis of the specific PCB congeners of additional data to be collected can be done to identify areas of significant increases. If no significant difference is noted, then a trackdown study is not necessary. However, if there is a significant difference then a trackdown study would be needed.

6. Previous Minimization Activities

Rules Section 4.30.9.E.7

Eddystone Generating Station has worked to prevent the release of PCB’s. As an industry where discharges have been covered by the National Pollutant Discharge Eliminations System (NPDES) and the Steam Electric Guidelines (40 CFR Part 423’ Section 12’ Paragraph (b)(2)) – “There shall be no discharge of polychlorinated biphenyl compounds such as those commonly used for transformer fluid”. Exelon Corporation has a monitoring program in place to sample and analyze transformer fluid. The monitoring has been performed at least every two years to monitor PCB concentrations. This program has been monitoring the transformer fluid condition for over 10 years.

7. Pollutant Minimization Measures

Rule Section 40.3.9.E.9

7.1 Actions to Minimize Known and Possible Sources

The facility currently has 24-precipitator transformers and 13 circuit breakers owned by Exelon Power. The #1 and #2 electrostatic precipitators contain the 24-precipitator transformers. These transformers are installed in a steel housing capable of containing the oil contents of each of the transformers it houses. Four transformers are located near the SO2 plant. These transformers are located on a paved area near a storm drain. The remaining equipment is located in the electrical yard areas. These areas are covered in stone and there are no drains near any of the transformers. One of the transformers has a dike surrounding it to help contain spills. The other units have no secondary containment. Table 1 contains a list of the equipment that contains PCBs and the latest concentrations of PCBs.

Regular inspections are performed on the existing transformers as SPCC management and inspections of PCB transformers.

The two auxiliary transformers that contained PCB’s have been retro-filled with PCB oil containing less than 2 ppm PCB’s. The 401E1 Auxiliary Transformers has been sampled after retrofill and has a present concentration of 61 ppm. This transformer will be declassified to PCB containing. The 301E1 Auxiliary Transformers has been sampled and is presently 47 ppm. There are no PCB transformers presently on the site.

7.2 Actions to Identify and Control Potential Sources

Eddystone Generating Station is investigating the presence of PCB runoff from Outfall 001. Outfall 001 is a stormwater only outfall. The piping will be cleaned by hydrolazing. Following hydrolazing the storm event will be evaluated against historical samples from Outfall 001. The evaluation will include average storm event PCB concentrations from the Philadelphia area and also deposition of PCB's as evaluated by Rutgers University.

The wastewater treatment plant effluent will be analyzed and evaluated for the presents of PCB's. The wastewater plant is the only influent stream to mix with the Eddystone once-through non-contact cooling water system. Based on the analytical results a trackdown study of the influent waste streams will be evaluated.

8. Source Prioritization

Rule Section 40.3.9.E.10

To date Eddystone has not been able to identify any sources of PCB's with the exception of external environmental sources that contribute to the loading at the outfall. Based future sampling results Eddystone will evaluate potential sources and investigate. This information will be documented in the annual progress report.

9. Key Dates

Rule Section 40.3.9.E.11

The cleaning of Outlet 001 is scheduled to be complete by November 11, 2005 and the sampling will be performed at the next qualified rain event. Cleaning has been performed and a sample is scheduled for the next rain event.

10. Measuring, Demonstrating and Reporting Progress

Rule Sections 40.3.9.E.12 and 40.3.9.E.13

10.1 Sampling and Analytical Approaches

Eddystone will be using the Delaware River Basin approved sampling methodology to obtain and analyze sample. Although not expected should levels in from the wastewater treatment be elevated alternate analytical methods would be chosen for a trackdown study to ensure data is reliable.

10.2 Estimated Baseline Load

The estimated baseline for Eddystone Generating Station is listed in the Phase I PCB TMDL developed by the Delaware River Basin Commission implemented by EPA Regions II and III. For Outfall 001 the baseline is .064 mg/day, this outfall is comprised of 100 percent stormwater. Outfall 005 is a combination of stormwater and non-contact cooling water. The ration of non-contact cooling water to stormwater is estimated to be 95 percent non-contact cooling water to 5 percent stormwater during rain events therefore no loading is listed. All other stormwater is discharged below river level and therefore not sampled.

10.3 Anticipated Reductions to Baseline Load

Without any knowledge of potential sources of active PCB leakage, an anticipated reduction from baseline cannot be estimated. The cleaning of stormdrains to remove sediments should reduce the source of PCB's that are attached to the sediment. The final outcome should be equivalent to rain water plus any atmospheric deposition.

10.4 Continuing Assessment

Best Management Practices (BMPs) will be evaluated at the Site for economical and technical feasibility. Some of the items listed below may already be occurring as BMPs, whereas, others have yet to be evaluated for applicability once additional information on the topics are reviewed.

1. Evaluate spill control plans, emergency response and Integrated Contingency Plans submitted to regulators that identify spill clean-up procedures, to make sure that they address potential PCB containing wastes and the proper clean-up and disposal of such waste streams.
2. Evaluate sediment control practices including potential asphalting, capping, vegetation planting and the addition of rip-rap for PCB "hot spots".
3. Evaluate the potential to improve the performance of existing WWTP equipment to optimize suspended solids and hydrocarbon removal efficiency.
4. Evaluate the Site for the potential installation of additional WWTP tertiary treatment equipment to improve suspended solids and hydrocarbon removal efficiency. Examples include effluent sand filtration.
5. Evaluate permanent or temporary containment of potential sources to prevent run-off.
6. Evaluate options for managing PCB containing equipment.
7. Evaluate replacement of high PCB content transformer oils to reduce potential spill impacts. If a maintenance reason exists for replacement of PCB containing transformer oils such as high moisture content, low dielectric strength or high acidity levels, a PCB remediation process would be undertaken and the PCB contaminated oil would be removed, properly disposed of and replaced with non-PCB containing oil.

8. Evaluate compliance with 40CFR §761 with identification, monitoring, containment, removal and replacement of PCB containing electrical equipment. Appendix B contains 40 CFR §761.
9. Evaluate analysis and disposal plans for excavated hydrocarbon contaminated soils, for example: analysis of excavated hydrocarbon contaminated soils for PCB contamination, cover & containment to reduce potential run-off concerns.
10. Any excavated soil containing PCB's above the State industrial re-use standards is taken off site for proper treatment and disposal.
11. Evaluate potential storm water collection and treatment vs. direct discharge.
12. Evaluate treatment costs vs. analysis or trackdown costs for small streams or high PCB individual streams.
13. Evaluate inspection, operation and maintenance procedures for monitoring effectiveness of existing or implemented BMPs. An example of inspection and maintenance of PCB-containing equipment from the Federal Register is included in Appendix C.
14. BMP Sources (documents in Appendix D)

Various web sources are available and can be utilized for identifying additional BMPs or for further information on existing BMP possibilities. Some of the identified websites include:

- http://www.forester.net/sw-0011-right.html
- http://www.forester.net/sw-0109-whatever.html

Proper disposal methods for the following items are taken from the EPA regulations for the Toxics Substance Control Act 40 CFR §761. These are some possible PCB contaminated items, which may require appropriate disposal under TSCA.

11. References

Delaware River Basin Commission, Resolution 2003-27. http://www.state.nj.us/drbc/Res2003-27.htm. 12/3/03.

Delaware River Basin Commission. September 2003. U.S. Environmental Protection Agency Regions II and III Total Maximum Daily Loads for Polychlorinated Biphenyls (PCBs) for Zones 2-5 of the Tidal Delaware River.

Health Effects of PCBs. http://www.epa.gov/oppt/pcb/effects.html. 6/24/02.

Integrated Contingency Plan, Eddystone Station version. 6/10/03.

List of Drinking Water Contaminants and MCLs. http://www.epa.gov/safewater/mcl.html#mcls. 8/13/03.

The Control of PCB-containing Equipment. http://www.plpsd.mb.ca/division/the.htm. 2/14/00.

Various Agencies. April 2003. Reducing PCB Loadings to the Delaware Estuary: A Staged Approach to Establishing TMDLs.

TABLE 1

TRANSFORMER	PCB Concentration (ppm)	Gallons
10A AUX TRANSFORMER	20.00	4800
10B AUX TRANSFORMER	8.00	2155
11 AUX POWER TRANSFORMER	53.00	1980
12 AUX POWER TRANSFORMER	1.00	1980
20A AUX TRANSFORMER	21.00	4800
20B AUX TRANSFORMER	11.00	2155
21 AUX POWER TRANSFORMER	19.00	1980
22 AUX POWER TRANSFORMER	13.00	1980
#3 TRANSFORMER	1.00	17500
#4 TRANSFORMER	5.00	17500
1A MAIN TRANSFORMER	4.00	8460
1B MAIN TRANSFORMER	4.00	8460
2A MAIN TRANSFORMER	12.00	10060
2B MAIN TRANSFORMER	7.00	10060
10 STATION POWER TRANSFORMER	1.00	6030
10B4 AUX TRANSFORMER	19.00	446
20 STATION POWER TRANSFORMER	1.00	6030
20B4 AUX TRANSFORMER	21.00	446
30 TRANSFORMER	1.00	11700
34H TRANSFORMER	1.00	8684
34L TRANSFORMER	1.00	4245
304E1 AUX TRANSFORMER	47.00	229
40 TRANSFORMER	1.00	11700
401E1 AUX TRANSFORMER	61.00	229
105 CIRCUIT BREAKER	3.00	3300
105 CIRCUIT BREAKER	4.00	3300
110 CIRCUIT BREAKER	13.00	220
110 CIRCUIT BREAKER	15.00	220
110 CIRCUIT BREAKER	17.00	220
15 CIRCUIT BREAKER	5.00	3000
15 CIRCUIT BREAKER	6.00	3000
205 CIRCUIT BREAKER	17.00	3300
205 CIRCUIT BREAKER	18.00	3300
205 CIRCUIT BREAKER	19.00	3300
210 CIRCUIT BREAKER	23.00	220
210 CIRCUIT BREAKER	27.00	220
25 CIRCUIT BREAKER	15.00	2622