

In the Matter of:

Entergy Nuclear Operations, Inc.  
(Indian Point Nuclear Generating Units 2 and 3)

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*Protecting People and the Environment*

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Vol. 1

# Generic Environmental Impact Statement for License Renewal of Nuclear Plants

## Supplement 38

### Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3

### Final Report Main Report and Comment Responses

Office of Nuclear Reactor Regulation

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# **Generic Environmental Impact Statement for License Renewal of Nuclear Plants**

## **Supplement 38**

### **Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3**

### **Final Report Main Report and Comment Responses**

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# ABSTRACT

1  
2 The U.S. Nuclear Regulatory Commission (NRC) considered the environmental impacts of  
3 renewing nuclear power plant operating licenses for a 20-year period in NUREG-1437,  
4 Volumes 1 and 2, "Generic Environmental Impact Statement for License Renewal of Nuclear  
5 Plants" (hereafter referred to as the GEIS),<sup>(1)</sup> and codified the results in Title 10, Part 51,  
6 "Environmental Protection Regulations for Domestic Licensing and Related Regulatory  
7 Functions," of the *Code of Federal Regulations* (10 CFR Part 51). In the GEIS (and its  
8 Addendum 1), the NRC staff identified 92 environmental issues and reached generic  
9 conclusions related to environmental impacts for 69 of these issues that apply to all plants or to  
10 plants with specific design or site characteristics. Additional plant-specific review is required for  
11 the remaining 23 issues. These plant-specific reviews are to be included in a supplement to the  
12 GEIS.

13 This supplemental environmental impact statement (SEIS) has been prepared in response to an  
14 application submitted to the NRC by Entergy Nuclear Operations, Inc. (Entergy), Entergy  
15 Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC (all applicants will be  
16 jointly referred to as Entergy) to renew the operating licenses for Indian Point Nuclear  
17 Generating Unit Nos. 2 and 3 (IP2 and IP3) for an additional 20 years under 10 CFR Part 54,  
18 "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." This SEIS  
19 includes the NRC staff's analysis which considers and weighs the environmental impacts of the  
20 proposed action, the environmental impacts of alternatives to the proposed action, and  
21 mitigation measures available for reducing or avoiding adverse impacts. It also includes the  
22 NRC staff's recommendation regarding the proposed action.

23 Regarding the 69 issues for which the GEIS reached generic conclusions, neither Entergy nor  
24 the NRC staff has identified information that is both new and significant for any issues that apply  
25 to IP2 and/or IP3. In addition, the NRC staff determined that information provided during the  
26 scoping process was not new and significant with respect to the conclusions in the GEIS.  
27 Therefore, the NRC staff concludes that the impacts of renewing the operating licenses for IP2  
28 and IP3 will not be greater than the impacts identified for these issues in the GEIS. For each of  
29 these issues, the NRC staff's conclusion in the GEIS is that the impact is of SMALL<sup>(2)</sup>  
30 significance (except for the collective offsite radiological impacts from the fuel cycle and high-  
31 level waste and spent fuel, which were not assigned a single significance level).

32 Regarding the remaining 23 issues, those that apply to IP2 and IP3 are addressed in this SEIS.  
33 The NRC staff determined that several of these issues were not applicable because of the type  
34 of facility cooling system or other reasons detailed within this SEIS. For the remaining  
35 applicable issues, the NRC staff concludes that the significance of potential environmental  
36 impacts related to operating license renewal is SMALL, with three exceptions—entrainment,  
37 impingement, and heat shock from the facility's heated discharge. Overall effects from  
38 entrainment and impingement are likely to be MODERATE. Impacts from heat shock potentially

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(1) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

(2) Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

## Abstract

1 range from SMALL to LARGE depending on the conclusions of thermal studies proposed by the  
2 New York State Department of Environmental Conservation (NYSDEC). Based on corrected  
3 data received since completing the draft SEIS, NRC staff concludes that impacts to the  
4 endangered shortnose sturgeon – which ranged from SMALL to LARGE in the draft SEIS – are  
5 likely to be SMALL.

6 The NRC staff's recommendation is that the Commission determine that the adverse  
7 environmental impacts of license renewals for IP2 and IP3 are not so great that preserving the  
8 option of license renewal for energy planning decision makers would be unreasonable. This  
9 recommendation is based on (1) the analysis and findings in the GEIS, (2) the environmental  
10 report and other information submitted by Entergy, (3) consultation with other Federal, State,  
11 Tribal, and local agencies, (4) the NRC staff's own independent review, and (5) the NRC staff's  
12 consideration of public comments received during the scoping process and in response to the  
13 draft SEIS.

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# EXECUTIVE SUMMARY

1  
2 By letter dated April 30, 2007, Entergy Nuclear Operations, Inc. (Entergy) submitted an  
3 application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating licenses  
4 for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) for an additional 20-year  
5 period. If the operating licenses are renewed, State regulatory agencies and Entergy will  
6 ultimately decide whether the plant will continue to operate based on factors such as the need  
7 for power, issues falling under the purview of the owners, or other matters within the State's  
8 jurisdiction, including acceptability of water withdrawal. Two state-level issues (consistency with  
9 State water quality standards, and consistency with State coastal zone management plans)  
10 need to be resolved. On April 2, 2010, the New York State Department of Environmental  
11 Conservation (NYSDEC) issued a Notice of Denial regarding the Clean Water Act Section 401  
12 Water Quality Certification. Entergy has since requested a hearing on the issue, and the matter  
13 will be decided through NYSDEC's hearing process. If the operating licenses are not renewed,  
14 then IP2 and IP3 must be shut down at or before the expiration date of their current operating  
15 licenses which expire September 28, 2013, and December 12, 2015, respectively.

16 The NRC has implemented Section 102 of the National Environmental Policy Act of 1969, as  
17 amended (42 U.S.C. 4321), in Title 10, Part 51, "Environmental Protection Regulations for  
18 Domestic Licensing and Related Regulatory Functions," of the *Code of Federal Regulations*  
19 (10 CFR Part 51). In 10 CFR 51.20(b)(2), the Commission requires preparation of an  
20 environmental impact statement (EIS) or a supplement to an EIS for renewal of a reactor  
21 operating license. In addition, 10 CFR 51.95(c) states that the EIS prepared at the operating  
22 license renewal stage will be a supplement to NUREG-1437, Volumes 1 and 2, "Generic  
23 Environmental Impact Statement for License Renewal of Nuclear Plants" (hereafter referred to  
24 as the GEIS).<sup>(1)</sup>

25 Upon acceptance of the IP2 and IP3 application, the NRC began the environmental review  
26 process described in 10 CFR Part 51 by publishing a notice of intent to prepare an EIS and  
27 conduct scoping. The NRC staff visited the IP2 and IP3 site in September 2007, held two public  
28 scoping meetings on September 19, 2007, and conducted two site audits on September 10–14,  
29 2007, and September 24–27, 2007. In the preparation of this supplemental environmental  
30 impact statement (SEIS) for IP2 and IP3, the NRC staff reviewed the IP2 and IP3 environmental  
31 report (ER) and compared it to the GEIS; consulted with other agencies; conducted an  
32 independent review of the issues following the guidance in NUREG-1555, "Standard Review  
33 Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License  
34 Renewal," issued October 1999; and considered the public comments received during the  
35 scoping process and in response to the draft SEIS. The public comments received during the  
36 scoping process that were considered to be within the scope of the environmental review are  
37 contained in the Scoping Summary Report for Indian Point Nuclear Generating Unit Nos. 2 and  
38 3, issued by NRC staff in December 2008. In Appendix A of this SEIS, the NRC staff adopts, by  
39 reference, the comments and responses in the Scoping Summary Report and provides  
40 information on how to electronically access the scoping summary or view a hard copy.

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<sup>(1)</sup> The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.



1 The NRC staff held public meetings in Cortlandt Manor, New York, on February 12, 2009 and  
2 described the preliminary results of the NRC environmental review, answered questions, and  
3 provided members of the public with information to assist them in formulating comments on the  
4 draft SEIS. The NRC staff considered and addressed all of the comments received. These  
5 comments are reflected in the SEIS or addressed in Appendix A, Part 2, to this SEIS.

6 This SEIS includes the NRC staff's analysis that considers and weighs the environmental  
7 effects of the proposed action, the environmental impacts of alternatives to the proposed action,  
8 and mitigation measures for reducing or avoiding adverse effects. It also includes the NRC  
9 staff's recommendation regarding the proposed action.

10 The Commission has adopted the following statement of purpose and need for license renewal  
11 from the GEIS:

12 The purpose and need for the proposed action (renewal of an operating license)  
13 is to provide an option that allows for power generation capability beyond the  
14 term of a current nuclear power plant operating license to meet future system  
15 generating needs, as such needs may be determined by State, utility, and, where  
16 authorized, Federal (other than NRC) decision makers.

17 The purpose of the NRC staff's environmental review, as defined in 10 CFR 51.95(c)(4) and the  
18 GEIS, is to determine the following:

19 ...whether or not the adverse environmental impacts of license renewal are so  
20 great that preserving the option of license renewal for energy planning decision  
21 makers would be unreasonable.

22 Both the statement of purpose and need and the evaluation criterion implicitly acknowledge that  
23 there are factors, in addition to license renewal, that will ultimately determine whether an  
24 existing nuclear power plant continues to operate beyond the period of the current operating  
25 license (or licenses).

26 NRC regulations (10 CFR 51.95(c)(2)) contain the following statement regarding the content of  
27 SEISs prepared at the license renewal stage:

28 The supplemental environmental impact statement for license renewal is not  
29 required to include discussion of need for power or the economic costs and  
30 economic benefits of the proposed action or of alternatives to the proposed  
31 action except insofar as such benefits and costs are either essential for a  
32 determination regarding the inclusion of an alternative in the range of alternatives  
33 considered or relevant to mitigation. In addition, the supplemental environmental  
34 impact statement prepared at the license renewal stage need not discuss other  
35 issues not related to the environmental effects of the proposed action and the  
36 alternatives, or any aspect of the storage of spent fuel for the facility within the  
37 scope of the generic determination in 10 CFR 51.23(a) ["Temporary storage of  
38 spent fuel after cessation of reactor operation—generic determination of no  
39 significant environmental impact"] and in accordance with 10 CFR 51.23(b).

40 The GEIS contains the results of a systematic evaluation of the consequences of renewing an  
41 operating license and operating a nuclear power plant for an additional 20 years. It evaluates  
42 92 environmental issues using the NRC's three-level standard of significance—SMALL,  
43 MODERATE, or LARGE—developed using the Council on Environmental Quality (CEQ)

Executive Summary

1 guidelines.

2 The following definitions of the three significance levels are set forth in footnotes to Table B-1 of  
3 Appendix B, "Environmental Effect of Renewing the Operating License of a Nuclear Power  
4 Plant," to 10 CFR Part 51, Subpart A, "National Environmental Policy Act—Regulations  
5 Implementing Section 102(2)":

6 SMALL—Environmental effects are not detectable or are so minor that they will  
7 neither destabilize nor noticeably alter any important attribute of the resource.

8 MODERATE—Environmental effects are sufficient to alter noticeably, but not to  
9 destabilize, important attributes of the resource.

10 LARGE—Environmental effects are clearly noticeable and are sufficient to  
11 destabilize important attributes of the resource.

12 For 69 of the 92 issues considered in the GEIS, the analysis in the GEIS reached the following  
13 conclusions:

14 (1) The environmental impacts associated with the issue have been determined to apply  
15 either to all plants or, for some issues, to plants having a specific type of cooling system  
16 or other specified plant or site characteristics.

17 (2) A single significance level (that is, SMALL, MODERATE, or LARGE) has been assigned  
18 to the impacts (except for collective offsite radiological impacts from the fuel cycle and  
19 from high-level waste and spent fuel disposal).

20 (3) Mitigation of adverse impacts associated with the issue has been considered in the  
21 analysis, and it has been determined that additional plant-specific mitigation measures  
22 are not likely to be sufficiently beneficial to warrant implementation.

23 These 69 issues were identified in the GEIS as Category 1 issues. In the absence of new and  
24 significant information, the staff relied on conclusions in the GEIS for issues designated as  
25 Category 1 in Table B-1 of Appendix B to 10 CFR Part 51, Subpart A.

26 Of the 23 issues that do not meet the criteria set forth above, 21 are classified as Category 2  
27 issues requiring analysis in a plant-specific supplement to the GEIS. The remaining two issues,  
28 environmental justice and chronic effects of electromagnetic fields, were not categorized.  
29 Environmental justice was not evaluated on a generic basis and must be addressed in a plant-  
30 specific supplement to the GEIS. Information on the chronic effects of electromagnetic fields  
31 was not conclusive at the time the GEIS was prepared.

32 This SEIS documents the NRC staff's consideration of all 92 environmental issues identified in  
33 the GEIS. The NRC staff considered the environmental impacts associated with alternatives to  
34 license renewal and compared the environmental impacts of license renewal and the  
35 alternatives. The alternatives to license renewal that were considered include the no-action  
36 alternative (not renewing the operating licenses for IP2 and IP3), alternative methods of power  
37 generation, and conservation. The NRC staff also considered an alternative that included  
38 continued operation of IP2 and IP3 with a closed-cycle cooling system. This alternative is  
39 considered for several reasons. First, the New York State Department of Environmental  
40 Conservation (NYSDEC) issued a preliminary determination in its 2003 draft and 2004 revised  
41 draft State Pollutant Discharge Elimination System (SPDES) permits that closed cycle cooling is  
42 the site-specific best technology available (BTA) to reduce impacts on fish and shellfish;

1 | currently the revised draft SPDES permit is the subject of NYSDEC proceedings, and the  
2 | existing SPDES permit continues in effect at this time. Second, NYSDEC affirmed this view in  
3 | its April 2, 2010, Notice of Denial of Entergy's Clean Water Act Section 401 Water Quality  
4 | Certification, indicating that closed cycle cooling would minimize aquatic impacts; that  
5 | determination is currently subject to further State-level adjudication. Third, NYSDEC has  
6 | published a draft policy on BTA indicating that "Wet closed-cycle cooling or its equivalent" is the  
7 | "minimum performance goal for existing industrial facilities that operate a CWIS [cooling water  
8 | intake system] in connection with a point source thermal discharge." Public comments on that  
9 | draft policy were submitted through July 9, 2010.

10 | Entergy and the NRC staff have established independent processes for identifying and  
11 | evaluating the significance of any new information on the environmental impacts of license  
12 | renewal. Neither Entergy nor the staff has identified information that is both new and significant  
13 | related to Category 1 issues that would call into question the conclusions in the GEIS. Similarly,  
14 | neither the scoping process nor the NRC staff has identified any new issue applicable to IP2  
15 | and IP3 that has a significant environmental impact. Therefore, the NRC staff relies on the  
16 | conclusions of the GEIS for all of the Category 1 issues that are applicable to IP2 and IP3.

17 | Entergy's license renewal application presents an analysis of the 21 Category 2 issues that are  
18 | applicable to IP2 and IP3, plus environmental justice and chronic effects from electromagnetic  
19 | fields, for a total of 23 issues. The NRC staff has reviewed the Entergy analysis and has  
20 | conducted an independent assessment of each issue. Six of the Category 2 issues are not  
21 | applicable because they are related to a type of existing cooling system, water use conflicts,  
22 | and ground water use not found at IP2 and IP3. Entergy has stated that its evaluation of  
23 | structures and components, as required by 10 CFR 54.21, "Contents of Application—Technical  
24 | Information," did not identify any major plant refurbishment activities or modifications as  
25 | necessary to support the continued operation of IP2 and IP3 for the license renewal period.  
26 | Entergy did, however, indicate that it plans to replace reactor vessel heads and control rod drive  
27 | mechanisms at IP2 and IP3. The NRC staff has evaluated the potential impacts of these  
28 | activities using the framework provided by the GEIS for addressing refurbishment issues.

29 | Seventeen environmental issues related to operational impacts and postulated accidents during  
30 | the renewal term are discussed in detail in this SEIS. These include 15 Category 2 issues and  
31 | 2 uncategorized issues, environmental justice and chronic effects of electromagnetic fields. The  
32 | NRC staff also discusses in detail the potential impacts related to the 10 Category 2 issues that  
33 | apply to refurbishment activities. The NRC staff concludes that the potential environmental  
34 | effects for most of these issues are of SMALL significance in the context of the standards set  
35 | forth in the GEIS with three exceptions—entrainment, impingement, and heat shock from the  
36 | facility's heated discharge. The NRC staff jointly assessed the impacts of entrainment and  
37 | impingement to be MODERATE based on NRC's analysis of representative important species.  
38 | Impacts from heat shock potentially range from SMALL to LARGE depending on the  
39 | conclusions of thermal studies proposed by the NYSDEC. Based on corrected data received  
40 | since completing the draft SEIS, the NRC staff concludes that impacts to the endangered  
41 | shortnose sturgeon – which ranged from SMALL to LARGE in the draft SEIS – are likely to be  
42 | SMALL.

43 | The NRC staff also determined that appropriate Federal health agencies have not reached a  
44 | consensus on the existence of chronic adverse effects from electromagnetic fields. Therefore,  
45 | no further evaluation of this issue is required.

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1 For severe accident mitigation alternatives (SAMAs), the staff concludes that a reasonable,  
2 comprehensive effort was made to identify and evaluate SAMAs. Based on its review of the  
3 SAMAs for IP2 and IP3 and the plant improvements already made, the NRC staff concludes that  
4 several SAMAs may be cost-beneficial. However, these SAMAs do not relate to adequate  
5 management of the effects of aging during the period of extended operation. Therefore, they do  
6 not need to be implemented as part of license renewal pursuant to 10 CFR Part 54,  
7 “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.”

8 Cumulative impacts of past, present, and reasonably foreseeable future actions were  
9 considered, regardless of what agency (Federal or non-Federal) or person undertakes such  
10 other actions. For purposes of this analysis, the NRC staff determined that the cumulative  
11 impacts to terrestrial and aquatic resources in the IP2 and IP3 environs would be LARGE, due  
12 primarily to past development and pollution, much of which preceded IP2 and IP3 or occurred  
13 as a result of other actions (for example, suburban development and hardening of the Hudson  
14 River shoreline).

15 The NRC staff’s analysis indicates that the adverse impacts of potential alternatives will differ  
16 from those of the proposed action. Most alternatives result in smaller impacts to aquatic life,  
17 while creating greater impacts in other resource areas. Often, the most significant  
18 environmental impacts of alternatives result from constructing new facilities or infrastructure.

19 The recommendation of the NRC staff is that the Commission determine that the adverse  
20 environmental impacts of license renewals for IP2 and IP3 are not so great that not preserving  
21 the option of license renewal for energy planning decision makers would be unreasonable. This  
22 recommendation is based on (1) the analysis and findings in the GEIS, (2) the ER and other  
23 information submitted by Entergy, (3) consultation with other Federal, State, Tribal, and local  
24 agencies, (4) the staff’s own independent review, and (5) the staff’s consideration of public  
25 comments received during the scoping process and in response to the draft SEIS.





## Abbreviations and Acronyms

1		CCWD	Cortlandt Consolidated Water District
2		CDF	core damage frequency
3		CDM	Clean Development Mechanism
4		CET	Containment Event Tree
5		CEQ	Council on Environmental Quality
6		CFR	<i>Code of Federal Regulations</i>
7		cfs	cubic foot (feet) per second
8		CHGEC	Central Hudson Gas & Electric Corporation
9		Ci	curie(s)
10		CI	confidence interval
11		cm	centimeter(s)
12		CMP	Coastal Management Plan
13		CMR	conditional mortality rate
14		CNP	Cook Nuclear Plant
15		CO	carbon monoxide
16		CO <sub>2</sub>	carbon dioxide
17		COE	cost of enhancement
18		COL	Combined License
19		Con Edison	Consolidated Edison Company of New York
20		CORMIX	Cornell University Mixing Zone Model
21		CPUE	catch-per-unit-effort
22		CRDM	control rod drive mechanism
23		CST	condensate storage tank
24		CV	coefficient of variation
25		CWA	Clean Water Act
26		CWIS	Circulating Water Intake System
27		CZMA	Coastal Zone Management Act
28		dB(A)	decibel(s)
29		DBA	Design-basis accident
30		DC	direct current
31		DDT	dichloro-diphenyl-trichloroethane
32		DEIS	Draft Environmental Impact Statement
33		DF	Decontamination Factor
34		DNA	deoxyribonucleic acid
35		DNR	Department of Natural Resources
36		DO	dissolved oxygen
37		DOC	dissolved organic carbon
38		DOE	U.S. Department of Energy
39		DOS	Department of State
40		DOT	U.S. Department of Transportation
41		DPS	Distinct Population Segment
42		DSEIS	Draft Supplemental Environmental Impact Statement
43		EA	Environmental Assessment
44		ECL	Environmental Conservation Law
45		EDG	emergency diesel generator

Abbreviations/Acronyms

1	EIA	Energy Information Administration
2	EIS	environmental impact statement
3	EFH	Essential Fish Habitat
4	ELF-EMF	extremely low frequency-electromagnetic field
5	EMR	entrainment mortality rate
6	Entergy	Entergy Nuclear Operations, Inc.
7	EOP	emergency operating procedure
8	EPA	U.S. Environmental Protection Agency
9	EPRI	Electric Power Research Institute
10	ER	Environmental Report
11	ER-M	effects-range-median
12	ESA	Endangered Species Act
13	F	Fahrenheit
14	F&O	Facts and Observations
15	FAA	Federal Aviation Administration
16	FDA	Food and Drug Administration
17	FEIS	Final Environmental Impact Statement
18	FERC	Federal Energy Regulatory Commission
19	FES	Final Environmental Statement
20	FJS	Fall Juvenile Survey
21	FPC	Federal Power Commission
22	fps	feet per second
23	FPS	fire protection system
24	FR	<i>Federal Register</i>
25	FSAR	Final Safety Analysis Report
26	FSS	Fall Shoals Survey
27	ft	foot (feet)
28	ft <sup>2</sup>	square feet
29	ft <sup>3</sup>	cubic feet
30	FWS	U.S. Fish and Wildlife Service
31	g	gram(s)
32	gal	gallon(s)
33	gC <sub>eq</sub> /kWh	gram(s) of carbon dioxide equivalents per kilowatt-hour
34	GEIS	<i>Generic Environmental Impact Statement for License Renewal of Nuclear</i>
35		<i>Plants, NUREG-1437</i>
36	GHG	greenhouse gas
37	GL	Generic Letter
38	gpm	gallon(s) per minute
39	GW	gigawatt
40	ha	hectare(s)
41	HAP	hazardous air pollutant
42	HLW	high-level waste
43	hr	hour(s)
44	HRA	Human Reliability Analysis



## Abbreviations and Acronyms

1	HRERF	Hudson River Estuary Restoration Fund
2	HRFI	Hudson River Fisheries Investigation
3	HRPC	Hudson River Policy Committee
4	HRSA	Hudson River Settlement Agreement
5	IAEA	International Atomic Energy Agency
6	IMR	impingement mortality rate
7	in.	inch(es)
8	INEEL	Idaho National Energy and Environmental Laboratory
9	IP1	Indian Point Nuclear Generating Unit No. 1
10	IP2	Indian Point Nuclear Generating Unit No. 2
11	IP3	Indian Point Nuclear Generating Unit No. 3
12	IPE	individual plant examination
13	IPEEE	individual plant examination of external events
14	ISFSI	Independent Fuel Storage Installation
15	ISLOCA	Interfacing Systems Loss of Coolant Accidents
16	IWSA	Integrated Waste Services Association
17	kg	kilogram(s)
18	km	kilometer(s)
19	km <sup>2</sup>	square kilometer(s)
20	kV	kilovolt(s)
21	kWh	kilowatt hour(s)
22	lb	pound(s)
23	L	liter(s)
24	LERF	Large Early Release Frequency
25	LLMW	low-level mixed waste
26	LLNL	Lawrence Livermore National Laboratory
27	LOCA	loss of coolant accident
28	LODI	Lagrangian Operational Dispersion Integrator
29	LOE	Line(s) of Evidence
30	lpm	liters per minute
31	LRA	license renewal application
32	LR	linear regression
33	LRS	Long River Survey
34	LSE	load serving entities
35	m	meter(s)
36	mm	millimeter(s)
37	m <sup>2</sup>	square meter(s)
38	m <sup>3</sup>	cubic meter(s)
39	m <sup>3</sup> /sec	cubic meter(s) per second
40	MAAP	Modular Accident Analysis Program
41	MACCS2	MELCOR Accident Consequence Code System 2
42	MBq	megabecquerel
43	mg	milligram(s)

Abbreviations/Acronyms

1	mgd	million gallons per day	
2	mg/L	milligram(s) per liter	
3	mGy	milligray	
4	mi	mile(s)	
5	min	minute(s)	
6	MIT	Massachusetts Institute of Technology	
7	mL	milliliter(s)	
8	MLES	Marine Life Exclusion System	
9	MMBtu	million British thermal unit(s)	
10	mps	meter(s) per second	
11	mrad	millirad(s)	
12	mrem	millirem(s)	
13	mRNA	messenger ribonucleic acid	
14	MSE	mean squared error	
15	MSL	mean sea level	
16	MSPI	Mitigating Systems Performance Indicator	
17	mSv	millisievert	
18	MT	metric ton(s)	
19	MTU	metric ton of uranium	
20	MW	megawatt	
21	MWd	megawatt-days	
22	MW(e)	megawatt(s) electric	
23	MW(h)	megawatt hour(s)	
24	MW(t)	megawatt(s) thermal	
25	MWSF	Mixed Waste Storage Facility	
26	NAAQS	National Ambient Air Quality Standards	
27	NARAC	National Atmospheric Release Advisory Center	
28	NAS	National Academy of Sciences	
29	NEA	Nuclear Energy Agency	
30	NEPA	National Environmental Policy Act of 1969, as amended	
31	NESC	National Electric Safety Code	
32	NGO	Nongovernmental Organization	
33	NHPA	National Historic Preservation Act	
34	NIEHS	National Institute of Environmental Health Sciences	
35	NIRS	Nuclear Information and Resource Service	
36	NMFS	National Marine Fisheries Service	
37	NJDEP	New Jersey Department of Environmental Protection	
38	NO <sub>2</sub>	nitrogen dioxide	
39	NO <sub>x</sub>	nitrogen oxide(s)	
40	NOAA	National Oceanic and Atmospheric Administration	
41	NPDES	National Pollutant Discharge Elimination System	
42	NRC	U.S. Nuclear Regulatory Commission	
43	NRHP	National Register of Historic Places	
44	NSSS	nuclear steam supply system	
45	NWJWW	Northern Westchester Joint Water Works	
46	NY/NJ/PHL	New York/New Jersey/Philadelphia	

## Abbreviations and Acronyms

1	NYCA	New York Control Area
2	NYCDEP	New York City Department of Environmental Protection
3	NYCRR	New York Code of Rules and Regulations
4	NYISO	New York Independent System Operator
5	NYPA	New York Power Authority
6	NYPSC	New York Public Service Commission
7	NYRI	New York Regional Interconnect, Inc.
8	NYSDEC	New York State Department of Environmental Conservation
9	NYSDOH	New York State Department of Health
10	NYSERDA	New York State Energy Research and Development Authority
11	NYSHPO	New York State Historic Preservation Office
12	O <sub>3</sub>	ozone 8-hour standard
13	OCNGS	Oyster Creek Nuclear Generating Station
14	ODCM	Offsite Dose Calculation Manual
15	OMB	Office of Management and Budget
16	OPR	Office of Protected Resources
17	PAB	primary auxiliary building
18	PAH	polycyclic aromatic hydrocarbon
19	PCB	polychlorinated biphenyls
20	pCi/L	picoCuries per liter
21	pCi/kg	picoCuries per kilogram
22	PDS	plant damage state
23	PILOT	payment-in-lieu-of-taxes
24	PM	particulate matter
25	PM <sub>2.5</sub>	particulate matter, 2.5 microns or less in diameter
26	PM <sub>10</sub>	particulate matter, 10 microns or less in diameter
27	POC	particulate organic carbon
28	PORV	power operated relief valve
29	POST	Parliamentary Office of Science and Technology
30	ppm	parts per million
31	ppt	parts per thousand
32	PRA	probabilistic risk assessment
33	PSA	probabilistic safety assessment
34	PV	photovoltaic
35	PWR	pressurized water reactor
36	PWW	Poughkeepsie Water Works
37	PYSL	post yolk-sac larvae
38	REMP	Radiological Environmental Monitoring Program
39	R-EMAP	regional environmental monitoring and assessment program
40	RAI	request for additional information
41	RCP	reactor coolant pump
42	RCRA	Resource Conservation and Recovery Act
43	RCS	reactor cooling system
44	REMP	radiological environmental monitoring program

Abbreviations/Acronyms

1	RHR	residual heat removal
2	Riverkeeper	Hudson River Fishermen’s Association
3	RIS	Representative Important Species
4	RKM	river kilometer(s)
5	RM	river mile(s)
6	RMP	Risk Management Plan
7	ROD	Record of Decision
8	ROI	region of influence
9	ROW	right-of-way
10	RPC	long-term replacement power costs
11	rpm	revolutions per minute
12	RRW	risk reduction worth
13	RWST	refueling water storage tank
14	s	second(s)
15	SAFSTOR	safe storage condition
16	SAMA	severe accident mitigation alternative
17	SAR	Safety Analysis Report
18	SAV	submerged aquatic vegetation
19	SBO	station blackout
20	Scenic Hudson	Scenic Hudson Preservation Conference
21	SCR	selective catalytic reduction
22	SECPOP	sector population, land fraction and economic estimation program
23	SEIS	Supplemental Environmental Impact Statement
24	SFP	Spent Fuel Pool
25	SGTR	Steam Generator Tube Ruptures
26	SI	Safety Injection
27	SO <sub>2</sub>	sulfur dioxide
28	SO <sub>x</sub>	sulfur oxide(s)
29	SPDES	State Pollutant Discharge Elimination System
30	SPU	stretch power uprate
31	sq mi	square mile(s)
32	SR	segmented regression
33	SRP	Standard Review Plan
34	SRT	Status Review Team
35	SSBR	spawning stock biomass per-recruit
36	SSE	safe shutdown earthquake
37	Sv	person-sievert
38	SWS	service water system
39	t	ton(s)
40	TDEC	Tennessee Department of Environment and Conservation
41	TI-SGTR	thermally-induced Steam Generator Tube Ruptures
42	TLD	Thermoluminescent dosimeter
43	TOC	total organic carbon
44	TRC	TRC Environmental Corporation

## Abbreviations and Acronyms

1	U.S.	United States
2	U.S.C.	United States Code
3	USACE	U.S. Army Corps of Engineers
4	USAEC	U.S. Atomic Energy Commission
5	USCB	U.S. Census Bureau
6	USDA	U.S. Department of Agriculture
7	USGS	U.S. Geological Survey
8	UWNY	United Water New York
9	V	volt(s)
10	VALWNF	value of non-farm wealth
11	VOC	volatile organic compound
12	WCDOH	Westchester County Department of Health
13	WISE	World Information Service on Energy
14	WJWW	Westchester Joint Water Works
15	WOE	weight of evidence
16	WOG	Westinghouse Owner's Group
17	YSL	yolk-sac larvae
18	YOY	young of year
19	yr	year(s)

# 1.0 INTRODUCTION

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of the *Code of Federal Regulations* (10 CFR Part 51), which implement the National Environmental Policy Act of 1969, as amended (NEPA), renewal of a nuclear power plant operating license requires the preparation of an environmental impact statement (EIS). In preparing the EIS, the NRC staff is required first to issue the statement in draft form for public comment and then to issue a final statement after considering public comments on the draft. To support the preparation of the EIS, the NRC staff prepared NUREG-1437, Volumes 1 and 2, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (hereafter referred to as the GEIS) (NRC 1996, 1999).<sup>(1)</sup> The GEIS is intended to (1) provide an understanding of the types and severity of environmental impacts that may occur as a result of license renewal of nuclear power plants under 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," (2) identify and assess the impacts that are expected to be generic to license renewal, and (3) support 10 CFR Part 51 by defining the number and scope of issues that need to be addressed by the applicants in plant-by-plant renewal proceedings. Use of the GEIS guides the preparation of complete plant-specific information in support of the operating license renewal process.

Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, operate the Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) nuclear power reactors, respectively, as indirect wholly owned subsidiaries of Entergy Corporation and indirect wholly owned subsidiaries of Entergy Nuclear Operations, Inc. (Entergy). IP2 and IP3 are located in Buchanan, New York.

IP2 has operated under operating license DPR-26 since August 1974. The IP2 operating license will expire on September 28, 2013. IP3 has operated under operating license DPR-64 since August 1976. The IP3 operating license will expire on December 12, 2015. Indian Point Unit No. 1 (IP1) was shut down in 1974 and is currently in SAFSTOR (a decommissioning strategy that includes maintenance, monitoring, and delayed dismantlement to allow radioactivity to decay prior to decommissioning).

Entergy, Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC, are joint applicants for the renewal of the operating licenses (the joint applicants will be referred to as Entergy). Entergy submitted an application to the NRC to renew the IP2 and IP3 operating licenses for an additional 20 years each under 10 CFR Part 54 on April 30, 2007 (Entergy 2007a). Pursuant to 10 CFR 54.23, "Contents of Application—Environmental Information," and 10 CFR 51.53(c), Entergy submitted an environmental report (ER) (Entergy 2007b) as part of the license renewal application in which Entergy analyzed the environmental impacts associated with the proposed license renewal action, considered alternatives to the proposed action, and evaluated mitigation measures for reducing adverse environmental effects. Entergy submitted supplemental information clarifying operating licenses and applicant names in a letter on May 3, 2007 (Entergy 2007c).

<sup>(1)</sup> The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

## Introduction

1 | This report is the plant-specific supplement to the GEIS (the supplemental EIS (SEIS)) for the  
2 | Entergy license renewal application. This SEIS is a supplement to the GEIS because it relies, in  
3 | part, on the findings of the GEIS. In August, 2009, the NRC staff issued a separate safety  
4 | evaluation report in accordance with 10 CFR Part 54.

### 5 | **1.1 Report Contents**

6 | The following sections of this introduction (1) describe the background for the preparation of this  
7 | SEIS, including the development of the GEIS and the process used by the NRC staff to assess  
8 | the environmental impacts associated with license renewal, (2) describe the proposed Federal  
9 | action to renew the IP2 and IP3 operating licenses, (3) discuss the purpose and need for the  
10 | proposed action, and (4) present the status of IP2 and IP3 compliance with environmental  
11 | quality standards and requirements that have been imposed by Federal, State, regional, and  
12 | local agencies that are responsible for environmental protection.

13 | The ensuing chapters of this SEIS closely parallel the contents and organization of the GEIS.  
14 | Chapter 2 describes the site, power plant, and interactions of the plant with the environment.  
15 | Chapters 3 and 4, respectively, discuss the potential environmental impacts of plant  
16 | refurbishment and plant operation during the renewal term. Chapter 5 contains an evaluation of  
17 | potential environmental impacts of plant accidents and includes consideration of severe  
18 | accident mitigation alternatives. Chapter 6 discusses the uranium fuel cycle and solid waste  
19 | management and greenhouse gas emissions. Chapter 7 discusses decommissioning, and  
20 | Chapter 8 discusses alternatives to license renewal. Finally, Chapter 9 summarizes the findings  
21 | of the preceding chapters and draws conclusions about the adverse impacts that cannot be  
22 | avoided, the relationship between short-term uses of man's environment and the maintenance  
23 | and enhancement of long-term productivity, and the irreversible or irretrievable commitment of  
24 | resources. Chapter 9 also presents the NRC staff's recommendation with respect to the  
25 | proposed license renewal action.

26 | Additional information is included in appendices. Appendix A contains public comments related  
27 | to the environmental review for license renewal and the NRC staff's responses to those  
28 | comments. Appendices B through G include the following:

- 29 | • the preparers of the supplement (Appendix B)
- 30 | • the chronology of the NRC staff's environmental review correspondence related to this  
31 | SEIS (Appendix C)
- 32 | • the organizations contacted during the development of this SEIS (Appendix D)
- 33 | • the IP2 and IP3 compliance status in Tables E-1 and E-2 and copies of consultation  
34 | correspondence prepared and sent during the evaluation process (Appendix E)
- 35 | • GEIS environmental issues that are not applicable to IP2 and IP3 (Appendix F)
- 36 | • the NRC staff's evaluation of severe accident mitigation alternatives (Appendix G)
- 37 | • the NRC staff's evaluation of impacts of the IP2 and IP3 cooling system (Appendix H)
- 38 | • statistical analyses conducted for Chapter 4 aquatic resources and appendix H  
39 | (Appendix I)

## 1 1.2 Background

2 Use of the GEIS, which examines the possible environmental impacts that could occur as a  
3 result of renewing individual nuclear power plant operating licenses under 10 CFR Part 54, and  
4 the established license renewal evaluation process, support the thorough evaluation of the  
5 impacts of operating license renewal.

### 6 1.2.1 Generic Environmental Impact Statement

7 The NRC initiated a generic assessment of the environmental impacts associated with the  
8 license renewal term to improve the efficiency of the license renewal process by documenting  
9 the assessment results and codifying the results in the Commission's regulations. This  
10 assessment is provided in the GEIS, which serves as the principal reference for all nuclear  
11 power plant license renewal EISs.

12 The GEIS documents the results of the systematic approach that the NRC staff used to evaluate  
13 the environmental consequences of renewing the licenses of individual nuclear power plants  
14 and operating them for an additional 20 years. For each potential environmental issue, the  
15 GEIS (1) describes the activity that affects the environment, (2) identifies the population or  
16 resource that is affected, (3) assesses the nature and magnitude of the impact on the affected  
17 population or resource, (4) characterizes the significance of both beneficial and adverse effects,  
18 (5) determines whether the results of the analysis apply to all plants, and (6) considers whether  
19 additional mitigation measures would be warranted for impacts that would have the same  
20 significance level for all plants.

21 The NRC's standard of significance for impacts was established using the Council on  
22 Environmental Quality (CEQ) term "significantly" (40 CFR 1508.27, which requires consideration  
23 of both "context" and "intensity"). Using the CEQ terminology, the NRC established three  
24 significance levels—SMALL, MODERATE, or LARGE. The definitions of the three significance  
25 levels are set forth in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, "National  
26 Environmental Policy Act—Regulations Implementing Section 102(2)," Appendix B,  
27 "Environmental Effect of Renewing the Operating License of a Nuclear Power Plant," as follows:

28 SMALL—Environmental effects are not detectable or are so minor that they will  
29 neither destabilize nor noticeably alter any important attribute of the resource.

30 MODERATE—Environmental effects are sufficient to alter noticeably, but not to  
31 destabilize, important attributes of the resource.

32 LARGE—Environmental effects are clearly noticeable and are sufficient to  
33 destabilize important attributes of the resource.

34 The GEIS assigns a significance level to each environmental issue, assuming that ongoing  
35 mitigation measures would continue.

36 The GEIS includes a determination of whether the analysis of the environmental issue could be  
37 applied to all plants and whether additional mitigation measures would be warranted. Issues  
38 are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1  
39 issues are those that meet all of the following criteria:

40 (1) The environmental impacts associated with the issue have been



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1 determined to apply either to all plants or, for some issues, to plants  
2 having a specific type of cooling system or other specified plant or site  
3 characteristics.

4 (2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has  
5 been assigned to the impacts (except for collective offsite radiological  
6 impacts from the fuel cycle and from high-level waste and spent fuel  
7 disposal).

8 (3) Mitigation of adverse impacts associated with the issue has been  
9 considered in the analysis, and it has been determined that additional  
10 plant-specific mitigation measures are likely not to be sufficiently  
11 beneficial to warrant implementation.

12 For issues that meet the three Category 1 criteria, no additional plant-specific analysis is  
13 required in this SEIS unless new and significant information is identified.

14 Category 2 issues are those that do not meet one or more of the criteria of Category 1;  
15 therefore, additional plant-specific review for these issues is required.

16 In the GEIS, the staff assessed 92 environmental issues and determined that 69 qualified as  
17 Category 1 issues, 21 qualified as Category 2 issues, and 2 issues were not categorized. The  
18 two issues not categorized are environmental justice and chronic effects of electromagnetic  
19 fields. Environmental justice was not evaluated on a generic basis and must be addressed in a  
20 plant-specific supplement to the GEIS. Information on the chronic effects of electromagnetic  
21 fields was not conclusive at the time the GEIS was prepared.

22 Of the 92 issues, 11 are related only to refurbishment, 6 are related only to decommissioning,  
23 67 apply only to operation during the renewal term, and 8 apply to both refurbishment and  
24 operation during the renewal term. A summary of the findings for all 92 issues in the GEIS is  
25 codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B.

### 26 **1.2.2 License Renewal Evaluation Process**

27 An applicant seeking to renew its operating license is required to submit an ER as part of its  
28 application. The license renewal evaluation process involves careful review of the applicant's  
29 ER and assurance that all new and potentially significant information not already addressed in  
30 or available during the GEIS evaluation is identified, reviewed, and assessed to verify the  
31 environmental impacts of the proposed license renewal.

32 In accordance with 10 CFR 51.53(c)(2) and (3), the ER submitted by the applicant must do the  
33 following:

- 34 • provide an analysis of the Category 2 issues in Table B-1 of 10 CFR Part 51, Subpart A,  
35 Appendix B, in accordance with 10 CFR 51.53(c)(3)(ii)
- 36 • discuss actions to mitigate any adverse impacts associated with the proposed action and  
37 environmental impacts of alternatives to the proposed action

38 In accordance with 10 CFR 51.53(c)(2), the ER does not need to do the following:

- 1 • consider the economic benefits and costs of the proposed action and alternatives to the  
2 proposed action except insofar as such benefits and costs are either (1) essential for  
3 making a determination regarding the inclusion of an alternative in the range of  
4 alternatives considered or (2) relevant to mitigation
- 5 • consider the need for power and other issues not related to the environmental effects of  
6 the proposed action and the alternatives
- 7 • discuss any aspect of the storage of spent fuel within the scope of the generic  
8 determination in 10 CFR 51.23(a) in accordance with 10 CFR 51.23(b)
- 9 • pursuant to 10 CFR 51.23(c)(3)(iii) and (iv), contain an analysis of any Category 1 issue  
10 unless there is significant new information on a specific issue

11 New and significant information is (1) information that identifies a significant environmental issue  
12 not covered in the GEIS and codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, or  
13 (2) information that was not considered in the analyses summarized in the GEIS and that leads  
14 to an impact finding that is different from the finding presented in the GEIS and codified in  
15 10 CFR Part 51.

16 In preparing to submit its application to renew the IP2 and IP3 operating licenses, Entergy  
17 developed a process to ensure that (1) information not addressed in or available during the  
18 GEIS evaluation regarding the environmental impacts of license renewal for IP2 and IP3 would  
19 be properly reviewed before submitting the ER and (2) such new and potentially significant  
20 information related to renewal of the licenses for IP2 and IP3 would be identified, reviewed, and  
21 assessed during the period of NRC review. Entergy reviewed the Category 1 issues that  
22 appear in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, to verify that the conclusions of  
23 the GEIS remain valid with respect to IP2 and IP3. This review was performed by personnel  
24 from Entergy who were familiar with NEPA issues and the scientific disciplines involved in the  
25 preparation of a license renewal ER.

26 The NRC staff also has a process for identifying new and significant information. That process  
27 is described in detail in NUREG-1555, "Standard Review Plans for Environmental Reviews for  
28 Nuclear Power Plants, Supplement 1: Operating License Renewal," issued March 2000 (NRC  
29 2000). The search for new information includes (1) review of an applicant's ER and the process  
30 for discovering and evaluating the significance of new information, (2) review of records of  
31 public comments, (3) review of environmental quality standards and regulations,  
32 (4) coordination with Federal, State, Tribal, and local environmental protection and resource  
33 agencies, and (5) review of the technical literature. New information discovered by the NRC  
34 staff is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues  
35 where new and significant information is identified, reconsideration of the conclusions for those  
36 issues is limited in scope to the assessment of the relevant new and significant information; the  
37 scope of the assessment does not include other facets of the issue that are not affected by the  
38 new information.

39 Chapters 3 through 7 discuss the environmental issues considered in the GEIS that are  
40 applicable to IP2 and IP3. At the beginning of the discussion of each set of issues, there is a  
41 table that identifies the issues to be addressed and lists the sections in the GEIS where the  
42 issue is discussed. Category 1 and Category 2 issues are listed in separate tables. For

## Introduction

1 Category 1 issues for which there is no new and significant information, the table is followed by  
2 a set of short paragraphs that state the GEIS conclusion codified in Table B-1 of  
3 10 CFR Part 51, Subpart A, Appendix B, followed by the staff's analysis and conclusion. For  
4 Category 2 issues, in addition to the list of GEIS sections where the issue is discussed, the  
5 tables list the subparagraph of 10 CFR 51.53(c)(3)(ii) that describes the analysis required and  
6 the SEIS sections where the analysis is presented. The SEIS sections that discuss the  
7 Category 2 issues are presented immediately following the table.

8 The NRC prepares an independent analysis of the environmental impacts of license renewal  
9 and compares these impacts with the environmental impacts of alternatives. The evaluation of  
10 the Entergy license renewal application began with the publication of a notice of acceptance for  
11 docketing, notice of opportunity for a hearing, and notice of intent to prepare an EIS and  
12 conduct scoping in the *Federal Register*, May 11, 2007 (NRC 2007; 72 FR 26850). A public  
13 scoping meeting was held on June 27, 2007, in Cortlandt Manor, New York. Comments  
14 received during the scoping period have been summarized by the NRC in a summary report  
15 issued in December of 2008 (Agencywide Documents Access and Management System  
16 (ADAMS) Accession No. ML083360115). The NRC staff adopts by reference the scoping  
17 summary report in Part 1 of Appendix A to this SEIS.

18 The NRC staff followed the review guidance contained in NUREG-1555, Supplement 1 (NRC  
19 2000). The NRC staff, and the contractor retained to assist the NRC staff, visited the IP2 and  
20 IP3 site on September 11 and 12, 2007, and again on September 24 and 25, 2007, to gather  
21 information and to become familiar with the site and its environs. The NRC staff also reviewed  
22 the comments received during scoping and consulted with Federal, State, Tribal, regional, and  
23 local agencies. A list of the organizations consulted is provided in Appendix D. Other  
24 documents related to IP2 and IP3 were reviewed and are referenced within this SEIS.

25 This SEIS presents the NRC staff's analysis that considers and weighs the environmental  
26 effects of the proposed renewal of the operating licenses for IP2 and IP3, the environmental  
27 impacts of alternatives to license renewal, and mitigation measures available for avoiding  
28 adverse environmental effects. Chapter 9, "Summary and Conclusions," provides the NRC  
29 staff's recommendation to the Commission on whether the adverse environmental impacts of  
30 license renewal are so great that preserving the option of license renewal for energy-planning  
31 decision makers would be unreasonable.

32 The NRC staff issued a draft SEIS in December 2008. A 75-day comment period began on the  
33 date of publication of the U.S. Environmental Protection Agency Notice of Filing of the draft  
34 SEIS to allow members of the public to comment on the preliminary results of the NRC staff's  
35 review. During this comment period, a public meeting was held in Cortlandt Manor, New York,  
36 on February 12, 2009. During this meeting, the NRC staff described the preliminary results of  
37 the NRC environmental review and answered questions to provide members of the public with  
38 information to assist them in formulating their comments. The comments received, and the  
39 NRC staff's responses to those comments, are presented in Appendix A to this SEIS.

### 40 **1.3 The Proposed Federal Action**

41 The proposed Federal action is renewal of the operating licenses for IP2 and IP3 (IP1 was shut  
42 down in 1974). IP2 and IP3 are located on approximately 239 acres of land on the east bank of  
43 the Hudson River at Indian Point, Village of Buchanan, in upper Westchester County, New York,

1 approximately 24 miles north of the New York City boundary line. The facility has two  
2 Westinghouse pressurized-water reactors. IP2 is currently licensed to generate  
3 3216 megawatts thermal (MW(t)) (core power) with a design net electrical capacity of  
4 1078 megawatts electric (MW(e)). IP3 is currently licensed to generate 3216 MW(t) (core  
5 power) with a design net electrical capacity of about 1080 MW(e). IP2 and IP3 cooling is  
6 provided by water from the Hudson River to various heat loads in both the primary and  
7 secondary portions of the plants. The current operating license for IP2 expires on  
8 September 28, 2013, and the current operating license for IP3 expires on December 12, 2015.  
9 By letter dated April 23, 2007, Entergy submitted an application to the NRC (Entergy 2007a) to  
10 renew the IP2 and IP3 operating licenses for an additional 20 years.

## 11 **1.4 The Purpose and Need for the Proposed Action**

12 Although a licensee must have a renewed license to operate a reactor beyond the term of the  
13 existing operating license, the possession of that license is just one of a number of conditions  
14 that must be met for the licensee to continue plant operation during the term of the renewed  
15 license. Once an operating license is renewed, State regulatory agencies and the owners of the  
16 plant will ultimately decide whether the plant will continue to operate based on factors such as  
17 the need for power or matters within the State's jurisdiction—including acceptability of water  
18 withdrawal, consistency with State water quality standards, and consistency with State coastal  
19 zone management plans—or the purview of the owners, such as whether continued operation  
20 makes economic sense.

21 Thus, for license renewal reviews, the NRC has adopted the following definition of purpose and  
22 need (GEIS Section 1.3):

23 The purpose and need for the proposed action (renewal of an operating license)  
24 is to provide an option that allows for power generation capability beyond the  
25 term of a current nuclear power plant operating license to meet future system  
26 generating needs, as such needs may be determined by State, utility, and where  
27 authorized, Federal (other than NRC) decision makers.

28 This definition of purpose and need reflects the Commission's recognition that, unless there are  
29 findings in the safety review required by the Atomic Energy Act of 1954, as amended, or  
30 findings in the NEPA environmental analysis that would lead the NRC to reject a license  
31 renewal application, the NRC does not have a role in the energy-planning decisions of State  
32 regulators and utility officials as to whether a particular nuclear power plant should continue to  
33 operate. From the perspective of the licensee and the State regulatory authority, the purpose of  
34 renewing the operating licenses is to maintain the availability of the nuclear plant to meet  
35 system energy requirements beyond the current term of the plant's licenses.

## 36 **1.5 Compliance and Consultations**

37 Entergy is required to hold certain Federal, State, and local environmental permits, as well as  
38 meet relevant Federal and State statutory requirements. In its ER, Entergy provided a list of the  
39 authorizations from Federal, State, and local authorities for current operations as well as  
40 environmental approvals and consultations associated with the IP2 and IP3 license renewals.  
41 Authorizations and consultations relevant to the proposed operating license renewal actions are

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1 included in Appendix E.

2 The NRC staff has reviewed Entergy's list and consulted with the appropriate Federal, State,  
3 Tribal, and local agencies to identify any compliance or permit issues or significant  
4 environmental issues of concern to the reviewing agencies. These agencies did not identify any  
5 new and significant environmental issues. The ER states that Entergy is in compliance with  
6 applicable environmental standards and requirements for IP2 and IP3. The NRC staff has not  
7 identified any environmental issues that are both new and significant.

8 Two state-level issues, consistency with State water quality standards, and consistency with  
9 State coastal zone management plans, have yet to be resolved. On April 2, 2010, the New York  
10 State Department of Environmental Conservation (NYSDEC) issued a Notice of Denial  
11 regarding the Clean Water Act Section 401 Water Quality Certification. Entergy has since  
12 requested a hearing on the issue, and the matter will be decided through NYSDEC's hearing  
13 process.

## 14 1.6 References

15 10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental  
16 Protection Regulations for Domestic Licensing and Related Regulatory Functions."

17 10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, "Requirements for  
18 Renewal of Operating Licenses for Nuclear Power Plants."

19 40 CFR Part 1508. *Code of Federal Regulations*, Title 40, *Protection of Environment*,  
20 Part 1508, "Terminology and Index."

21 Entergy Nuclear Operations, Inc. (Entergy). 2007a. "Indian Point, Units 2 & 3, License  
22 Renewal Application." April 23, 2007. ADAMS Accession No. ML071210512.

23 Entergy Nuclear Operations, Inc. (Entergy). 2007b. "Applicant's Environment Report,  
24 Operating License Renewal Stage." (Appendix E to "Indian Point, Units 2 & 3, License Renewal  
25 Application".) April 23, 2007. ADAMS Accession No. ML071210530.

26 Entergy Nuclear Operations, Inc. (Entergy). 2007c. Letter from Fred Dacimo, Indian Point  
27 Energy Center Site Vice President, to the U.S. NRC regarding Indian Point Nuclear Generating  
28 Units Nos. 2 and 3. Docket Nos. 50-247, 50-286. May 3, 2007. ADAMS Accession No.  
29 ML071280700.

30 National Environmental Policy Act of 1969 (NEPA). 42 *United States Code* 4321, *et seq.*

31 U.S. Nuclear Regulatory Commission (NRC). 1996. "Generic Environmental Impact Statement  
32 for License Renewal of Nuclear Power Plants." NUREG-1437, Volumes 1 and 2, Washington,  
33 DC.

34 U.S. Nuclear Regulatory Commission (NRC). 1999. "Generic Environmental Impact Statement  
35 for License Renewal of Nuclear Plants Main Report," Section 6.3, "Transportation," Table 9.1,  
36 "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants."  
37 NUREG-1437, Volume 1, Addendum 1, Washington, DC.

38 U.S. Nuclear Regulatory Commission (NRC). 2000. "Standard Review Plans for Environmental  
39 Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal."  
40 NUREG-1555, Supplement 1, Washington, DC.

- 1 U.S. Nuclear Regulatory Commission (NRC). 2007. "Entergy Nuclear Operations, Inc.; Notice
- 2 of Receipt and Availability of Application for Renewal of Indian Point Nuclear Generating Unit
- 3 Nos. 2 and 3; Facility Operating License Nos. DPR-26 and DPR-64 for an Additional 20-Year
- 4 Period." *Federal Register*, Volume 72, Number 91, p. 26850. May 11, 2007.
- 5 U.S. Nuclear Regulatory Commission (NRC). 2009. "Summary Report: Indian Point Nuclear
- 6 Generating Station Unit Nos. 2 and 3." Washington, DC.

## 2.0 DESCRIPTION OF NUCLEAR POWER PLANT AND SITE AND PLANT INTERACTION WITH THE ENVIRONMENT

Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3) are located on approximately 239 acres (97 hectares (ha)) of land in the Village of Buchanan in upper Westchester County, New York. The facility is on the eastern bank of the Hudson River at river mile (RM) 43 (river kilometer (RKM) 69) about 2.5 miles (mi) (4.0 kilometers (km)) southwest of Peekskill, the closest city, and about 24 mi (39 km) north of New York City.

Both IP2 and IP3 use Westinghouse pressurized-water reactors and nuclear steam supply systems (NSSSs). Primary and secondary plant cooling is provided by a once-through cooling water intake system that supplies cooling water from the Hudson River. The plant and its surroundings are described in Section 2.1, and the plant's interaction with the environment is presented in Section 2.2.

Indian Point Nuclear Generating Station Unit No. 1 (IP1, now permanently shut down) shares the site with IP2 and IP3. IP1 is located between IP2 and IP3. IP1 was shut down on October 31, 1974, and is in a safe storage condition (SAFSTOR) awaiting final decommissioning.

### 2.1 Plant and Site Description and Proposed Plant Operation During the Renewal Term

The entirety of the Indian Point site is surrounded by a perimeter fence, establishing an area known as the "owner controlled area." Security personnel patrol all roads within the site. Within the fence lies an area of greater security known as the "protected area." The protected area is more heavily guarded and controlled by a second fence and an intrusion detection system. The protected area is accessible only through manned security buildings and gates requiring electronic identification. In addition, spaces within the protected area designated as "vital areas" have additional access controls (Entergy 2006a).

The area within a 6-mi (10-km) radius of the IP2 and IP3 site includes the Village of Buchanan, located about 0.5 mi (0.8 km) southeast of the site, and the City of Peekskill, located 2.5 mi (4.0 km) northeast. In the 2000 U.S. census, populations of these towns were 2,189 and 22,441, respectively. The largest town within a 6-mi (10-km) radius of the site is Haverstraw, New York, with a 2000 population of approximately 33,811 (USCB 2000). Haverstraw is located to the southwest on the western bank of the Hudson River. Several other small villages, including Verplanck and Montrose, lie within a 6-mi (10-km) radius of the IP2 and IP3 site. The area within a 6-mi (10-km) radius of the site also includes several thousand acres of the Bear Mountain State Park located across the Hudson River, the nearly 2000-acre (809-ha) Camp Smith (a New York State military reservation) located 2.3 mi (3.7 km) north of the site, and a portion—about 2000 acres (809 ha)—of the U.S. Military Academy at West Point.

The area within a 50-mi (80-km) radius of the site includes parts of New York, New Jersey, and Connecticut. New York City, located approximately 24 mi (39 km) south of the plant, is the largest city within 50 mi (80 km) with a 2006 population of approximately 8,214,426 (USCB 2006). Other population centers include Danbury and Stamford, Connecticut; Newark, New Jersey; and Poughkeepsie, New York. The area within a 50-mi (80-km) radius also includes all

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1 of the U.S. Military Academy at West Point, located 7.5 mi (12 km) northwest of the site, and the  
2 Picatinny Arsenal, located 35.5 mi (57.1 km) southwest of the site in New Jersey (Entergy  
3 2007a).

4 The region surrounding the Indian Point site has undulating terrain with many peaks and  
5 valleys. Dunderberg Mountain lies on the western side of the Hudson River 1 mi (1.6 km)  
6 northwest of the site. North of Dunderberg Mountain, high grounds reach an elevation of  
7 800 feet (ft) (244 meters (m)) above the western bank of the Hudson River. To the east of the  
8 site lie the Spitzenberg and Blue Mountains. These peaks are about 600 ft (183 m) in height.  
9 There is also a weak, poorly defined series of ridges that run in a north-northeast direction east  
10 of IP2 and IP3. The Timp Mountains are west of the facility. These mountains rise to a  
11 maximum elevation of 846 ft (258 m). Elevations south of the site are 100 ft (30.5 m) or less  
12 and gradually slope toward the Village of Verplanck (Entergy 2007a).

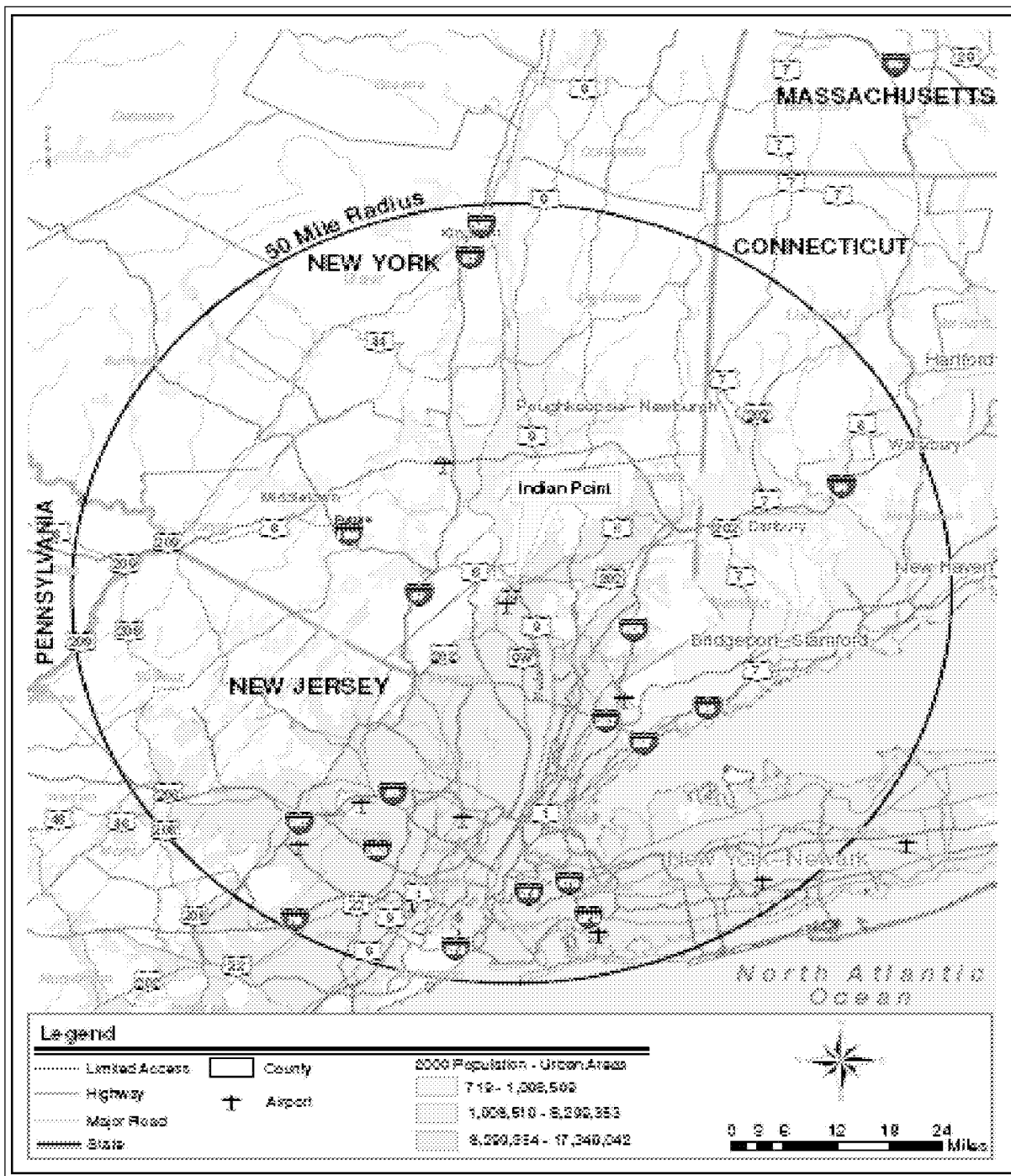
13 The site location and features within 50-mi (80-km) and 6-mi (10-km) radii are illustrated in  
14 Figures 2-1 and 2-2, respectively.

### 15 **2.1.1 External Appearance and Setting**

16 As discussed in Section 2.1, the immediate area around the Indian Point site is completely  
17 enclosed by a security fence. Access to the site is controlled at a security gate on Broadway  
18 (main entrance). Controlled access to the site is also available using the existing wharf on the  
19 Hudson River. The wharf is used to receive heavy equipment shipped to the site by barge.  
20 There are no rail lines that service the site. The nearest residence is less than 0.5 mi (0.8 km)  
21 from IP2 and IP3 and about 100 m (328 ft) beyond the site boundary to the east-southeast  
22 (ENN 2007a).

23 The facility can be seen easily from the river. Surrounding high ground and vegetation make it  
24 difficult to see the facility from beyond the security fence on land, except from Broadway. The  
25 334-ft (102-m) tall superheater stack for IP1, the 134-ft (40.8-m) tall IP2 and IP3 turbine  
26 buildings, and the 250-ft (76.2-m) tall reactor containment structures are the tallest structures on  
27 the site (Entergy 2007a).

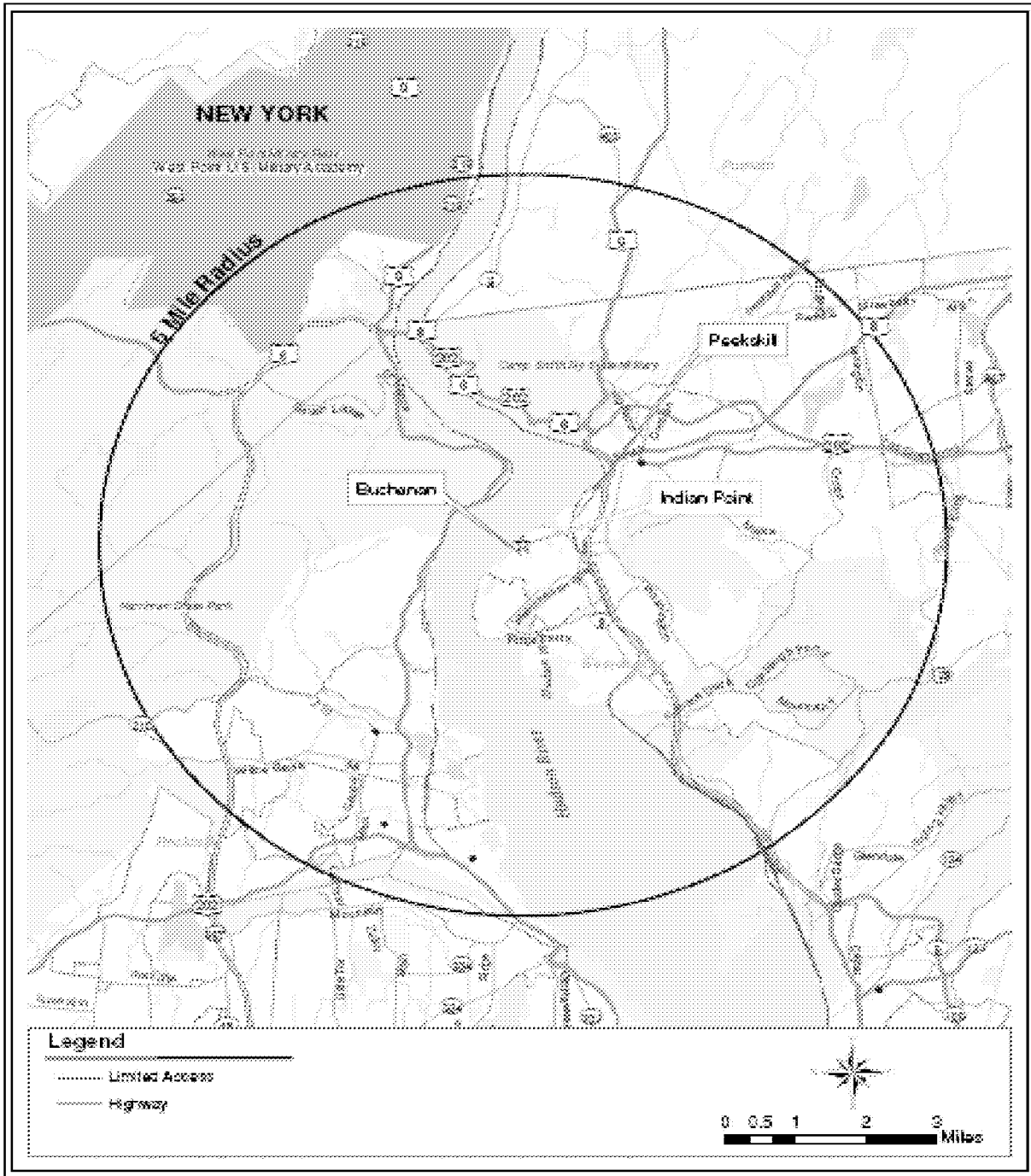




1 Source: Entergy 2007a

2 **Figure 2-1. Location of IP2 and IP3, 50-mi (80-km) radius**

3



1  
2 Source: Entergy 2007a

3 **Figure 2-2. Location of IP2 and IP3, 6-mi (10-km) radius**

4

1 Other visible IP2 and IP3 site features include auxiliary buildings, intake structures, the  
2 discharge structure, electrical switchyard, and associated transmission lines (Entergy 2007a).  
3 The site boundary and general facility layout are depicted in Figures 2-3 and 2-4, respectively.

4 The facility contains several stationary bulk petroleum and chemical storage tanks. Bulk  
5 chemical storage tanks are registered with the New York State Department of Environmental  
6 Conservation (NYSDEC) via Hazardous Substance Bulk Storage Registration Certificates. The  
7 tanks and their contents are managed in accordance with the NYSDEC Chemical Bulk Storage  
8 Regulations. The IP2 bulk petroleum storage tanks are registered with NYSDEC via a Major Oil  
9 Storage Facility License, while the IP3 tanks are registered with the Westchester County  
10 Department of Health via a Petroleum Bulk Storage Registration Certificate.

11 IP2 and IP3 each use two main transformers to increase voltage from their respective turbine  
12 generators. The transformers increase generator output from 22 kilovolts (kV) to 345 kV.  
13 Power is then delivered to the Consolidated Edison Company (Con Edison) transmission grid by  
14 way of two double-circuit 345-kV lines. These lines connect the main onsite transformers to the  
15 offsite Buchanan substation which is located immediately across Broadway near the main  
16 entrance to the site. The lines that connect the transformers to the substation are about 2000 ft  
17 (610 m) in length and, except for the terminal 100 ft where they cross over Broadway (a public  
18 road) and enter the substation, lines are located within the site boundary (Entergy 2007a). The  
19 345-kV transmission lines that distribute power from the substation are shown in Figure 2-3.

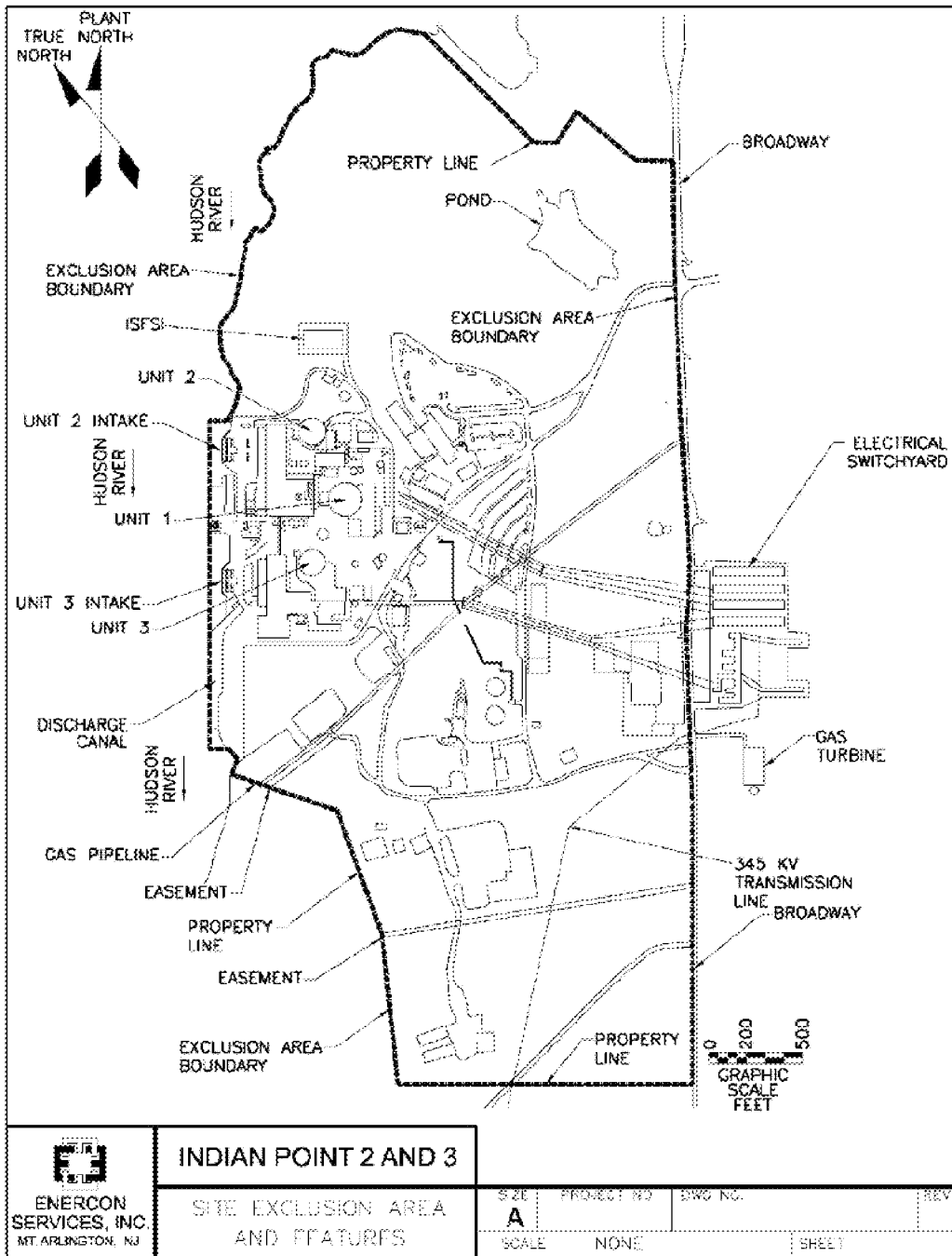
## 20 **2.1.2 Reactor Systems**

21 As noted in Section 2.0, both IP2 and IP3 employ Westinghouse pressurized-water reactors and  
22 four-loop NSSSs. Each NSSS loop contains a reactor coolant pump and a steam generator.  
23 The reactor coolant system transfers the heat generated in the reactor core to the steam  
24 generators, which produce steam to drive the electrical turbine generators (Entergy 2007b).

25 IP2 is currently licensed to operate at a core power of 3216 megawatt thermal (MW(t)), which  
26 results in a turbine generator output of approximately 1078 megawatt electric (MW(e)). IP3 is  
27 currently licensed to operate at 3216 MW(t), which results in a turbine generator output of  
28 approximately 1080 MW(e). IP2 and IP3 have similar designs with independent functional and  
29 safety systems. The units share the following systems (Entergy 2007b):

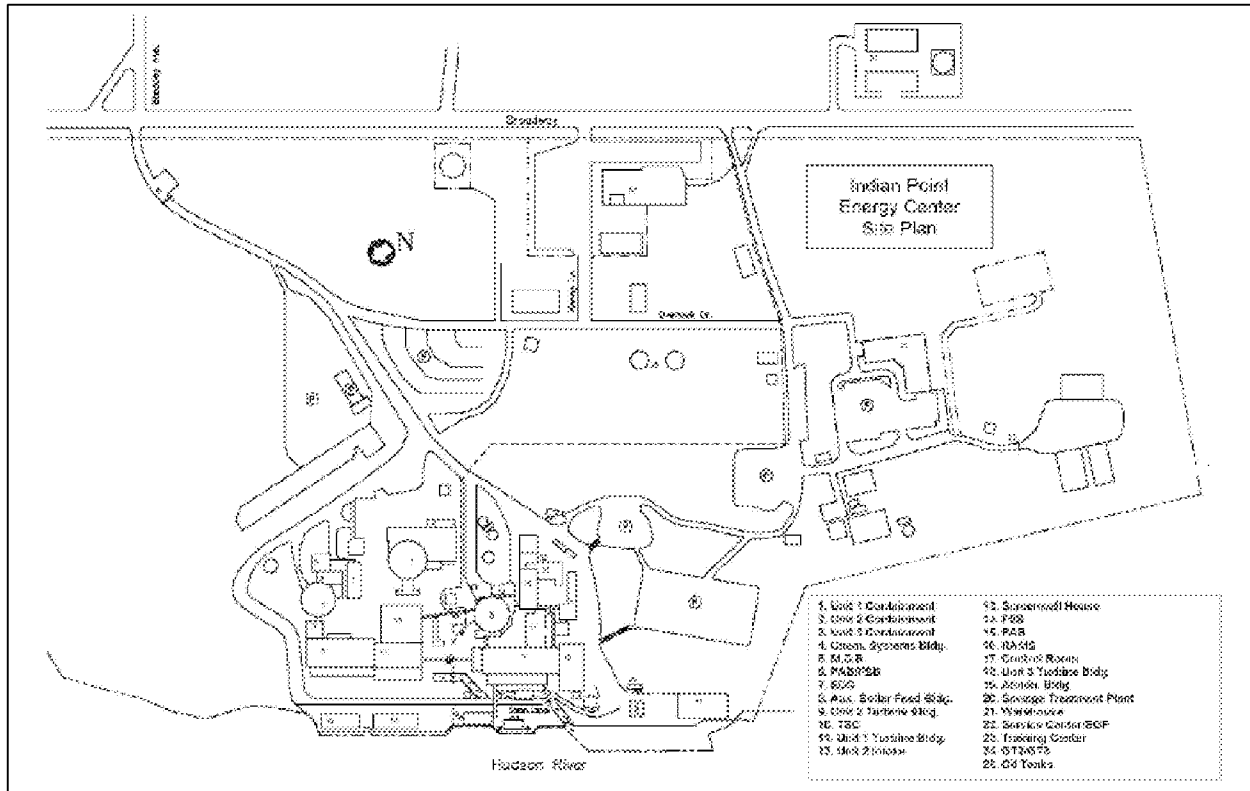
- 30 • discharge canal, outfall structure, and associated instrumentation and sampling systems
- 31 • electrical supplies and interties
- 32 • station air interties
- 33 • demineralized water, condensate makeup, and hydrogen interties
- 34 • city water and fire protection interties
- 35 • dedicated No. 2 fuel oil systems for diesel generators
- 36 • sewage treatment facility
- 37 • auxiliary steam system intertie

Plant and the Environment



1 Source: Entergy 2007a

2 **Figure 2-3. IP2 and IP3 property boundaries and environs**



1 Source: Entergy 2007a

2 **Figure 2-4. IP2 and IP3 site layout**

- 3
- 4 • service boiler fuel oil supply system
  - 5 • liquid steam generator blowdown, radioactive waste processing, and discharge (to IP1) facilities

6 The nuclear fuel for IP2 and IP3 is made of low-enriched (less than 5 percent by weight  
 7 uranium-235) uranium dioxide pellets stacked in pre-pressurized tubes made from zircaloy or  
 8 ZIRLO. The fuel tube rods have welded end plugs. Based on core design values, IP2 and IP3  
 9 operate at an individual rod average fuel burnup of no more than 62,000 megawatt-days per  
 10 metric ton of heavy metal. This ensures that peak burnups remain within the acceptable limits  
 11 specified in Table B-1 of Appendix B, "Environmental Effect of Renewing the Operating License  
 12 of a Nuclear Power Plant," to Subpart A, "National Environmental Policy Act—Regulations  
 13 Implementing Section 102(2)," of Title 10, Part 51, "Environmental Protection Regulations for  
 14 Domestic Licensing and Related Regulatory Functions," of the *Code of Federal Regulations*  
 15 (10 CFR Part 51) (Entergy 2006a). Reactor fuel that has exhausted a certain percentage of its  
 16 fissile uranium content so that it is no longer an efficient fissile fuel source is referred to as spent  
 17 fuel. The spent fuel is removed from the reactor core and replaced by fresh fuel during routine  
 18 refueling outages. Refueling outages at IP2 and IP3 typically occur every 24 months. The  
 19 spent fuel assemblies are then stored in the spent fuel pool (SFP) in the fuel storage building.

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1 Located north of IP2 inside the protected area fence, the spent fuel will be transferred to dry  
2 storage (Entergy 2007a) at an onsite independent spent fuel storage installation (ISFSI). The  
3 first fuel was moved from IP2 to the ISFSI pad, which is approximately 100 ft (30.5 m) wide by  
4 200 ft (61.0 m) long, during the first week of January 2008 (Entergy 2008).

5 IP2 and IP3 containment buildings completely enclose each unit's reactor and the reactor  
6 coolant system. The containment buildings are designed to minimize leakage of radioactive  
7 materials to the environment if a design-basis loss-of-coolant accident were to occur. The  
8 containment structures have an outer shell of reinforced concrete and an inner steel liner  
9 (Entergy 2007b).

10 The IP2 containment building contains a containment purge supply and exhaust system and a  
11 containment pressure relief system. The purge supply and exhaust system provides fresh air to  
12 the containment and filters air released from containment. The containment pressure relief  
13 system regulates normal pressure in the containment during reactor power operation (Entergy  
14 2007b).

15 The IP3 containment building contains a vapor containment heating and ventilation purge  
16 system and a vapor containment pressure relief system. The heating and ventilation system  
17 regulates fresh air flow into the containment and filters air before its dispersion to the  
18 environment. The vapor containment pressure relief system regulates pressure changes in  
19 containment during reactor power operation (Entergy 2007b).

### 20 2.1.3 Cooling and Auxiliary Water Systems

21 IP2 and IP3 have once-through condenser cooling systems that withdraw water from and  
22 discharge it to the Hudson River. The systems are described in detail in the IP2 and IP3  
23 environmental report (ER) (Entergy 2007a). This section provides a general description based  
24 on the information provided by Entergy in the ER.

25 The maximum design flow rate for each cooling system is approximately 1,870 cubic feet per  
26 second (cfs), 840,000 gallons per minute (gpm), or 53.0 cubic meters per second ( $\text{m}^3/\text{s}$ ).

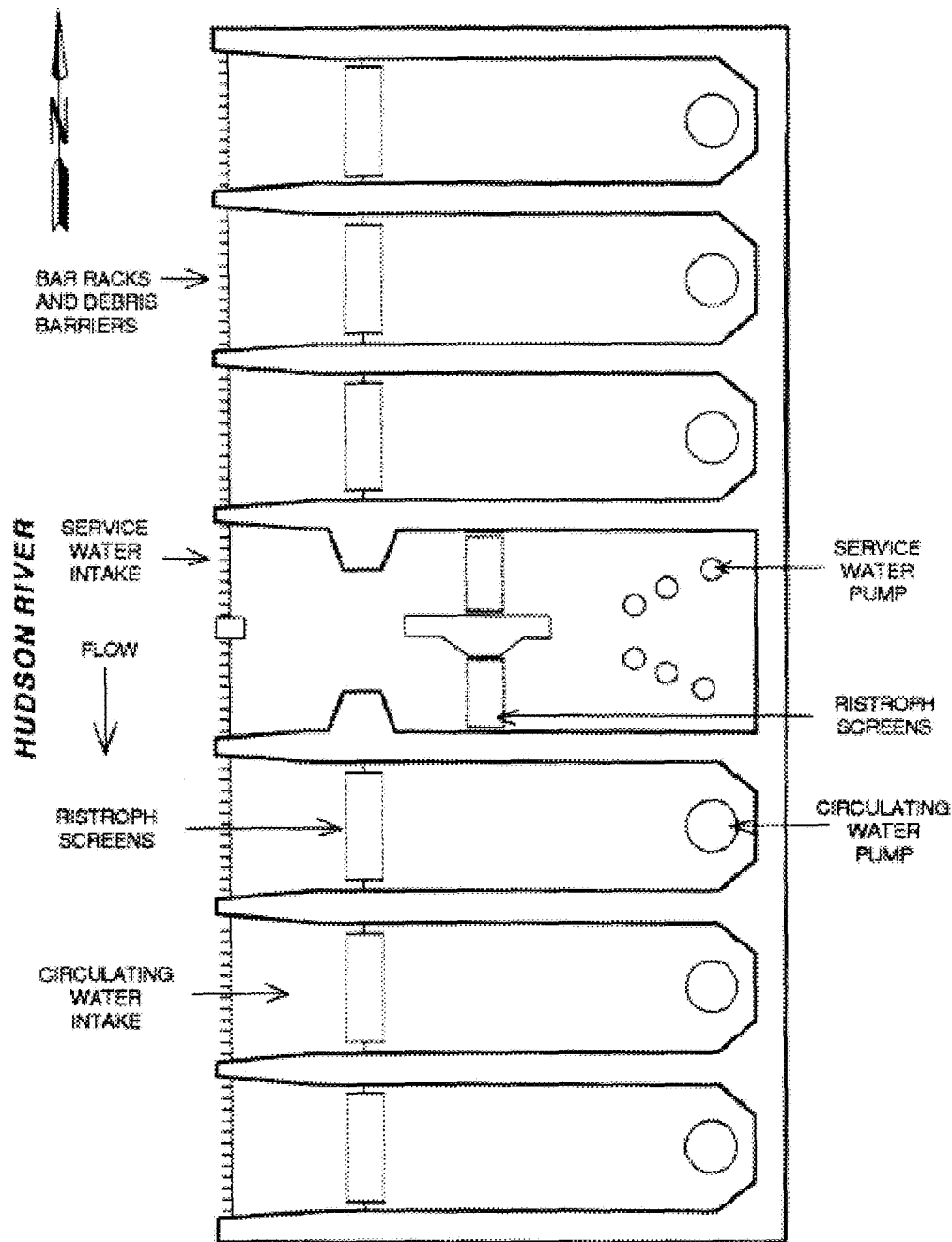
27 Two shoreline intake structures—one for each unit—are located along the Hudson River on the  
28 northwestern edge of the site and provide cooling water to the site. Each structure consists of  
29 seven bays, six for circulating water and one for service water. The IP2 intake structure has  
30 seven independent bays, while the IP3 intake structure has seven bays that are served by a  
31 common plenum. In each structure, six of the seven bays contain cooling water pumps, and the  
32 seventh bay contains service/auxiliary water pumps. Before it is pumped to the condensers,  
33 river water passes through traveling screens in the intake structure bays to remove debris and  
34 fish.

35 The six IP2 circulating water intake pumps are dual-speed pumps. When operated at high  
36 speed (254 revolutions per minute (rpm)), each pump provides 312 cfs (140,000 gpm;  
37  $8.83 \text{ m}^3/\text{s}$ ) and a dynamic head of 21 ft (6.4 m). At low speed (187 rpm), each pump provides  
38 187 cfs (84,000 gpm;  $5.30 \text{ m}^3/\text{s}$ ) and a dynamic head of 15 ft (4.6 m). The six IP3 circulating  
39 water intake pumps are variable-speed pumps. When operated at high speed (360 rpm), each  
40 pump provides 312 cfs (140,000 gpm;  $8.83 \text{ m}^3/\text{s}$ ); at low speed, it provides a dynamic head of  
41 29 ft (8.8 m) and 143 cfs (64,000 gpm;  $4.05 \text{ m}^3/\text{s}$ ). In accordance with the October 1997  
42 Consent Order (issued pursuant to the Hudson River Settlement Agreement; see

1 Section 2.2.5.3 for more information), the applicant adjusts the speed of the intake pumps to  
2 mitigate impacts to the Hudson River.

3 Each coolant pump bay is about 15 ft (4.6 m) wide at the entrance, and the bottom is located  
4 27 ft (8.2 m) below mean sea level. Before entering the intake structure bays, water flows under  
5 a floating debris skimmer wall, or ice curtain, into the screen wells. This initial screen keeps  
6 floating debris and ice from entering the bay. At the entrance to each bay, water also passes  
7 through a subsurface bar screen to prevent additional large debris from becoming entrained in  
8 the cooling system. Next, smaller debris and fish are screened out using modified Ristroph  
9 traveling screens. Figures 2-5 through 2-8 illustrate the IP2 and IP3 intake structures and bays.  
10

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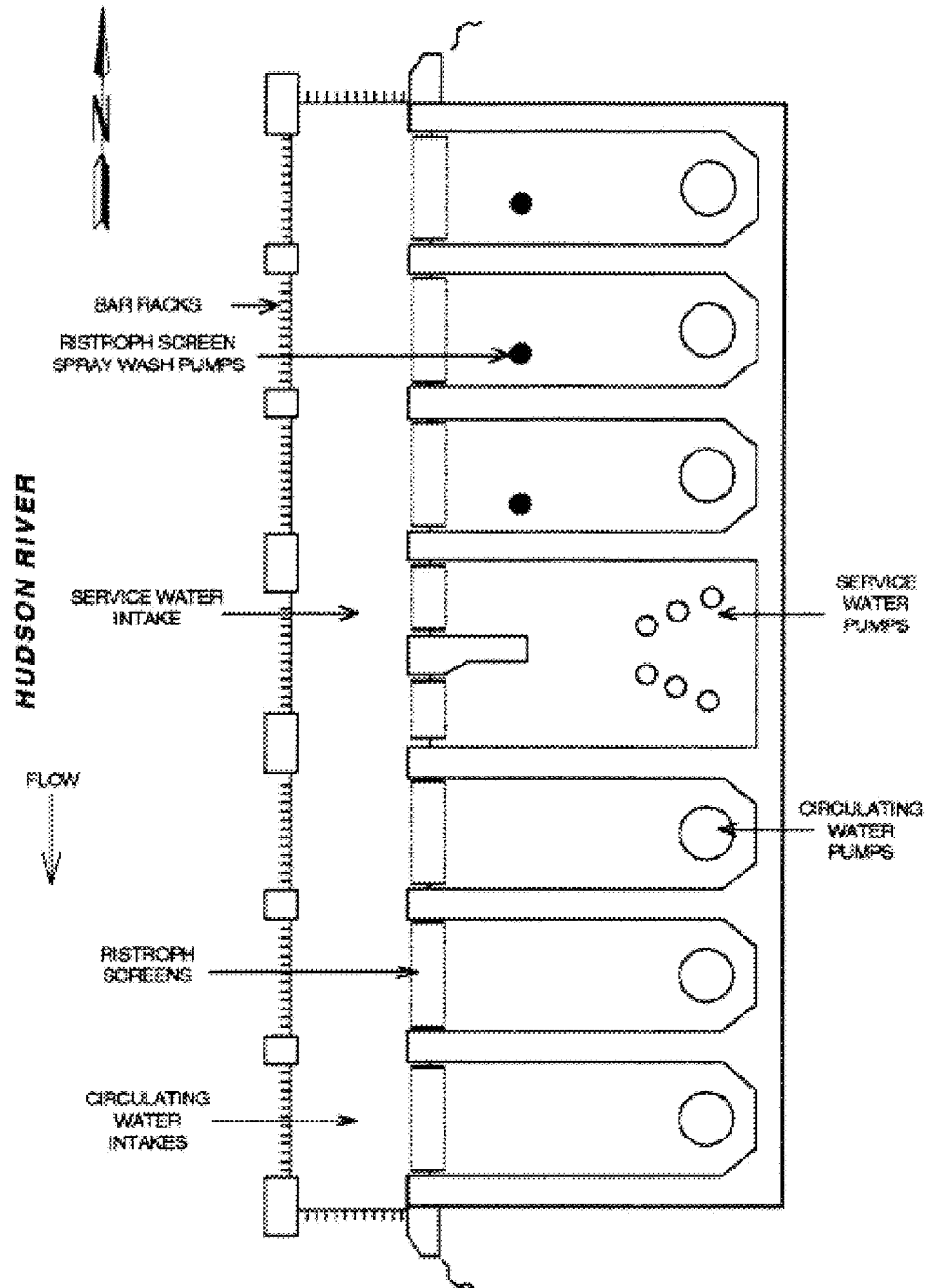
1 Source: Entergy 2007a

2

3

Figure 2-5. IP2 intake structure





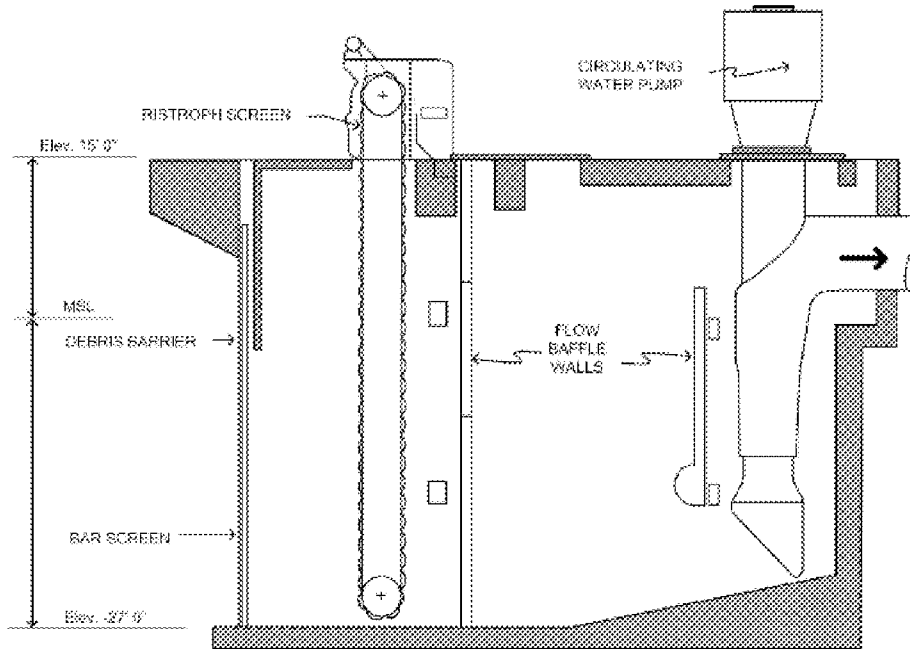
1 Source: Entergy 2007a

2

3

Figure 2-6. IP3 intake structure

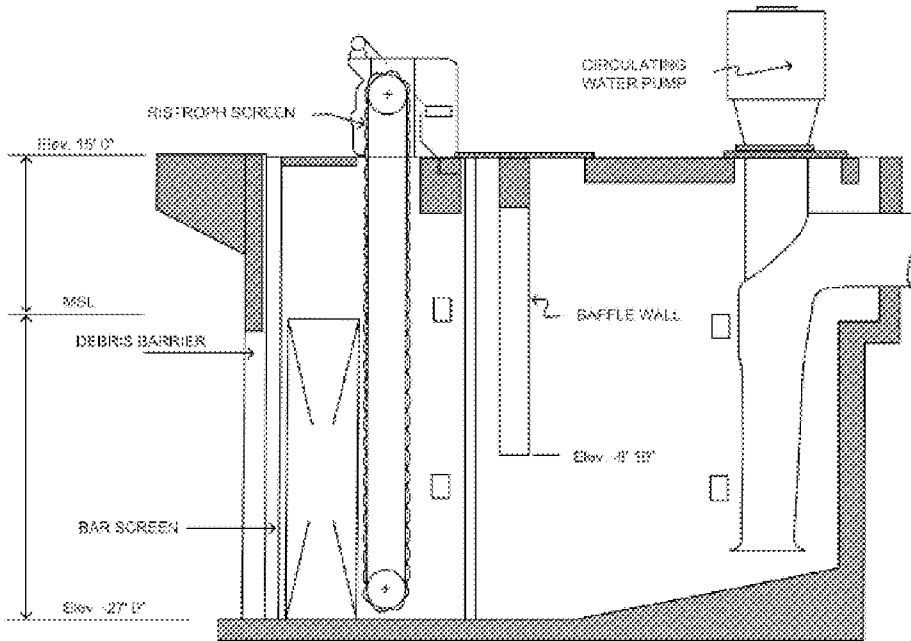
Plant and the Environment



1  
2 Source: Entergy 2007a

3

Figure 2-7. IP2 intake system



4  
5 Source: Entergy 2007a

6

7

Figure 2-8. IP3 intake system

1 The modified Ristroph traveling screens consist of a series of panels that rotate continuously.  
2 As each screen panel rotates out of the intake bay, impinged fish are retained in water-filled  
3 baskets at the bottom of each panel and are carried over the headshaft, where they are washed  
4 out onto a mesh using low-pressure sprays from the rear side of the machine. The 0.25-by-  
5 0.5-inch (in.) (0.635-by-1.27 centimeters (cm)) mesh is smooth to minimize fish abrasion by the  
6 mesh. Two high-pressure sprays remove debris from the front side of the machine after fish  
7 removal.

8 From the mesh, fish return to the river via a 12-in. (30-cm) diameter pipe. For IP2, the pipe  
9 extends 200 ft (61.0 m) into the river north of the IP2 intake structure and discharges at a depth  
10 of 35 ft (11 m). The IP3 fish return system discharges to the river by the northwest corner of the  
11 discharge canal.

12 After moving through the condensers, cooling water is discharged to the discharge canal via a  
13 total of six 96-in. (240-cm) diameter pipes. The cooling water enters below the surface of the  
14 40-ft (12-m) wide canal. The canal discharges to the Hudson River through an outfall structure  
15 located south of IP3 at about 4.5 feet per second (fps) (1.4 meters per second (mps)) at full  
16 flow. As the discharged water enters the river, it passes through 12 discharge ports (4-ft by  
17 12-ft each (1-m by 3.7-m)) across a length of 252 ft (76.8 m) about 12 ft (3.7 m) below the  
18 surface of the river. The increased discharge velocity, about 10 fps (3.0 mps), enhances mixing  
19 to minimize thermal impact.

20 The discharged water is at an elevated temperature, and therefore, some water is lost because  
21 of evaporation. Based on conservative estimates, the staff of the U.S. Nuclear Regulatory  
22 Commission (NRC) estimates that this induced evaporation resulting from the elevated  
23 discharge temperature would be less than 60 cfs (27,000 gpm or 1.7 m<sup>3</sup>/s). This loss is about  
24 0.5 percent of the annual average downstream flow of the Hudson River, which is more than  
25 9000 cfs (4 million gpm or 255 m<sup>3</sup>/s). The average cooling water transient time ranges from  
26 5.6 minutes for the IP3 cooling water system to 9.7 minutes for the IP2 system.

27 Auxiliary water systems for service water are also provided from the Hudson River via the  
28 dedicated bays in the IP2 and IP3 intake structures. The primary role of service water is to cool  
29 components (e.g., pumps) that generate heat during operation. Secondary functions of the  
30 service water include the following:

- 31 • protect equipment from potential contamination from river water by providing cooling to  
32 intermediate freshwater systems
- 33 • provide water for washing the modified Ristroph traveling screens
- 34 • provide seal water for the main circulating water pumps

35 The IP2 service water bay has six identical centrifugal sump-type pumps, each having a  
36 capacity of at least 11 cfs (5000 gpm; 0.31 m<sup>3</sup>/s) at 220-ft (67-m) total design head. The IP3  
37 service water bay also has 6 similar pumps, each rated at 13 cfs (6000 gpm; 0.378 m<sup>3</sup>/s) and  
38 195-ft (59.4-m) total design head. The average approach velocity at the entrance to each  
39 service water bay when all pumps are operating is about 0.2 fps (0.06 mps). Each service  
40 water bay also contains two Ristroph screens to reduce fish entrainment.

41 Additional service water is provided to the nonessential service water header for IP2 through the  
42 IP1 river water intake structure. The IP1 intake includes four intake bays each with a coarse bar

1 screen and a single 0.125-in. (0.318-cm) mesh screen. The intake structure contains two 36-cfs  
2 (16,000-gpm; 1.0-m<sup>3</sup>/s) spray wash pumps. The screens are washed automatically and  
3 materials are sluiced to the Hudson River.

#### 4 **2.1.4 Radioactive Waste Management Systems and Effluent Control Systems**

5 IP2 and IP3 radioactive waste systems are designed to collect, treat, and dispose of radioactive  
6 and potentially radioactive wastes that are byproducts of plant operations. These byproducts  
7 include activation products resulting from the irradiation of reactor water and impurities therein  
8 (principally metallic corrosion products) and fission products resulting from their migration  
9 through the fuel cladding or uranium contamination within the reactor coolant system.  
10 Operating procedures for radioactive waste systems are designed to ensure that radioactive  
11 wastes are safely processed and discharged from the plant within the limits set forth in  
12 10 CFR Part 20, "Standards for Protection against Radiation"; Appendix I, " Numerical Guides  
13 | for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is  
14 Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor  
15 Effluents," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"; the  
16 plant's technical specifications; and the IP2 and IP3 Offsite Dose Calculation Manual (ODCM)  
17 (Entergy 2007a).

18 Radioactive wastes resulting from plant operations are classified as liquid, gaseous, or solid.  
19 Liquid radioactive wastes are generated from liquids received directly from portions of the  
20 reactor coolant system or were contaminated by contact with liquids from the reactor coolant  
21 system. Gaseous radioactive wastes are generated from gases or airborne particulates vented  
22 from reactor and turbine equipment containing radioactive material. Solid radioactive wastes  
23 are solids from the reactor coolant system, solids that came into contact with reactor coolant  
24 system liquids or gases, or solids used in the reactor coolant system or steam and power  
25 conversion system operation or maintenance.

26 As indicated in Section 2.1.2, reactor fuel that has exhausted a certain percentage of its fissile  
27 uranium content is referred to as spent fuel. Spent fuel assemblies are removed from the  
28 reactor core and replaced with fresh fuel assemblies during routine refueling outages, typically  
29 | every 24 months. Spent fuel assemblies are then stored for a period of time in the Spent Fuel  
30 Pit (SFP) in the fuel storage building and may later be transferred to dry storage at a recently  
31 constructed onsite ISFSI. Entergy has constructed an ISFSI in the north end of the IP2 and IP3  
32 site in an area that was previously undeveloped. The facility is planned to hold up to 78 Holtec  
33 International HI-STORM 100S(B) casks (Entergy 2007a).

34 The IP2 and IP3 ODCM contains the methodology and parameters used to calculate offsite  
35 doses resulting from radioactive gaseous and liquid effluents and the gaseous and liquid  
36 effluent monitoring alarm and trip setpoints used to verify that radioactive discharges meet  
37 regulatory limits. The ODCM also contains the radioactive effluent controls and radiological  
38 environmental monitoring activities and descriptions of the information that should be included in  
39 the annual Radiological Environmental Operating Report and annual Radioactive Effluent  
40 Release Report (Entergy 2007a).

#### 1 **2.1.4.1 Liquid Waste Processing Systems and Effluent Controls**

2 The liquid waste processing system collects, holds, treats, processes, and monitors all liquid  
3 radioactive wastes for reuse or disposal.

##### 4 IP2

5 In IP2, the liquid waste holdup system collects low-level radioactive waste from throughout the  
6 facility and holds the waste until it can be processed. During normal plant operations the  
7 system receives input from numerous sources, such as equipment drains and leak lines,  
8 chemical laboratory drains, decontamination drains, demineralizer regeneration, reactor coolant  
9 loops and reactor coolant pump secondary seals, valve and reactor vessel flange leak lines, and  
10 floor drains. Liquid waste is divided into two general classifications—high-quality liquid waste  
11 from the reactor coolant drain tank and routine liquid waste from the waste holdup tank which  
12 contains reactor coolant. The IP2 liquid wastes are transferred from the waste holdup tank to  
13 the IP1 waste collection system (described later in this section). The liquid waste can also be  
14 transferred from the waste holdup tank to the waste condensate tank, where its radioactivity can  
15 be analyzed to determine whether the waste is acceptable for discharge into the condenser  
16 circulating water and into the Hudson River.

17 In the event of primary reactor coolant water (radioactive) leakage into the secondary-side water  
18 (nonradioactive) system, potentially contaminated water that collects in the secondary-side  
19 drains may be collected and sent to a collection point in the auxiliary boiler feedwater building  
20 for eventual processing.

##### 21 IP3

22 In IP3, the liquid waste holdup system collects low-level radioactive waste from throughout the  
23 facility and holds the waste until it can be processed. During normal plant operations, the  
24 system receives input from numerous sources, such as equipment drains and leak lines,  
25 radioactive chemical laboratory drains, decontamination drains, demineralizer regeneration,  
26 reactor coolant loops and reactor coolant pump secondary seals, valve and reactor vessel  
27 flange leak-offs, and floor drains. The system consists of three tanks—a 24,500 gallon (gal)  
28 (92,700 liter (L)) waste holdup tank located in the waste holdup pit, and the two 62,000 gal  
29 (235,000 L) waste holdup tanks located in the liquid radioactive waste storage facility.

30 The liquid radioactive waste storage facility, which houses the 62,000 gal (235,000 L) waste  
31 tanks, is an underground concrete structure. The 62,000 gal (235,000 L) tanks are supported  
32 on concrete piers. The building is supported on hard rock. The foundation consists of a rigid  
33 2 in. (5.0 cm) thick slab that is waterproofed. The reinforced concrete walls of the building are  
34 also waterproofed. The roof is made of 3 in. (7.6 cm) reinforced concrete poured on a steel  
35 deck and beam system.

36 When the waste has been sampled and analyzed and found to be acceptable for discharge, it is  
37 pumped from the waste holdup tank to the monitor tanks. When one monitor tank is filled, it is  
38 isolated, and the waste liquid is recirculated and sampled for radioactive and chemical analysis  
39 while the second tank is in service accumulating waste. If the waste material in the filled  
40 monitor tank meets release standards, the waste liquid is pumped to the service water  
41 discharge for release into the Hudson River. If it does not meet applicable release standards, it  
42 is returned to the waste holdup tanks for additional processing. Entergy performs radioactive  
43 and chemical analyses to determine the amount of radioactivity released. There is also a

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1 radiation monitor which provides surveillance over the operation to ensure that the discharge is  
2 within applicable radiation standards. If the radioactivity in the liquid waste being discharged  
3 exceeds the radiation standard, the discharge is terminated.

### 4 IP1

5 Radioactive waste storage and processing facilities located in IP1 provide additional waste  
6 processing services for IP2. IP1 contains four tanks with a capacity of 75,000 gal (284,000 L)  
7 each. From these tanks, the liquid can be processed by use of sluicable demineralizer vessels.  
8 There is also a portable demineralization system located in the IP1 Chemical System Building to  
9 process liquid waste. This system uses a number of inline ion exchanger resin beds and filters  
10 to remove radionuclides and chemicals from the waste stream. Once the contents of the waste  
11 tanks meet release criteria, the liquid waste is discharged into the river.

### 12 Liquid Releases

13 Liquid releases to the Hudson River are limited to the extent possible to satisfy the dose design  
14 objectives of Appendix I to 10 CFR Part 50. IP2 and IP3 have controls, described in their  
15 ODCMs, for limiting the release of radioactive liquid effluents. The controls are based on the  
16 concentrations of radioactive materials in liquid effluents and the calculated projected dose to a  
17 hypothetical member of the public. Concentrations of radioactive material that may be released  
18 in liquid effluents are limited to the concentrations specified by 10 CFR Part 20. For the  
19 calendar year, the ODCM limits the dose to a member of the public from liquid effluents to  
20 3 millirem (mrem) (0.03 millisievert (mSv)) to the total body and 10 mrem (0.10 mSv) to any  
21 organ (Entergy 2007a).

22 Entergy maintains radioactive liquid effluent discharges in accordance with the procedures and  
23 methodology described in the ODCM. The liquid radioactive waste processing system is used  
24 to reduce radioactive materials in liquid effluents before discharge to meet the as low as  
25 reasonably achievable (ALARA) dose objectives in Appendix I to 10 CFR Part 50.

26 The NRC staff reviewed the IP2 and IP3 radioactive effluent release reports for 2002 through  
27 2006 for liquid effluents (Entergy 2003a, 2003b, 2004, 2005a, 2006b, 2007c) to determine  
28 whether releases were reasonable. In 2006,  $5.99 \times 10^7$  gal ( $2.27 \times 10^8$  L) of radiological liquid  
29 effluents diluted with  $1.47 \times 10^{12}$  gal ( $5.58 \times 10^{12}$  L) of water were discharged from the IP2 and IP3  
30 site. The amount of radioactivity discharged in the form of fission and activation products from  
31 the IP2 and IP3 site in 2006 totaled  $5.92 \times 10^{-2}$  curies (Ci) ( $2.19 \times 10^3$  megabecquerels (MBq)). A  
32 total of  $1.56 \times 10^3$  Ci ( $5.77 \times 10^7$  MBq) of tritium was released from the IP2 and IP3 site in 2006. A  
33 total of  $3.82 \times 10^{-1}$  Ci ( $1.41 \times 10^4$  MBq) of dissolved and entrained gases was released in liquid  
34 discharges from the IP2 and IP3 site in 2006 (Entergy 2007c). The liquid discharges for 2006  
35 are consistent with the radioactive liquid effluents discharged from 2002 through 2005. In  
36 section 2.2.7, NRC staff reviewed the most-recent effluent release reports (2009; Entergy 2010)  
37 and confirmed that radioactive wastes reported by Entergy remain reasonable and are within  
38 applicable limits. The NRC staff expects variations in the amount of radioactive effluents  
39 released from year to year by Entergy based on the overall performance of the plant and the  
40 number and scope of maintenance and refueling outages. The liquid radioactive wastes  
41 reported by Entergy are reasonable and are within applicable limits, and the NRC staff noted no  
42 unusual trends.

43 Though Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control  
44 rod drive mechanisms during the period of extended operation, such replacement actions are

1 not likely to result in a significant increase of liquid radioactive effluents being discharged  
2 compared to the amount discharged during normal plant operations. This is based on  
3 consideration that liquids generated, processed, and released during the outage will likely be  
4 offset by the amount of liquid waste that would not be generated, processed, and released  
5 during normal plant operations during the outage period. Based on the NRC staff's evaluation  
6 of recent historical releases in the previous paragraph and based on the NRC staff's expectation  
7 that no significant increase in liquid effluents from the potential replacement of the reactor heads  
8 and control rod drive mechanisms is likely to occur, the NRC staff expects similar quantities of  
9 radioactive liquid effluents to be generated during normal operation and outages from IP2 and  
10 IP3 during the period of extended operation.

#### 11 Releases to Groundwater

12 In addition to the planned radioactive liquid discharges made through the liquid waste  
13 processing system, Entergy identified a new release pathway as a result of the discovery of  
14 tritium contamination in the ground outside the IP2 SFP. This release was listed as an  
15 abnormal release in the 2006 radioactive effluent release report. The applicant included a  
16 detailed radiological assessment of all the liquid effluent releases and the projected doses in its  
17 2006 annual radioactive effluent release report (Entergy 2007c). The following information is  
18 from that report.

19 The applicant estimated that approximately 0.19 Ci ( $7.03 \times 10^3$  MBq) of tritium migrated directly to  
20 the Hudson River by the groundwater flow path in 2006, resulting in an approximate total body  
21 dose of  $2.10 \times 10^{-6}$  mrem ( $2.10 \times 10^{-8}$  mSv). The amount of tritium released through this pathway  
22 is approximately 0.015 percent of the tritium released to the river from routine releases. Tritium  
23 releases in total (groundwater as well as routine liquid effluent) represent less than  
24 0.001 percent of the Federal dose limits for radioactive effluents from the site. Strontium-90,  
25 nickel-63, and cesium-137 collectively contributed approximately  $5.70 \times 10^{-4}$  Ci (21.1 MBq) from  
26 the groundwater pathway, which resulted in a calculated annual dose of approximately  
27  $1.78 \times 10^{-3}$  mrem ( $1.78 \times 10^{-5}$  mSv) to the total body, and  $7.21 \times 10^{-3}$  mrem ( $7.21 \times 10^{-5}$  mSv) to the  
28 critical organ, which was the adult bone (primarily because of strontium-90). Storm drain  
29 releases to the discharge canal were conservatively calculated to be approximately  $9.40 \times 10^{-2}$  Ci  
30 ( $3.48 \times 10^3$  MBq) of tritium, resulting in an approximate total body dose of  $2.00 \times 10^{-8}$  mrem  
31 ( $2.00 \times 10^{-10}$  mSv). Entergy asserts that the annual dose to a member of the public from the  
32 combined groundwater and storm water pathways at IP2 and IP3 remains well below NRC and  
33 U.S. Environmental Protection Agency (EPA) radiation protection standards (Entergy 2007c).  
34 The NRC staff further discusses releases to groundwater, including inspection results, in  
35 Section 2.2.7 of this SEIS.

#### 36 **2.1.4.2 Gaseous Waste Processing Systems and Effluent Controls**

##### 37 IP2

38 The gaseous radioactive waste processing system and the plant ventilation system control,  
39 collect, process, store, and dispose of gaseous radioactive wastes generated as a result of  
40 normal operations. During plant operations, gaseous waste is generated by degassing the  
41 reactor coolant and purging the volume control tank, displacing cover gases as liquid  
42 accumulates in various tanks, equipment purging, and sampling operations and automatic gas  
43 analysis for hydrogen and oxygen in cover gases. The majority of the gas received by the

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1 waste disposal system during normal plant operations is cover gas displaced from the chemical  
2 and volume control system holdup tanks as they fill with liquid.

3 Vented gases flow to a waste gas compressor suction header. One of two compressors is in  
4 continuous operation, with the second unit designed to operate as a backup for peak load  
5 conditions. From the compressors, gas flows to one of four large gas decay tanks. The control  
6 arrangement on the gas decay tank inlet header allows plant personnel to place one large tank  
7 in service and to select a second large tank for backup. When the tank in service becomes  
8 pressurized to a preset level, a pressure transmitter automatically opens the inlet valve to the  
9 backup tank, closes the inlet valve to the filled tank, and triggers an alarm to alert personnel to  
10 select a new backup tank. Gas held in the decay tanks can either be returned to the chemical  
11 and volume control system holdup tanks or be discharged to the environment, provided that the  
12 gas meets radiation limits.

13 Six additional small gas decay tanks are available for use during degassing of the reactor  
14 coolant system before the reactor is brought to a cold shutdown. The reactor coolant fission  
15 gas activity is distributed among the six tanks through a common inlet header. A radiation  
16 monitor in the sample line to the gas analyzer checks the gas decay tank radioactivity inventory  
17 each time a sample is taken for hydrogen-oxygen analysis. An alarm notifies plant personnel  
18 when the inventory limit is approached so that another tank can be placed into service.

19 Before a tank's contents can be discharged into the environment, they must be sampled and  
20 analyzed to verify that sufficient decay of the radioactive material has occurred and to document  
21 the amount of radioactivity that will be released. If appropriate radioactivity criteria are met, the  
22 gas is discharged to a plant vent at a controlled rate and checked by a radiation monitor in the  
23 vent. In addition to the radiation monitor, gas samples are manually taken and analyzed to  
24 ensure that radiation protection limits are maintained. During a release, a trip valve in the  
25 discharge line closes automatically when there is an indication of a high radioactivity level in the  
26 plant vent (Entergy 2007a).

### 27 IP3

28 The gaseous radioactive waste processing system and the plant ventilation system control,  
29 collect, process, store, and dispose of gaseous radioactive wastes generated as a result of  
30 normal operations. During plant operations, gaseous waste is generated by degassing the  
31 reactor coolant and purging the volume control tank, displacement of cover gases as liquid  
32 accumulates in various tanks, equipment purging, sampling operations and automatic gas  
33 analysis for hydrogen and oxygen in cover gases, and venting of actuating nitrogen for pressure  
34 control valves.

35 The majority of the gas received by the waste disposal system during normal operations is  
36 cover gas displaced from the chemical and volume control system holdup tanks as they fill with  
37 liquid. Since this gas must be replaced when the tanks are emptied during processing, facilities  
38 are provided to return gas from the decay tanks to the holdup tanks. A backup supply from the  
39 nitrogen header is provided for makeup if the return flow from the gas decay tanks is not  
40 available.

41 Gases vented to the vent header flow to the waste gas compressor header. One of the two  
42 compressors is in continuous operation with the second unit as a backup for peak load  
43 conditions. From the compressors, gas flows to one of four large gas decay tanks. The control  
44 arrangement on the gas decay tanks inlet header allows for the operation of one tank with a



1 second tank as backup. When the tank in service is filled, a pressure transmitter automatically  
2 opens the inlet valve to the backup tank and closes the valve of the filled tank and sounds an  
3 alarm. Plant personnel then select a new tank to be the backup and repeat the process.

4 Gases are held in the decay tanks to reduce the amount of radioactivity released into the  
5 environment. These gases can either be returned to the chemical and volume control system  
6 holdup tanks or discharged to the environment if the radioactivity meets radiation standards.

7 There are six additional small gas decay tanks for use during degassing of the reactor coolant  
8 before the reactor is brought to a cold shutdown. The reactor coolant fission gas activity  
9 inventory is distributed equally among the six tanks through the use of a common header. The  
10 total radioactivity in any one gas decay tank is controlled in order to limit the potential  
11 radiological consequences if any tank ruptures.

12 Before a tank's contents can be released into the environment, they must be sampled and  
13 analyzed to verify that there was sufficient decay and to provide a record of the type and  
14 quantity of radioactivity to be released. Once these steps are completed, the gas may be  
15 released to the plant vent at a controlled rate and monitored by a radiation monitor. The  
16 radiation monitor, upon detecting high radioactivity levels, can automatically close the discharge  
17 line to the plant vent. Samples are also taken manually to document releases (Entergy 2007a).

#### 18 Gaseous Releases

19 Entergy maintains radioactive gaseous effluents in accordance with the procedures and  
20 methodology described in the ODCM. The gaseous radioactive waste processing system is  
21 effectively used to reduce radioactive materials in gaseous effluents before discharge to meet  
22 the ALARA dose objectives in Appendix I to 10 CFR Part 50.

23 The NRC staff reviewed the IP2 and IP3 annual radioactive effluent release reports from 2002  
24 through 2006 for gaseous effluents (Entergy 2003a, 2003b, 2004, 2005a, 2006b, 2007c) to  
25 determine whether the releases were reasonable. There were no abnormal gaseous releases  
26 from IP2 and IP3 in 2006. The amount of radioactivity discharged in the form of fission and  
27 activation gases from the operating reactors at the IP2 and IP3 site in 2006 totaled  $2.20 \times 10^2$  Ci  
28 ( $8.14 \times 10^6$  MBq). A total of 20.8 Ci ( $7.69 \times 10^5$  MBq) of tritium was released from the IP2 and IP3  
29 site in 2006. A total of  $7.87 \times 10^{-4}$  Ci (29.1 MBq) of radioiodines and  $4.76 \times 10^{-5}$  Ci (1.76 MBq) of  
30 particulates was released from the IP2 and IP3 site in 2006 (Entergy 2007c). The gaseous  
31 discharges for 2006 are consistent with the radioactive gaseous effluents discharged from 2002  
32 through 2005. In section 2.2.7, NRC staff reviewed the most-recent effluent release reports  
33 (2009; Entergy 2010a) and confirmed that radioactive releases reported by Entergy remain  
34 reasonable and within applicable limits. The NRC staff expects variations in the amount of  
35 radioactive effluents released from year to year based on the overall performance of the plant  
36 and the number and scope of maintenance and refueling outages. The gaseous radioactive  
37 wastes reported by Entergy are reasonable and is within applicable limits, and the NRC staff  
38 noted no unusual trends.

39 Though Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control  
40 rod drive mechanisms during the period of extended operation, such replacement actions are  
41 not likely to result in a significant increase in discharges of gaseous radioactive effluents above  
42 the amount discharged during normal plant operations. This is based on consideration that any  
43 gaseous effluents released during the outage will be offset by the amount of gaseous effluents  
44 that would not be generated, processed, and released during normal plant operations. Based on

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1 the NRC staff's evaluation of recent historical releases in the previous paragraph and based on  
2 the NRC staff's expectation that no significant increase in gaseous effluents from the potential  
3 replacement of the reactor heads and control rod drive mechanisms will occur, the NRC staff  
4 expects that similar quantities of radioactive gaseous effluents will be generated during normal  
5 operations and outages at IP2 and IP3 during the period of extended operation.

### 6 **2.1.4.3 Solid Waste Processing**

7 IP2 and IP3 solid radioactive wastes include solidified waste derived from processed liquid and  
8 sludge products; spent resins, filters, and paper; and glassware used in the radiation-controlled  
9 areas of the plant. Waste resin is stored in the spent resin storage tank to allow radioactive  
10 decay. When a sufficient volume of resin is accumulated, it is moved from storage and placed  
11 into a high-integrity container. The wet waste is then dewatered and prepared for transportation  
12 in accordance with the plant's process control program. The process control program contains  
13 the criteria and requirements that the waste must meet to comply with NRC and U.S.  
14 Department of Transportation (DOT) requirements for transportation of radioactive waste on the  
15 public roads. The other solid radioactive wastes, such as paper, rags, and glassware, are also  
16 processed for shipping in accordance with the process control program. Entergy, when  
17 possible, sends the solid radioactive waste to a material recovery center or to a facility licensed  
18 to incinerate and perform other techniques to reduce the waste volume before disposal.  
19 Additional interim radioactive waste storage space is located in the IP1 containment.

#### 20 IP2

21 At IP2, the original four steam generators are stored in the Original Steam Generator Storage  
22 Facility. The facility is made of reinforced concrete and is designed to contain contaminated  
23 materials and allow for decontamination of materials if necessary. The structure is built to  
24 prevent both the intrusion of water into the facility and the leakage of contaminated water from  
25 the facility. The floor of the facility is sloped to direct any liquids to a sump. The floor slab and  
26 lower portion of the walls have a protective coating to facilitate decontamination, if required. A  
27 passive high-efficiency filter is used to prevent airborne contamination from being vented  
28 outside the facility. This facility is located within the owner-controlled area outside of the  
29 protected area.

#### 30 IP3

31 At IP3, solid radioactive waste (dry activated waste or solidified resins) may be stored in the IP3  
32 Interim Radioactive Waste Storage Facility before being shipped off site. The facility is a  
33 concrete structure designed to minimize the impact of stored materials on the public and the  
34 environment. It is shielded to limit the offsite annual radiation dose to less than 5 mrem  
35 (0.05 mSv). As at IP2, a reinforced concrete structure is used to store the original four steam  
36 generators, which were removed in 1989. This structure, called the Replaced Steam Generator  
37 Storage Facility, is shielded to reduce radiation exposure, and all openings are sealed with no  
38 provision for ventilation. There is a locked and locally alarmed labyrinth entrance that allows for  
39 periodic surveillance of the steam generators. There are no gaseous or liquid releases from this  
40 facility.

#### 41 Solid Waste Shipment

42 IP2 and IP3 radioactive waste shipments are packaged in accordance with NRC and DOT  
43 requirements. The type and quantities of solid radioactive waste generated at and shipped from

1 the site vary from year to year, depending on plant activities (i.e., refueling outage, maintenance  
2 work, and fuel integrity). Entergy ships radioactive waste to the Studsvik facility in Erwin,  
3 Tennessee, the Race facility in Memphis, Tennessee, or the Duratek facility in Oak Ridge,  
4 Tennessee, where the wastes undergo additional processing before being sent to a facility for  
5 disposal. In the recent past, Entergy had shipped waste to the Barnwell facility in Barnwell  
6 County, South Carolina, or the Envirocare facility in Clive, Utah, for disposal (Entergy 2007a).  
7 In July 2008, however, the State of South Carolina closed access to radioactive waste  
8 generators in States that are not part of the Atlantic Low-Level Waste Compact. New York is  
9 not in this compact. (Envirocare, however, remains open for Class A wastes.)

10 In the near term, Entergy is working to address the loss of the low-level solid radioactive waste  
11 disposal repository in Barnwell, South Carolina. During the NRC environmental site audit, IP2  
12 and IP3 staff indicated that they would be able to safely store their low-level waste on site in  
13 existing onsite buildings. Entergy indicates that it is currently developing a comprehensive plan  
14 to address the potential need for long-term storage. The radiation dose from the storage of  
15 low-level radioactive waste would be required to continue to result in doses to members of the  
16 public that are below the limits in 10 CFR Part 20 and 40 CFR Part 190, "Environmental  
17 Radiation Protection Requirements for Normal Operations of Activities in the Uranium Fuel  
18 Cycle," which apply to all operations and facilities at the site.

19 In 2006, Entergy made a total of 49 shipments of Class A, B, and C solid radioactive waste to  
20 offsite processing vendors. The solid waste volumes were  $5.31 \times 10^4$  cubic feet ( $1.50 \times 10^3$  m<sup>3</sup>) of  
21 resins, filters, evaporator bottoms, and dry active waste, with an activity of  $9.49 \times 10^2$  Ci  
22 ( $3.51 \times 10^7$  MBq). Entergy shipped no irradiated components or control rods in 2006 (Entergy  
23 2007c). The solid waste volumes and radioactivity amounts generated in 2006 are typical of  
24 annual waste shipments made by Entergy. The NRC staff expects variations in the amount of  
25 solid radioactive waste generated and shipped from year to year based on the overall  
26 performance of the plant and the number and scope of maintenance work and refueling  
27 outages. The NRC staff finds that the volume and activity of solid radioactive waste reported by  
28 Entergy are reasonable, and no unusual trends were noted.

29 Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control rod drive  
30 mechanisms during the period of extended operation (Entergy 2008), and such replacement  
31 actions are likely to result in a small increase in the amount of solid radioactive waste  
32 generated. This is partly because the number of personnel working at the plant will increase,  
33 leading to increased use of protective clothing and safety equipment and an increased use of  
34 filters. Also, work activities will create a general increase in debris that will have to be disposed  
35 of as radioactive waste. However, the increased volume is expected to be within the range of  
36 solid waste that can be safely handled by IP2 and IP3 during the period of extended operation.  
37 In the GEIS (NRC 1996), NRC indicated that doses from onsite storage of assemblies removed  
38 during refurbishment would be "very small and insignificant." Retired vessel heads will likely be  
39 stored on site in a concrete building (Entergy 2008), subject to regular monitoring and dose  
40 limits under 10 CFR Part 20 and 40 CFR Part 190.

### 41 **2.1.5 Nonradioactive Waste Systems**

42 IP2 and IP3 generate solid, hazardous, universal, and mixed waste from routine facility  
43 operations and maintenance activities.

1 **2.1.5.1 Nonradioactive Waste Streams**

2 Nonradioactive waste is produced during plant maintenance, cleaning, and operational  
3 processes. Most of the wastes consist of nonhazardous waste oil and oily debris and result  
4 from operation and maintenance of oil-filled equipment.

5 The facility generates solid waste, as defined by the Resource Conservation and Recovery Act  
6 (RCRA), as part of routine plant maintenance, cleaning activities, and plant operations. These  
7 solid waste streams include nonradioactive resins and sludges, putrescible wastes, and  
8 recyclable wastes.

9 Universal wastes constitute a majority of the remaining waste volumes generated at the facility.  
10 Universal waste is hazardous waste that has been specified as universal waste by EPA.  
11 Universal wastes, including mercury-containing equipment, batteries, fluorescent bulbs, and  
12 pesticides, have specific regulations (40 CFR Part 273, "Standards for Universal Waste  
13 Management") to ensure proper collection and recycling or treatment.

14 Hazardous wastes routinely make up a small percentage of the total wastes generated at the  
15 IP2 and IP3 facility and include spent and expired chemicals, laboratory chemical wastes, and  
16 other chemical wastes (Entergy 2007a). Hazardous waste is nonradioactive waste that is listed  
17 by EPA as hazardous waste or that exhibits characteristics of ignitability, corrosivity, reactivity,  
18 or toxicity (40 CFR Part 261, "Identification and Listing of Hazardous Waste"). RCRA, as well  
19 as the NYSDEC regulatory requirements set forth in Title 6 of the New York Codes, Rules, and  
20 Regulations (NYCRR) Parts 371-376, that regulate storage and handling of hazardous waste  
21 and require a hazardous waste permit for facilities that store large quantities of hazardous waste  
22 for more than 90 days.

23 Low-level mixed waste (LLMW) is waste that exhibits hazardous characteristics and contains  
24 low levels of radioactivity. LLMW at IP2 and IP3 is regulated under RCRA and NYSDEC  
25 regulatory requirements as set forth in 6 NYCRR Parts 373 and 374.

26 IP2 has mixed waste storage facilities covered by a Permit, NYD991304411, issued by  
27 NYSDEC under 6 NYCRR Part 373, for the accumulation and temporary storage of mixed  
28 wastes onsite for more than 90 days. Mixed wastes are temporarily stored onsite for more than  
29 90 days at IP3 based on a mixed waste conditional exemption for Permit NYD085503746, per 6  
30 NYCRR Part 374-1.9.

31 Some amounts of chemical and biocide wastes are produced at the facility from processes used  
32 to control the pH in the coolant, to control scale, to control corrosion, to regenerate resins, and  
33 to clean and defoul the condensers. These waste liquids are typically discharged in accordance  
34 with the site's State Pollutant Discharge Elimination System (SPDES) Permit, NY-0004472,  
35 along with cooling water discharges (Entergy 2007a).

36 Hazardous and universal wastes are collected in central collection areas. The materials are  
37 received in various forms and are packaged to meet all regulatory requirements before final  
38 disposition at an appropriate offsite facility. Entergy tracks wastes like waste oil, oily debris,  
39 glycol, lighting ballasts containing polychlorinated biphenyls (PCBs), fluorescent lamps,  
40 batteries, and hazardous wastes (i.e., paints, lead abatement waste, broken lamps, off-  
41 specification and expired chemicals)—by volume at the facility. The total amount of tracked  
42 hazardous and universal wastes for 2006 was 17,987 pounds (lb) (8,158 kilograms (kg)) with  
43 waste oil making up 70 percent of the total weight (Entergy 2007a).

1 Most sanitary wastewater from the IP2 and IP3 facility operations is transferred to the Village of  
2 Buchanan publicly owned treatment works system. A few isolated areas at the facility have their  
3 own septic tanks. Although the sanitary wastewaters are nonradioactive, a radiation monitoring  
4 system continuously monitors the effluent from the protected area (Entergy 2007a).

5 The testing of the emergency generators and boiler operations generates nonradioactive  
6 gaseous effluents. Emissions are managed in accordance with IP2 and IP3 air quality permits,  
7 3-5522-00011/00026 and 3-5522-00105/00009, respectively (Entergy 2007a).

#### 8 **2.1.5.2 Pollution Prevention and Waste Minimization**

9 Entergy's Waste Minimization Plan describes programs that have been implemented at the  
10 facility. This plan is used in conjunction with other waste minimization procedures, waste  
11 management procedures (including on-site recycling), chemical control procedures, and other  
12 site-specific procedures to reduce waste generation (Entergy 2007a).

#### 13 **2.1.6 Facility Operation and Maintenance**

14 Maintenance activities conducted at IP2 and IP3 include inspection, testing, and surveillance to  
15 maintain licensing requirements and to ensure compliance with environmental and safety  
16 requirements. Various programs and activities currently exist at the facility to maintain, inspect,  
17 test, and monitor the performance of facility equipment. These maintenance activities include  
18 inspection requirements for reactor vessel materials, in-service inspection and testing of boilers  
19 and pressure vessels, the maintenance structures monitoring program, and water chemistry  
20 maintenance.

21 Additional programs include those implemented to meet technical specification surveillance  
22 requirements, those implemented in response to the NRC generic communications, and various  
23 periodic maintenance, testing, and inspection procedures. Certain program activities are  
24 performed during the operation of the unit, while others are performed during scheduled  
25 refueling outages. As mentioned in Section 2.1.2, Entergy typically refuels IP2 and IP3 on  
26 24-month cycles.

#### 27 **2.1.7 Power Transmission System**

28 The applicant has identified two 345-kV transmission lines that connect IP2 and IP3 to the Con  
29 Edison electrical transmission grid. Feeder W95 and feeder W96 deliver power from IP2 and  
30 IP3, respectively, to the Buchanan substation located across Broadway near the entrance to the  
31 IP2 and IP3 site. Other than these two transmission lines, no other lines or facilities were  
32 constructed specifically to connect the two generating units to the existing transmission grid.  
33 Because the Buchanan substation and the regional transmission system to which it connects  
34 were designed and constructed before IP2 and IP3 (Entergy 2007a; NRC 1975; USAEC 1972),  
35 they are beyond the scope of this evaluation.

36 Each of the W95 and W96 lines is approximately 2000 ft (610 m) long. The lines are within the  
37 site except for the terminal 100-ft (30.5-m) segments that cross Broadway and enter the  
38 substation. In addition to transmitting the output power from IP2 and IP3 off site, the  
39 transmission system also provides IP2 and IP3 with the auxiliary power necessary for startup  
40 and normal shutdown. Offsite (standby) power is supplied to IP2 and IP3 by 138-kV input lines

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1 that use the same transmission towers as the W95 and W96 output lines (Entergy 2005b;  
2 NRC 1975). The W95 and W96 lines are each within a separate right-of-way (ROW), so the  
3 ROWs total approximately 4000 ft (1220 m) in length. About 500 ft (150 m) of this ROW length  
4 is vegetated; the remainder crosses roads, parking lots, buildings, and other facilities. In the  
5 vegetated segments, the NRC staff observed that the ROW is approximately 150 ft (46 m) wide,  
6 the growth of trees is prevented, and a cover of mainly grasses and forbs is maintained.

## 7 **2.2 Plant Interaction with the Environment**

### 8 **2.2.1 Land Use**

9 Within the 239-acre (97-ha) Indian Point site, IP2 and IP3 (see Figure 2-3) are located north and  
10 south, respectively, of IP1, which is in SAFSTOR until it is eventually decommissioned. The  
11 developed portion of the IP2 and IP3 site is approximately 124.3 acres (50.3 ha), or over half  
12 the site (see Figure 2-3). The remaining portions of the site are unused, undeveloped, and  
13 include fields and forest uplands (approximately 112.4 acres (45.5 ha) and wetlands, streams,  
14 and a pond (2.4 acres (0.97 ha)). Much of the site (approximately 159 acres (64.3 ha)) has  
15 been disturbed at some time during the construction and operation of the three units (ENN  
16 2007b).

17 The immediate area around the station is completely enclosed by a fence with access to the  
18 station controlled at a security gate. The plant site can be accessed by road or from the Hudson  
19 River. Land access to the plant site is from Broadway (main entrance). The existing wharf is  
20 used to receive heavy equipment as needed, although access to the site from the river is  
21 controlled by site access procedures. The plant site is not served by railroad. The exclusion  
22 area, as defined by 10 CFR 100.3, "Definitions," surrounds the site as shown in Figure 2-3  
23 (Entergy 2007a).

### 24 **2.2.2 Water Use**

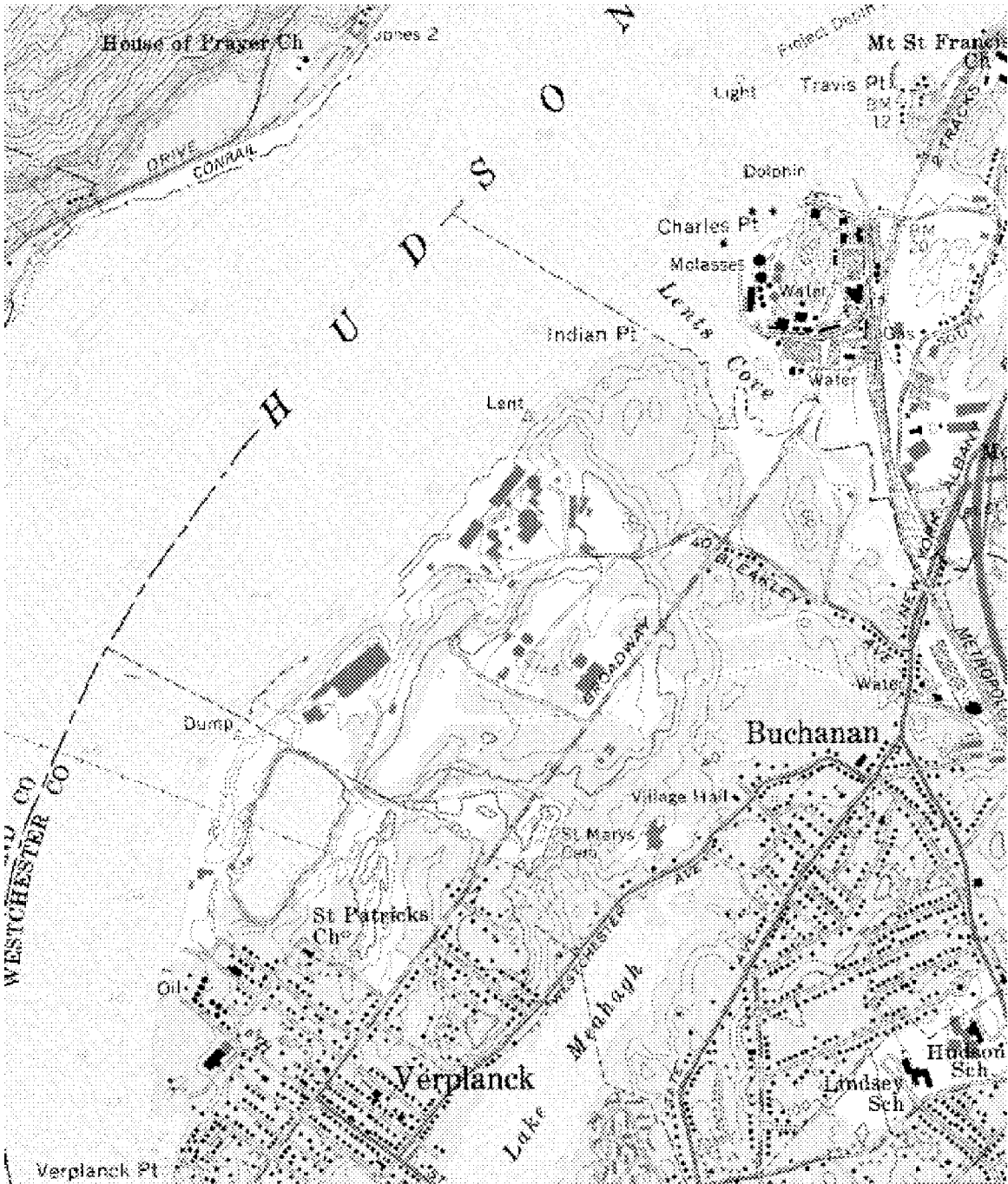
25 The Hudson River is an important regional resource of significant aesthetic value in addition to  
26 providing transportation, recreation, and water supply. The Hudson River at IP2 and IP3 is  
27 tidally influenced and becomes increasingly so as it proceeds south. IP2 and IP3 have a once-  
28 through condenser cooling system that withdraws water from the Hudson River. The same  
29 amount of water that is withdrawn for condenser cooling is discharged. However, the  
30 discharged water is at an elevated temperature and, therefore, can induce some additional  
31 evaporation. The NRC staff conservatively estimates that this induced evaporation from  
32 elevated discharge temperature is less than 60 cfs (1.7 m<sup>3</sup>/s). The remaining consumptive  
33 water uses are insignificant relative to induced evaporation.

### 34 **2.2.3 Water Quality**

35 Being tidally influenced, the salinity of the Hudson River varies as upstream flows and tides  
36 fluctuate. The salinity decreases when stream flows increase and tides drop. The salinity  
37 increases during periods of low flow and high tides. The periodic higher salinity levels limit  
38 some of the uses that a lower salinity river might support (e.g., drinking water supply).

1 Discharges to the Hudson River are regulated by the Clean Water Act (CWA). The CWA is  
2 administered by EPA. EPA has delegated responsibility for administration of the National  
3 Pollutant Discharge Elimination System to NYSDEC. The IP2 and IP3 ownership submitted  
4 timely and sufficient applications to renew its SPDES permits before the expiration of those  
5 permits in 1992. The 1987 SPDES permit for the facility remains in effect while NYSDEC  
6 administrative proceedings continue. Pursuant to the New York State Administrative Procedure  
7 Act, the facility SPDES permit does not expire until NYSDEC makes its final determination. To  
8 date, this final determination has not been made. In 1991, NYSDEC, the facility owners, and  
9 several stakeholder groups entered

1



2 Source: Maptech, Inc.

3

4 Figure 2-9. Topographic features surrounding IP2 and IP3

5



1 into a consent order (issued pursuant to the Hudson River Settlement Agreement; see  
2 Section 2.2.5.3 for more information) to mitigate impacts of the thermal plume entering the  
3 Hudson River from the plant's discharge. On April 2, 2010, the New York State Department of  
4 Environmental Conservation (NYSDEC) issued a Notice of Denial regarding the IP2 and IP3  
5 Clean Water Act Section 401 Water Quality Certification. Entergy has since requested a  
6 hearing on the issue, and the matter will be decided through NYSDEC's hearing process.

7 IP2 and IP3 do not intentionally discharge contaminants in a manner that would contaminate the  
8 groundwater beneath the site. However, in 2005, tritium was located beneath the IP2 and IP3  
9 site. During a subsequent subsurface monitoring program at the site, radioactive forms of  
10 cesium, cobalt, nickel, and strontium also were found. The radiological impact of these leaks on  
11 groundwater is discussed in Section 2.2.7 of this SEIS (the leaks are also mentioned in  
12 Section 2.1.4.1 of this SEIS).

## 13 **2.2.4 Meteorology and Air Quality**

### 14 **2.2.4.1 Climate**

15 IP2 and IP3 are located in the Village of Buchanan, New York, in Westchester County on the  
16 eastern bank of the Hudson River at approximately RM 43 (RKM 69). The river bisects the area  
17 within a 6-mi (9.7-km) radius of the site and geographically separates Westchester County from  
18 Rockland County to the west. The Hudson River flows northeast to southwest at the site but  
19 turns sharply northwest approximately 2 mi northeast of the plant. The western bank of the  
20 Hudson River is flanked by the steep, heavily wooded slopes of the Dunderberg and West  
21 Mountains to the northwest (elevations 1086 and 1257 ft (331 and 383 m) above mean sea level  
22 (MSL), respectively) and Buckberg Mountain to the west-southwest (elevation 793 ft (242 m)  
23 above MSL). These peaks extend to the west and gradually rise to slightly higher peaks  
24 (Entergy 2007a).

25 The climate is continental, characterized by rapid changes in temperature, resulting in hot  
26 summers and cold winters. The area, being adjacent to the St. Lawrence River Valley storm  
27 track, is subject to cold air masses approaching from the west and north. It has a variable  
28 climate, characterized by frequent and swift changes. The climate is also subject to some  
29 modification by the Atlantic Ocean. The moderating effect on temperatures is more pronounced  
30 during the warmer months than in winter when bursts of cold air sweep down from Canada. In  
31 the warmer seasons, temperatures rise rapidly in the daytime. However, temperatures also fall  
32 rapidly after sunset so that the nights are relatively cool. Occasionally, there are extended  
33 periods of oppressive heat up to a week or more in duration. Winters are usually cold and  
34 sometimes fairly severe. Furthermore, the area is also close to the path of most storm and  
35 frontal systems that move across the North American continent. Weather conditions often  
36 approach from a westerly direction, and the frequent passage of weather systems often helps  
37 reduce the length of both warm and cold spells. This is also a major factor in keeping periods of  
38 prolonged air stagnation to a minimum (NOAA 2004).

39 The State of New York has a climate that varies greatly. For example, the average January  
40 temperature ranges from 14° Fahrenheit (F) (-10° Celsius (C)) in the central Adirondack  
41 Mountains to 30°F (-1.1°C) on Long Island. The average July temperature in the central  
42 Adirondacks is 66°F (19°C), and 74°F (23°C) on Long Island. The highest temperature ever  
43 recorded in the State was 108°F (42°C) at Troy on July 22, 1926. The lowest recorded

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1 temperature, -52°F (-47°C), occurred at Old Forge, in the Fulton Chain of Lakes area, on  
2 February 18, 1979 (World Book Encyclopedia 2006). In Westchester County, where IP2 and  
3 IP3 are located, temperatures are mild in the summer and cold in the winter. Buchanan, New  
4 York, has a mean daily maximum temperature range from 28°F (-2.2°C) in winter to 87°F  
5 (31°C) in summer. The mean daily minimum temperatures range from about 20°F (-6.7°C) in  
6 winter to about 72°F (22°C) in summer (Indian Point Energy Center 2004).

7 Precipitation varies considerably in New York. The areas of Tug Hill, the southwestern slopes  
8 of the Adirondacks, the central Catskills, and the southeast areas usually receive 44 in.  
9 (110 cm) of rain a year, while other portions of the State get only 36 in. (91 cm). The Great  
10 Lakes, with their broad expanse of open water, supply moisture for abundant winter snowfall.  
11 Syracuse, Rochester, and Buffalo routinely receive annual snowfalls that are the highest for any  
12 major city in the United States (World Book Encyclopedia 2006). Most of the precipitation in this  
13 area is derived from moisture-laden air transported from the Gulf of Mexico and cyclonic  
14 systems moving northward along the Atlantic coast. The annual rainfall is rather evenly  
15 distributed over the year. Also, being adjacent to the track of storms that move through the  
16 Saint Lawrence River Valley, and under the influence of winds that sweep across Lakes Erie  
17 and Ontario to the interior of the State, the area is subject to cloudiness and winter snow  
18 flurries. Furthermore, the combination of a valley location and surrounding hills produces  
19 numerous advection fogs which also reduce the amount of sunshine received (NOAA 2004).

20 In the IP2 and IP3 Buchanan area, precipitation averages 37 in. (94 cm) per year and is  
21 distributed rather evenly throughout the 12-month period. The lowest amount is in February,  
22 and the highest is in May (Indian Point Energy Center 2004). Although the Village of Buchanan  
23 area is subject to a wide range of snowfall amounting to as little as 20 in. (51 cm) or as much as  
24 70 in. (180 cm), Westchester County snowfall amounts typically average between approximately  
25 25 to 55 in. (64 to 140 cm) per year (NRCC 2006).

26 Wind velocities are moderate. The north-south Hudson River Valley has a marked effect on the  
27 lighter winds, and in the warm months, average wind direction is usually southerly. For the most  
28 part, the winds at Buchanan have northerly and westerly components. Destructive winds rarely  
29 occur. Tornadoes, although rare, have struck the area, causing major damage (NOAA 2004).

30 On average, seven tornadoes strike New York every year (USDOC 2006a). Westchester  
31 County has had a total of eight tornadoes since 1950, seven of which have been F1 or less  
32 ("weak" tornadoes). The eighth tornado, which struck portions of Westchester County on  
33 July 12, 2006, was rated as an F2 at its maximum intensity (briefly a "strong" tornado) but was  
34 an F1 for most of its existence. Based on climatic data compared to other regions of the United  
35 States, the probability of a tornado striking the IP2 and IP3 site is small, and tornado intensities  
36 in Westchester County are relatively low (USDOC 2006b).

### 37 2.2.4.2 Meteorological System

38 Entergy's meteorological system consists of three instrumented towers, redundant power and  
39 ventilation systems, redundant communication systems, and a computer processor/recorder.

40 Entergy describes the primary system as a 122-m (400-ft) instrumented tower located on the  
41 site that provides the following:

- 42 • wind direction and speed measurement at a minimum of two levels, one of which is  
43 representative of the 10-m (33-ft) level

- 1 • standard deviations of wind direction fluctuations as calculated at all measured levels
- 2 • vertical temperature difference for two layers (122–10 m (400–33 ft) and 60–10 m (197–
- 3 33 ft))
- 4 • ambient temperature measurements at the 10-m (33-ft) level
- 5 • precipitation measurements near ground level
- 6 • Pasquill stability classes as calculated from temperature difference (Indian Point Energy
- 7 Center 2005)

8 The meteorological measurement system is located in a controlled environmental housing and  
9 connected to a power supply system with a redundant power source. A diesel generator  
10 provides immediate power to the meteorological tower system within 15 seconds after an  
11 outage trips the automatic transfer switch. Support systems include an uninterruptible power  
12 supply, dedicated ventilation systems, halon fire protection, and dedicated communications  
13 (Indian Point Energy Center 2005).

14 Entergy indicates that the meteorological system transmits 15-minute average data  
15 simultaneously to two loggers at the primary tower site. One data logger transmits to a  
16 computer that determines joint frequency distributions, and the second transmits to a computer  
17 in the Buchanan Service Center that allows remote access to the data. Meteorological data can  
18 be transmitted simultaneously to emergency responders and the NRC in a format designated by  
19 NUREG-0654/FEMA-REP-1. Fifteen-minute averages of meteorological parameters for the  
20 preceding 12 hours are available from the system (Indian Point Energy Center 2005).

21 The backup meteorological system is independent of the primary system and consists of a  
22 backup tower located approximately 2700 ft (833 m) north of the primary tower and a data  
23 acquisition system located in the Emergency Operations Facility. The backup system provides  
24 measurements at the 10-m (33-ft) level of wind direction and speed and an estimate of  
25 atmospheric stability (Pasquill category using sigma theta, which is a standard deviation of wind  
26 fluctuation). The backup system provides information in real-time mode. Changeover from the  
27 primary system to the backup system occurs automatically. In the event of a failure of the  
28 backup meteorological measurement system, a standby backup system exists at the 10-m  
29 (33-ft) level of the Buchanan Service Center building roof. It also provides measurements of the  
30 10-m (33-ft) level of wind direction and speed and an estimate of atmospheric stability (Pasquill  
31 category using sigma theta, which is a standard deviation of wind fluctuations). The changeover  
32 from the backup system to the standby system also occurs automatically. As in the case of the  
33 primary system, the backup meteorological measurement system and associated controlled  
34 environmental housing system are connected to a power system which is supplied from  
35 redundant power sources. In addition to the backup meteorological measurement system, a  
36 backup communications line to the meteorological system is operational. During an interim  
37 period, the backup communications are provided via telephone lines routed through a telephone  
38 company central office separate from the primary circuits (Indian Point Energy Center 2005).

### 39 **2.2.4.3 Air Quality**

40 Under the Clean Air Act, EPA established National Ambient Air Quality Standards (NAAQS) for  
41 specific concentrations of certain pollutants, called criteria pollutants. Areas in the United States  
42 having air quality as good as or better than these standards (i.e., pollutant levels lower than the

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1 NAAQS) were designated as attainment areas for the various pollutants. Areas with monitored  
2 pollutant levels greater than these standards are designated as nonattainment areas. Areas in  
3 the United States whose pollutant levels were greater than the NAAQS and are now lower than  
4 the NAAQS are designated as maintenance areas.

5 Four states are located within a 50-mi (80-km) radius of the site. These include Pennsylvania's,  
6 Connecticut, New York, and New Jersey. The 50-mi (80-km) radius includes nonattainment  
7 areas for the ozone (O<sub>3</sub>) 8-hour standard, particulate matter less than 10 microns in diameter  
8 (PM<sub>10</sub>), and particulate matter less than 2.5 microns in diameter (PM<sub>2.5</sub>). The portion of  
9 Pennsylvania (Pike County) located within the 50-mi (80-km) radius is in attainment for all  
10 criteria pollutants.

11 The currently designated nonattainment areas for Connecticut counties within a 50-mi (80-km)  
12 radius of the site are as follows:

- 13 • Fairfield and New Haven\*—O<sub>3</sub> and PM<sub>2.5</sub>
- 14 • Litchfield—O<sub>3</sub>

15 The currently designated nonattainment areas for New Jersey counties within a 50-mi (80-km)  
16 radius of the site are as follows:

- 17 • Bergen, Essex, Hudson, Morris, Passaic, Somerset, and Union\*—O<sub>3</sub> and PM<sub>2.5</sub>
- 18 • Sussex\*—O<sub>3</sub>

19 The currently designated nonattainment areas for New York counties within a 50-mi (80-km)  
20 radius of the site are as follows:

21 Bronx, Kings, Nassau, Orange, Queens, Richmond, Rockland, Suffolk, and Westchester\*—O<sub>3</sub>  
22 and PM<sub>2.5</sub>

- 23 • Dutchess and Putnam—O<sub>3</sub>
- 24 • New York\*—O<sub>3</sub>, PM<sub>10</sub>, and PM<sub>2.5</sub>

25 Note that the counties labeled with an "\*" are part of the EPA-designated "New York—New  
26 Jersey—Long Island Nonattainment Area" (EPA 2006a).

27 New York State air permits for IP2 and IP3, 3-5522-00011/00026 and 3-5522-000105/00009,  
28 respectively, regulate emissions from boilers, turbines, and generators. These permits restrict  
29 nitrogen oxides (NO<sub>x</sub>) emissions to 23.75 tons (t) (22 metric tons (MT)) per year per station by  
30 restricting engine run time and fuel consumption. IP2 and IP3 are not subject to the Risk  
31 Management Plan (RMP) requirements described in 40 CFR Part 68, as no RMP-regulated  
32 chemicals stored on site exceed the threshold values listed in 40 CFR Part 68 (Entergy 2007a).

33 There are no Mandatory Class I Federal areas designated by the National Park Service, U.S.  
34 Fish and Wildlife Service (FWS), or the U.S. Forest Service within 50 mi (80 km) of the site.  
35 Class I areas are locations in which visibility is an important attribute. As defined in the Clean  
36 Air Act, they include several types of areas that were in existence as of August 7, 1977—  
37 national parks over 6000 acres (2430 ha), national wilderness areas, and national memorial  
38 parks over 5000 acres (2020 ha), and international parks (NPS 2006a). The closest Class I

1 Area is Lye Brook Wilderness Area, Vermont, approximately 150 mi (240 km) east-northeast of  
2 IP2 and IP3 (NPS 2006b).

### 3 **2.2.5 Aquatic Resources**

4 In this section, the NRC staff describes the physical, chemical, and biological characteristics of  
5 the Hudson River estuary. In addition, the NRC staff describes the major anthropogenic events  
6 that have influenced the estuary and the history of regulatory action over the past 50 years.

#### 7 **2.2.5.1 The Hudson River Estuary**

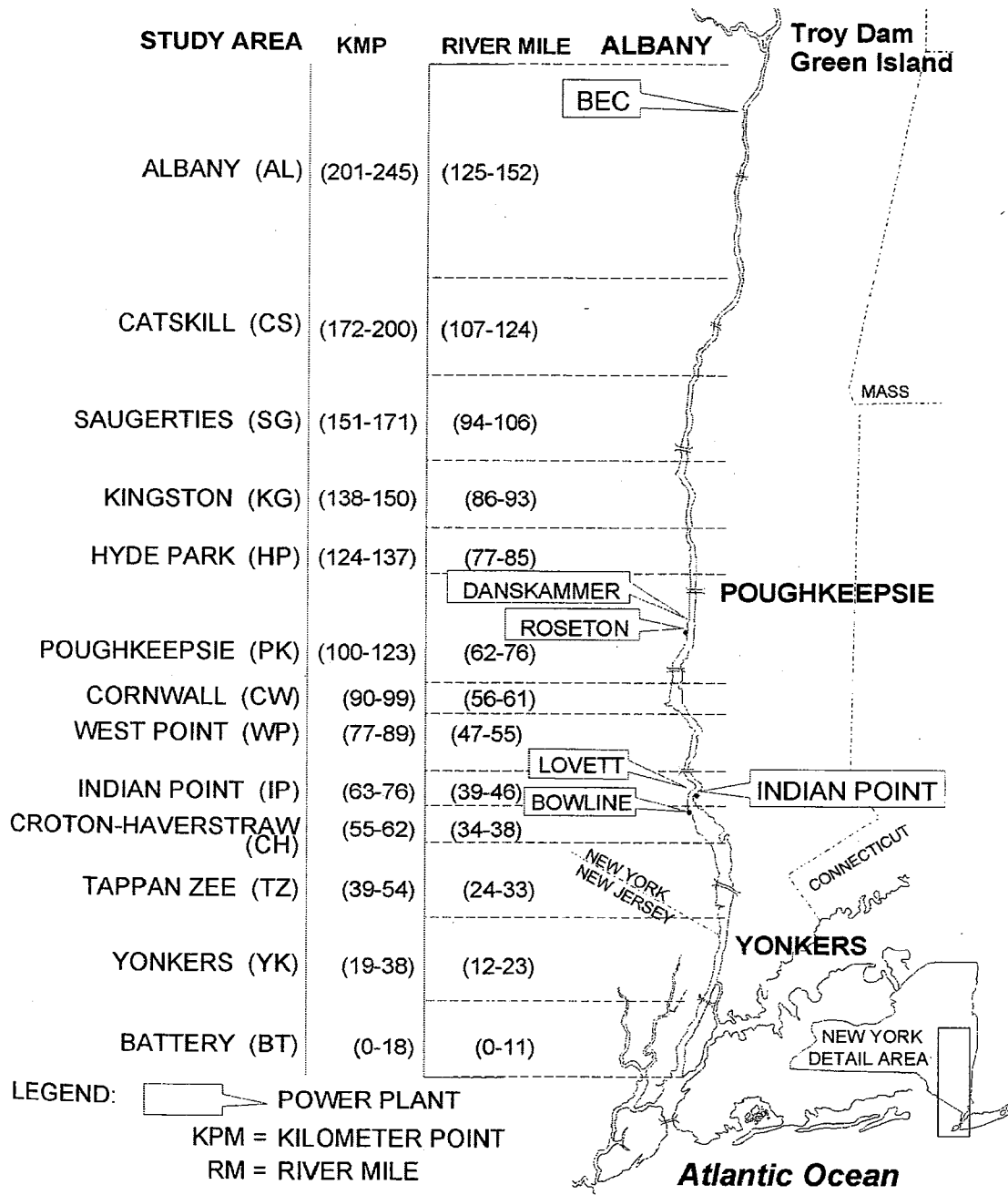
##### 8 Watershed Description

9 The Hudson River originates at Tear-of-the-Clouds in the Adirondack Mountains of northern  
10 New York State. From its source, the river flows south 315 mi (507 km) to its mouth at the  
11 Battery, at the south end of the island of Manhattan. The Hudson River basin extends 128 mi  
12 (206 km) from east to west and 238 mi (383 km) from north to south and drains an area of  
13 13,336 square miles (sq mi) (34,540 sq km), with most of this area located in the eastern-central  
14 part of New York State and small portions in Vermont, Massachusetts, Connecticut, and New  
15 Jersey (Abood et al. 2006). The basin is bounded by the St. Lawrence and Lake Champlain  
16 drainage basins to the north; the Connecticut and Housatonic River basins to the east; the  
17 Delaware, Susquehanna, Oswego, and Black River basins to the west; and the basins of small  
18 tributaries and New York Harbor on the south. From the Troy Dam to the Battery, the lower  
19 Hudson River basin is about 154 mi (248 km) long and drains an area of about 5277 sq mi  
20 (13,670 sq km). The average slope of the lower Hudson River, defined in terms of the half-tide  
21 level, is about 0.6 m (2 ft) over 150 mi (240 km) (Abood et al. 2006). During the development of  
22 the multi-utility studies in the 1970s, the lower portion of the Hudson River from the Troy Dam to  
23 the Battery was divided into 13 study areas (river segments), depicted in Figure 2-10. The  
24 study area and river segment designations identified in the figure will be used to discuss  
25 monitoring results and data collection locations throughout this document.

##### 26 Lower Hudson River Basin Habitats

27 The lower Hudson River estuary contains a variety of habitats, including tidal marshes, intertidal  
28 mudflats, and subtidal aquatic beds. These habitats exist throughout the length of the river and  
29 can be freshwater, brackish, or saline. The freshwater communities are generally located north  
30 of Newburgh (CHGEC 1999), with brackish communities found farther south. There are four  
31 locations within the estuary designated as National Estuarine Research Reserve System Sites  
32 by the National Oceanic and Atmospheric Administration (NOAA) and NYSDEC, including, from  
33 north to south, Stockport Flats, Tivoli Bay, Iona Island, and Piermont Marsh (NOAA 2008), as  
34 shown in Figure 2-11. The lower Hudson River basin also contains Haverstraw Bay, shown in  
35 Figure 2-11, a significant nursery area for a variety of fish, including striped bass, white perch,  
36 Atlantic tomcod, and Atlantic sturgeon, and a wintering area for the federally listed endangered  
37 shortnose sturgeon (FWS 2008a).

38



1 Source: Abood et al. 2006

2 **Figure 2-10. Hudson study area and river segments**

3 |



1  
2

Figure 2-11. Hudson river area and national estuarine research sites

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1 Community type and habitat characteristics are influenced by the extent of tidal excursions,  
2 which are controlled by tidal stage and river flow. During drought periods, the 100 milligrams  
3 per liter (mg/L) (0.1 parts per thousand (ppt)) salinity front can extend up to 130 km (81 mi)  
4 above the ocean entrance (Abood et al. 2006).

5 In general, narrow, shallow river reaches with high current flow have extensive bottom scour  
6 and low organic carbon levels. The coarse gravel substrate provides spawning habitat for some  
7 species. Similar characteristics can also be found where tributaries to the main river stem join  
8 the Hudson. High current speeds through deep basins can generate turbulent flow that keeps  
9 weakly swimming zoo- and ichthyoplankton suspended in the water column and away from silty  
10 nearshore locations and potential predators. Shallow, shore-zone habitats often support  
11 submerged aquatic vegetation that provides habitat and protection for juvenile fish and other  
12 aquatic communities. Broad, shallow basins often create depositional environments where fine  
13 sediments, high levels of organic carbon, and nutrients are present. These environments are  
14 generally highly productive and may serve as nursery areas for juvenile fish species (CHGEC  
15 1999).

16 Human activities, however, have significantly affected the lower Hudson River estuary.  
17 Increasing human populations along the estuary throughout recent history have contributed to  
18 increased habitat alteration. Section 2.2.5.2 examines human influences in greater detail.

19 The construction of railroad lines along the banks of the river disrupted the connection of the  
20 river to marshland and wetland habitats. Construction of causeways interfered with or  
21 completely blocked tributary inlets, disrupting sediment transport and other natural phenomena.  
22 Anthropogenic activities also resulted in the dredging of some habitats and the filling of others.  
23 The historical impacts to the lower Hudson River habitats are discussed later in this section.

24 To describe the predominant habitat features associated with the lower Hudson River estuary,  
25 Central Hudson Gas and Electric Corporation (CHGEC; 1999) divided the lower river from the  
26 Troy Dam to the Battery into five subsections of roughly comparable volume consisting of one or  
27 more of the regions and river segments identified in Figure 2-10. Beginning at the Troy Dam,  
28 the first subsection extends from RM 152 to 94 (RKM 245 to 151) and includes the Albany,  
29 Catskill, and Saugerties study areas. This subsection of the river is relatively narrow and has  
30 extensive shoals and numerous tributaries. Within this subsection and approximately 6.2 mi  
31 (10 km) south of the Troy Dam, the river is about 574 ft (175 m) wide—the narrowest part of the  
32 lower Hudson (Abood et al. 2006). The slope of the river is also greatest in this subsection and  
33 generates current velocities greater than in other areas.

34 The second subsection of the river defined by CHGEC (1999) extends from RM 93 to 56  
35 (RKM 150 to 90) and includes the Kingston, Hyde Park, Poughkeepsie, and Cornwall study  
36 areas. This subsection contains a series of progressively deeper basins, and the volume of this  
37 area is approximately 1.5 times larger than that of the adjacent upriver areas. Shallow shoreline  
38 and shoal areas are common only in the southernmost end of this subsection.

39 The third subsection of the river defined by CHGEC (1999) extends from RM 55 to 39 (RKM 89  
40 to 63), and includes the West Point and IP2 and IP3 study areas. At this location, the Hudson  
41 Highlands land mass forced glaciers through a narrow constriction, resulting in the deepest and  
42 most turbulent flow observed in the lower Hudson. Within this subsection, the river channel  
43 narrows abruptly, bends sharply to the east, and reaches a depth of over 150 ft (46 m). At the  
44 lower portions of this subsection, the river bottom consists of a series of progressively shallower



1 gouges that result in a corrugated bottom that ends in shallow water behind the Hudson  
 2 Highlands. The IP2 and IP3 and Bowline Point power stations (along with the no-longer-  
 3 operating Lovett station) are located within this river subsection.

4 The fourth subsection of the river defined by CHGEC (1999) is located from RM 38 to 24  
 5 (RKM 62 to 39) and includes the Croton-Haverstraw and Tappan Zee study areas (Figure 2-10).  
 6 This is the widest and shallowest portion of the lower Hudson River and has the most extensive  
 7 shoal and shore zone areas. The presence of slow-moving currents and shoal areas results in  
 8 the deposition of suspended sediment, organic carbon, and nutrients. The major source of  
 9 suspended sediment to the Hudson is associated with watershed basin runoff and erosion, and  
 10 basin-wide loads have been estimated at 800,000 tons per year (t/yr; 726,000 MT/yr) (Abood et  
 11 al. 2006). The presence of slow-moving currents, shoal and shore-zone habitat, and high  
 12 carbon and nutrient inputs makes this a highly productive portion of the lower Hudson River and  
 13 provides important spawning and nursery areas for juvenile fish.

14 The fifth subsection of the river defined by CHGEC (1999) begins at RM 24 (RKM 38) and  
 15 extends to the river's entrance into New York Harbor, encompassing the Yonkers and Battery  
 16 study areas. In this subsection, the river again constricts and gradually deepens as it enters  
 17 New York Harbor. In this location, the river is generally straight and contains few shoal areas or  
 18 shore-zone habitats. The final 12 mi (19 km) of the lower Hudson have extensive armoring and  
 19 contain little remaining natural shoreline (CHGEC 1999).

#### 20 Sampling Strata Definitions

21 In order to effectively sample and study the lower Hudson, researchers have attempted to  
 22 define specific zones, habitats, or locations within the river. These specific locations, often  
 23 called strata, provide researchers with a quantitative way to sample the environment and  
 24 integrate the resulting information. A variety of attempts have been made to define the channel  
 25 morphology and thus the potential strata of the lower Hudson. Miller et al. (2006) describe three  
 26 major habitat areas in the lower Hudson:

- 27 (1) Intertidal: Areas exposed at low tide and submerged at high tide that include mud flats,  
 28 sand, broadleaf marsh, and emergent intertidal vegetation.
- 29 (2) Shallows: Areas of the river less than 6.6 ft (2.0 m) deep at mean low tide. This habitat  
 30 supports submerged aquatic vegetation (SAV) in the river and is considered one of the  
 31 most productive habitats in the estuary and of great ecological importance.
- 32 (3) Deepwater: Areas of the river greater than 6.6 ft (2.0 m) deep at mean low tide. This  
 33 area represents the limit of light penetration and generally does not support SAV.

34 During the development of the Hudson River Utilities studies of the lower Hudson River in the  
 35 1970s, the study areas and river segments were divided into four primary strata to support fish  
 36 and plankton investigations. These strata provide a geomorphological basis for partitioning the  
 37 river and are still used to define sampling locations (ASA 2007):

- 38 (4) Shore: The portion of the Hudson River estuary extending from the shore to a depth of  
 39 10 ft (3.0 m). This area was primarily sampled by beach seine.
- 40 (5) Shoal: The portion of the Hudson River extending from the shore to a depth of 20 ft  
 41 (6.1 m) at mean low tide.

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1 (6) Bottom: The portion of Hudson River extending from the bottom to 10 ft (3.0 m) above  
2 the bottom where the river depth is greater than 20 ft (6.1 m) mean low tide.

3 (7) Channel: The portion of the Hudson River not considered bottom where river depth is  
4 greater than 20 ft (6.1 m) at mean low tide.

### 5 Hydrodynamics and Flow Characteristics

6 In the lower Hudson River, freshwater flow is one of the most important factors in determining  
7 and influencing the physical, chemical, and biological processes in the estuary and the resulting  
8 interactions within the food web. Hydrodynamics and flow characteristics are controlled by a  
9 complex series of interactions that include short- and long-term fluctuations in meteorological  
10 conditions, precipitation and runoff in the upstream portion of the watershed, the influence of  
11 tides and currents in downstream portions of the river, and the presence of a “salt wedge” that  
12 moves up- or downstream depending on river flow and tidal fluctuation (Blumberg and  
13 Hellweger 2006). Freshwater flow varies throughout the year, with maximum flow occurring  
14 during the months of March through May, with low-flow conditions beginning in June and  
15 continuing until November (Abood et al. 2006). Under normal conditions, approximately  
16 75 percent of the total freshwater flow enters the lower Hudson River at Troy, with the remaining  
17 portion contributed by tributaries discharging into the upper reach of the estuary (CHGEC 1999;  
18 Abood et al. 2006). Because of tidal oscillation in the estuary, it is not possible to accurately  
19 measure freshwater flow in the lower estuary. Freshwater flow is, however, monitored by the  
20 U.S. Geological Survey (USGS) at Green Island, the farthest downstream USGS gauge above  
21 tidewater (CHGEC 1999; Abood et al. 2006). Data recorded from this gauge from 1948 to 2006  
22 show that the mean annual flow was approximately 14,028 cfs (397.23 m<sup>3</sup>/s). The lowest  
23 recorded annual flow was 6400 cfs (180 m<sup>3</sup>/s) in 1965; the highest was 22,100 cfs (626 m<sup>3</sup>/s)  
24 in 1976. Measured flows from Green Island from 1996 to 2006 ranged from 11,400 cfs  
25 (323 m<sup>3</sup>/s) in 2002 to over 18,000 cfs (510 m<sup>3</sup>/s) in 1996 (USGS 2008).

### 26 Salinity

27 CHGEC (1999) describes four salinity habitat zones in the Hudson River:

28 (8) polyhaline (high salinity): RM 1–19 (RKM 1–31)

29 (9) mesohaline (moderate salinity): RM 19–40 (RKM 31–64)

30 (10) oligohaline (low salinity): RM 40–68 (RKM 64–109)

31 (11) tidal freshwater: RM 68–152 (RKM 109–245)

32 The IP2 and IP3 and Bowline Point facilities are located in the oligohaline zone and generally  
33 experience salinities of 0.5 to 5 ppt. The actual salinity present at a given time and place can  
34 vary considerably in the lower regions of the river because of salinity intrusion, which occurs  
35 throughout the year. The typical tidal excursion in the lower Hudson River is generally 3 to 6 mi  
36 (5 to 10 km), but can extend up to 12 mi (19 km) upstream. During the spring, the salt front is  
37 located between Yonkers and Tappan Zee and moves upstream to just south of Poughkeepsie  
38 during the summer (Blumberg and Hellweger 2006). Abood et al. (2006) report that, during  
39 drought periods, the salt front (defined as water with a salinity of 100 mg/L (0.1 ppt)) can extend  
40 up to RM 81. Stratification also occurs within this salt-intruded reach. Studies by Abood et al.  
41 (2006) suggest that from 1997–2003, salinity in the Hudson River has increased approximately  
42 15 percent for a given flow rate. The authors suggest that this conclusion be viewed with

1 caution and that further analysis is required to confirm this finding. Real-time monitoring of the  
2 salt front position on the lower Hudson River is provided by USGS and can be accessed via its  
3 Web site (USGS 2008).

#### 4 Temperature

5 Water temperatures in the Hudson River vary seasonally, with a maximum temperature of 25°C  
6 (77°F) occurring in August and a minimum temperature of 1°C (34°F) occurring in January–  
7 February. The magnitude and distribution of water temperatures in the estuary are influenced  
8 by a variety of factors and complex relationships. Abood et al. (2006) identified four categories  
9 of parameters that play a significant role in water temperature—(1) atmospheric conditions,  
10 including radiation, evaporation, and conduction, (2) hydrodynamic conditions, including channel  
11 geometry, flow, and dispersion, (3) boundary conditions associated with the temperature of the  
12 ocean and freshwater, and (4) anthropogenic inputs, including those associated with activities  
13 that use river water for cooling purposes. The four parameters are interrelated and collectively  
14 influence temperature ranges and distributions in the estuary. Anthropogenic influences are of  
15 particular concern because they generally represent a constant influence on the system that  
16 may be controlled or managed, unlike those influences associated with climate, river  
17 morphology/geometry, and natural interactions between the river and ocean. Abood et al.  
18 (2006) indicate that the greatest percentage of artificial (anthropogenic) heat input into the lower  
19 Hudson River estuary is associated with the use of river water for condenser cooling in support  
20 of electrical power generation. The authors indicate that there are currently six power plants  
21 operating in the lower Hudson River estuary, with a total electrical generation of approximately  
22 6000 MW(e), that use the Hudson River as cooling water. These plants collectively use 4.6  
23 million gpm (290 m<sup>3</sup>/s) and produce approximately 8x10<sup>11</sup> British thermal units per day (Btu/day)  
24 (2.3x10<sup>8</sup> kilowatt-hours per day (kWh/day), or 9800 MW of thermal power output).  
25 Anthropogenic activities can also result in a net cooling effect on the river. An example given by  
26 Abood et al. (2006) suggests that a 1-million-gallon-per-day (mgd) (3800-m<sup>3</sup>/day) sewage  
27 effluent facility discharging water at 18°C (64°F) during the summer would cool the river  
28 because river ambient temperatures are higher.

29 Attempts to determine long-term changes to the temperature of the lower Hudson River are  
30 often confounded by changes in measurement locations and procedures, especially in long-term  
31 studies.

32 An analysis of long-term temperature trends in the lower Hudson River was attempted by  
33 Ashizawa and Cole (1994), using data obtained from the Poughkeepsie Water Works (PWW),  
34 which processes drinking water. This facility is located in the Poughkeepsie study area  
35 approximately 30 mi (48 km) upstream from IP2 and IP3 (Figure 2-10). A nearly continuous  
36 data set is available from PWW, beginning in 1908 and continuing to the present day. The data  
37 set represents water withdrawn from the Hudson River approximately 14 ft (4.3 m) below low  
38 tide. The results of the study show that the overall mean annual water temperature at the intake  
39 location was 12.2°C (54°F), and that water temperatures were highly correlated with air  
40 temperature during the winter and spring months. Although the overall trends in temperature  
41 suggested a gradual warming, the authors concluded that the relationship was not monotonic  
42 (i.e., showing change in only one direction over time). Rather, there were periods of both  
43 increasing and decreasing temperatures, with episodes of statistically significant warming  
44 occurring approximately 22.7 percent of the time and episodes of significant cooling occurring  
45 11.5 percent of the time. During the period from 1918 to 1990, the authors observed a

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1 significant increase in temperature, with a rate of warming of 0.12°C (0.22°F) per decade. The  
2 sharpest increase during that time occurred from 1971 to 1990 at 0.46°C (0.83°F) per decade;  
3 the sharpest cooling occurred from 1908 to 1923 at 0.79°C (1.42°F) per decade. The authors  
4 noted that there has been only one cooling event since 1923 (1968 to 1977), which occurred  
5 during a time of greater than average rainfall and record-setting freshwater flows, illustrating the  
6 complex relationships between weather, river flow, hydrodynamic connections, and  
7 anthropogenic effects discussed earlier.

### 8 Dissolved Oxygen

9 As discussed above, obtaining reliable data and trends associated with temperature and  
10 dissolved oxygen (DO) can be problematic in dynamic, open-ended systems. Measurements  
11 obtained during routine sampling within the river provide only a snapshot of actual conditions;  
12 measurements taken continuously from fixed, known locations provide long-term records, but  
13 only for the point or area of interest. Declines in DO can be caused by both natural and  
14 anthropogenic activities and may be transient or persist episodically or continually through time.

15 In some cases, observed declines in DO at specific times and locations in the Hudson River  
16 have been at least partially attributed to the appearance of invasive species, such as zebra  
17 mussels (Caraco et al. 2000). Even episodic events can have serious implications for fish and  
18 invertebrate communities and dramatically alter marine and estuarine food webs. To evaluate  
19 long-term DO trends in the lower Hudson River, Abood et al. (2006) examined two long-term  
20 data sets of DO observations collected by the New York City Department of Environmental  
21 Protection (NYCDEP) and covering the lower reaches of the river. Measurements of DO taken  
22 in August from 1975 to 2000 during the Long River Surveys indicate the lowest percent  
23 saturation (less than 75 percent) at West Point and the highest (greater than 90 percent) at the  
24 Kingston and Catskill reaches (Figure 2-10). Percent saturation at the river segment  
25 encompassing IP2 and IP3 was approximately 76 percent. Based on the NYCDEP data set, the  
26 authors concluded that there has been a substantial increase in DO since the early 1980s,  
27 probably resulting from the significant upgrades to the Yonkers and North River Sewage  
28 Treatment Plants in the lower reach of the Hudson.

### 29 Organic Matter

30 Organic matter can enter and influence a food web from two sources—autochthonous inputs,  
31 which are produced within the aquatic system, and allochthonous inputs, which are imported to  
32 the aquatic system from the surrounding terrestrial watershed (Caraco and Cole 2006). In the  
33 lower Hudson River, autochthonous sources of carbon originating within the river are associated  
34 with the primary production of phytoplankton and macrophyte communities. Studies by Caraco  
35 and Cole (2006) of the Hudson River from Albany to Newburgh during May–August 1999 and  
36 2000 concluded that runoff from the upper Hudson and Mohawk River watershed was  
37 responsible for the majority of the allochthonous sources of carbon, represented as dissolved  
38 organic carbon (DOC) and particulate organic carbon (POC). Inputs from sewage, adjoining  
39 marshes, and tributaries accounted for less than 25 percent of the inputs. Total organic carbon  
40 (TOC) inputs were on average highest at the uppermost stretch of the Hudson and decreased  
41 down river by over twofold. Allochthonous loads were approximately fourfold lower in 1999 than  
42 in 2000 for all three river sections studied. The authors noted that the importance of  
43 allochthonous and autochothonous loads varied more than thirtyfold across space and time and  
44 that the variation was related to hydrologic inputs. During the summer of 1999 (the driest in

1 15 years), loadings of allochthonous inputs were low, but phytoplankton biomass and primary  
2 productivity were high. The resulting ratio of autochthonous/allochthonous inputs was tenfold  
3 greater than that measured during the summer of 2000 (the wettest in 15 years). These data  
4 suggest to the NRC staff that variations in sources and the importance of carbon inputs can be  
5 influenced by a variety of nonanthropogenic factors and result in changes to food web structure  
6 and function that directly impact higher trophic levels.

7 Nitrogen loading to rivers and estuaries comes primarily from forest and agricultural drainage,  
8 discharge from sewage treatment plants, and from nonpoint sources associated with  
9 urbanization. The most common forms of nitrogen in these systems are amino compounds  
10 originating from plant and animal proteins (CHGEC 1999). In the Hudson River, nitrate is the  
11 major contributor to the total nitrogen load, and in the lower Hudson River, approximately half of  
12 the total inorganic nitrogen loading is attributed to wastewater treatment systems and urban  
13 runoff (CHGEC 1999).

14 Total nitrogen and ammonia concentrations in the Hudson from Troy to Yonkers (obtained from  
15 EPA STORET) show differing trends from 1975 through 1992. Total nitrogen concentrations  
16 appear to vary without trend, while ammonia concentrations appear to be highest in river  
17 stretches near Yonkers and at locations upstream of Poughkeepsie (CHGEC 1999).

18 Phosphorus, in the form of phosphates, enters river systems as leachates from rock formations  
19 and soil. Additional inputs are associated with wastewater treatment plant discharges.  
20 Inorganic phosphates are used by plants and converted to organic forms that are used by  
21 animals (CHGEC 1999). Total phosphorus concentrations in the Hudson River during August  
22 1974 suggest that the highest concentrations are associated with the lower 25 RM (40 RKM).  
23 Ortho-phosphorus concentrations from the EPA STORET database from 1975 through 1992  
24 suggest that the highest concentrations are associated with the Yonkers-Piermont and  
25 Glenmont-Troy areas of the upper river.

26 The distribution and ratios of allochthonous and autochthonous nutrient inputs form the basis of  
27 complex food webs that can have large influences on upper trophic levels. Macronutrients such  
28 as carbon, nitrogen, phosphorus, and silicon are used by plants as raw materials to produce  
29 new biomass through photosynthesis. In some freshwater systems, the lack or excess of a  
30 specific macronutrient can limit growth or contribute to eutrophication and result in basinwide  
31 impacts to aquatic resources.

## 32 **2.2.5.2 Significant Environmental Issues Associated with the Hudson River Estuary**

### 33 Early Settlement

34 Anthropogenic impacts to the Hudson River ecosystem have existed for many centuries, with a  
35 possible origin approximately 11,000 years ago, after the retreat of the Wisconsin-stage ice  
36 sheet (CHGEC 1999). Swaney et al. (2006) categorized changes in watershed characteristics  
37 and effects based on four broad time scales—pre-European settlement, precolonial and colonial  
38 settlement, 19<sup>th</sup> century, and 20<sup>th</sup> century (Table 2-1). To put the scale of the anthropogenic  
39 impacts to the Hudson River watershed in context, the human population within the watershed  
40 has grown from approximately 230,000 at the time of the first census in 1790 to approximately 5  
41 million today (not including parts of the boroughs of New York City outside the watershed, such  
42 as Queens). In 1609, the Hudson River watershed was almost entirely forested; by 1880,  
43 68 percent of the watershed was farmland. Available records show that from the early 18<sup>th</sup>  
44 century to 1993, nearly 800 dams were constructed in the watershed, ranging in height from 2 to

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1 700 ft (0.6 to 213 meters) (Swaney et al. 2006). A brief chronology of significant events that  
2 occurred from pre-European settlement to modern times is presented below.

3 Before settlement by European explorers, impacts associated with aboriginal populations were  
4 restricted to those from activities associated with hunting and gathering, and localized fires.  
5 During precolonial and colonial settlement, immigrants cleared large portions of forest cover to  
6 accommodate agriculture. These activities altered watershed dynamics and increased  
7 settlement loads and temperature in streams and rivers. Dramatic anthropogenic impacts  
8 occurred during the 19<sup>th</sup> century as populations along rivers, streams, and coastal areas  
9 increased, land clearing continued, and construction of roads, bridges, railroads, canals, and  
10 industrial centers occurred to support the emerging industrial revolution. The emergence of  
11 tanning and logging activities resulted in large-scale clearing of forests, construction of roads  
12 that were later expanded into highways and railroad lines, and the development of dams and  
13 canals to control floods and divert water for human needs. All of these activities resulted in  
14 profound changes to the dynamics of the Hudson River watershed. In some cases, the  
15 presence of railroad lines or highways effectively isolated nearby wetland communities from the  
16 main stem of the river; in other cases, wetland and marsh areas were filled and destroyed.  
17 Dredging and dam development significantly altered the flow characteristics of the Hudson River  
18 and influenced the migratory patterns of many species (Swaney et al. 2006).

19 During the latter part of the 19<sup>th</sup> century, the growing human population created increased  
20 pollution and nutrient loading, which remained unregulated until the mid-20<sup>th</sup> century.  
21 Anthropogenic impacts occurring during the 20<sup>th</sup> century include the expansion of human  
22 population centers, further development of infrastructure to support industrial development  
23 (highways, roads, rail lines, factories), and a gradual shift in agricultural practices from  
24 traditional methods to new technologies that used specialized fertilizers, pesticides, and other  
25 agrochemicals. Industrialization during the 19<sup>th</sup> and 20<sup>th</sup> centuries also provided pathways for  
26 invasive species and nuisance organisms to colonize new habitats via canals, ship ballast  
27 water, and accidental or deliberate agricultural introductions (Swaney et al. 2006).

28 During the latter part of the 20<sup>th</sup> century, environmental awareness of degraded conditions  
29 resulted in the creation of important environmental laws and monitoring programs and  
30 significant improvements to wastewater treatment facilities. The laws and activities resulted in  
31 significant improvements to some water-quality parameters and a new awareness of emerging  
32 threats (e.g., the presence of endocrine-disrupting pharmaceuticals, nanomaterials, and other  
33 contaminants or constituents). A brief description of some of the significant environmental  
34 issues and anthropogenic events is presented below (Swaney et al. 2006).

### 35 Dredging, Channelization, and Dam Construction

36 As described above, dredging, channelization, and dam construction within the Hudson River  
37 watershed has occurred for over 200 years. The U.S. Army Corps of Engineers (USACE) has  
38 maintained a shipping channel from the ocean to the Port of Albany since the late 18th century  
39 and dredges the channel on an as-needed basis (CHGEC 1999). Dredging in some river  
40 segments occurs every 5 years (Miller et al. 2006). In some cases, dredging has significantly  
41 changed the hydrodynamic characteristics of the river and resulted in significant losses of  
42 intertidal and shallow water nursery habitats for fish (Miller et al. 2006). As described above,  
43 from the early 18<sup>th</sup> century to 1993, nearly 800 dams were constructed in the watershed,  
44 ranging in height from 2 to 700 ft (0.6 to 213 m) (Swaney et al. 2006). A study of the inorganic

1 and organic content of marshes within the watershed by Peteet et al. (2006) revealed a pattern  
2 of decreasing inorganic content with the arrival of the Europeans to the present day that was  
3 probably the result of the construction of tributary dams. The presence of dams, river  
4 channelization, and shoreline armoring to protect road and rail lines disconnects or interferes  
5 with normal river processes and often results in an overall decrease of sediment transport into  
6 and through the estuary. Because these structures are now an existing part of the landscape, in  
7 most cases, it is extremely difficult or impossible to restore historical river structure and function.

#### 8 Industry and Water Use Impacts

9 As described above, anthropogenic impacts on the watershed from aboriginal cultures were  
10 generally small and restricted to effects associated with hunter-gatherer community activities  
11 and the presence of fires. Before the 1900s, the dominant industries were those of the primary  
12 sector (agriculture, forestry, fishing, and mining). During the 1900s, there was an increase in  
13 the use of the Hudson River to provide transportation, drinking water, and water for industrial  
14 activities. During the development of industrial activity, there was a progressive increase in  
15 secondary sector industries, including the manufacture of food products, textiles, pulp and paper  
16 products, chemical, machinery, and transportation-related goods (CHGEC 1999).

17 The Hudson River was and is used as a source of potable water, a location for permitted waste  
18 disposal, a mode of transportation, and a source of cooling water by industry and municipalities.  
19 As of 1999, at least five municipalities use the lower Hudson as a source of potable water, and  
20 Rohmann et al. (1987) identified 183 separate industrial and municipal discharges to the  
21 Hudson and Mohawk rivers. The chemical industry has the greatest number of industrial users,  
22 followed by oil, paper, and textile manufacturers; sand, gravel, and rock processors; power  
23 plants; and cement companies (CHGEC 1999).

24

1  
2  
3

**Table 2-1. Historical Impacts on the Hudson River Watershed**

<b>Pre-European Settlement</b>	
Aboriginal agriculture	Localized fires and associated changes in biomass, habitat, and nutrient dynamics
<b>Precolonial and Colonial Settlement</b>	
Land clearing	Removal of forest cover and changes in habitat and streamflow characteristics
<b>19<sup>th</sup> Century</b>	
Tanning	Preferential clearing of forests leading to increased sediment and organic loads to water bodies
Logging	Extensive clearing of forests that affects water quality and habitat
Agriculture	Clearing of forests, use of fertilizers and nitrogen-fixing crops
Canal and dam development	Increase of waterborne invasive species, wetland drainage, flow alterations, habitat fragmentation
Railroad development	Increased access to forests leading to risk of fire; terrestrial, wetland, and aquatic habitat loss
Road development	Increases in impervious surfaces and runoff
Urbanization and industrialization	Increased pollution from unregulated sewage and factory waste discharges
Dam development for water supply infrastructure needs	Changes in flow regime and sediment transport
Highway and road development	Increase in impervious surfaces and runoff, impacts to terrestrial communities
Agriculture decline	Changes in land use practices (reforestation or increased land development)
Changing agricultural practices	Increased inorganic nutrients (fertilizers) and changes in organic (manure) loads
Urban development and sprawl	Impervious surface impacts, increased runoff, construction impacts, stream channelization

Adapted from: Swaney et al. 2006

4



1 At present, there are 11 facilities along the lower Hudson River with water discharges of 50 mgd  
2 (189,000 m<sup>3</sup>/day) or greater (Table 2-2). Of these, two are associated with wastewater  
3 discharge, and nine are associated with power generation. Between Poughkeepsie and  
4 Yonkers (RM 24–77 (RKM 39–124)), there are four steam power generating stations that use  
5 water from the Hudson River for condenser cooling (Danskammer Point, Roseton, IP2 and IP3,  
6 and Bowline Point). Of these, IP2 and IP3 have traditionally used the greatest quantity of water  
7 for cooling (2800 mgd, or 10.6 million m<sup>3</sup>/day), and Danskammer Point the least. Presently,  
8 Roseton operates intermittently, based on energy needs and the current prices of oil and natural  
9 gas. Excluding the water use of Roseton, the IP2 and IP3 facility accounts for 60 percent of the  
10 water use from RM 24–77 (RKM 39–124). Impacts associated with industrial water use can  
11 include impingement or entrainment of fish, larval forms, and invertebrates from water intake;  
12 heat or cold shock associated with water discharges; and the cumulative effects of the  
13 discharge of low levels of permitted chemicals (CHGEC 1999).

#### 14 Municipal Wastewater Treatment Plants

15 Wastewater collection and sewage treatment construction began in New York City in the late  
16 17<sup>th</sup> century, and many of the sewer systems were connected in lower and central Manhattan  
17 Island between 1830 and 1870. The first wastewater treatment system was constructed in 1886  
18 and included a screen system designed to protect bathers on Coney Island (Brosnan and  
19 O’Shea 1996.)

20 In 2004, the NYSDEC identified 610 municipal wastewater treatment plants in New York State  
21 (NYSDEC 2004a). These facilities produce a total discharge flow of approximately 3694 mgd  
22 (13.98 million m<sup>3</sup>/day). In the lower Hudson River basin, there are 78 secondary treatment  
23 facilities with a total flow of 556 mgd (2.1 million m<sup>3</sup>/day), 41 tertiary facilities with a total flow of  
24 11 mgd (42,000 m<sup>3</sup>/day), and 10 other/unknown facilities with a total flow of approximately  
25 1 mgd (3800 m<sup>3</sup>/day). The total flow associated with all 129 facilities is approximately 568 mgd  
26 (2.15 million m<sup>3</sup>/day). There are 33 facilities that use what is described as less than primary,  
27 primary, or intermediate treatment. A total of 404 facilities employ secondary treatment, and  
28 173 employ tertiary treatment (NYSDEC 2004a).

29 As discussed above, the increasing populations along the Hudson River and within the  
30 watershed resulted in an increased discharge of sewage into the Hudson and an overall  
31 degradation of water quality. Beginning in 1906 with the creation of the Metropolitan Sewerage  
32 Commission of New York, a series of studies was conducted to formulate plans to improve  
33 water quality within the region (Brosnan and O’Shea 1996). In the freshwater portion of the  
34 lower Hudson River, the most dramatic improvements in wastewater treatment were made  
35 between 1974 and 1985, resulting in a decrease in the discharge of suspended solids by  
36 56 percent.

37 Improvements in the brackish portion of the river were even greater. In the New York City area,  
38 the construction and upgrading of water treatment plants reduced the discharge of untreated  
39 wastewater from 450 mgd (1.7 million m<sup>3</sup>/day) in 1970 to less than 5 mgd (19,000 m<sup>3</sup>/day) in  
40 1988 (CHGEC 1999). The discharge of raw sewage was further reduced between 1989 and  
41 1993 by the implementation of additional treatment programs (Brosnan and O’Shea 1996).

42 During the 1990s, three municipal treatment plants located in the lower Hudson River converted  
43 to full secondary treatment—North River (1991), North Bergen MUA-Woodcliff (1991), and  
44 North Hudson Sewerage Authority West New York (1992). In addition, the North Hudson

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Sewerage Authority-Hoboken plant, located on the western bank of the Hudson River opposite Manhattan Island, went to full secondary treatment in 1994 (CHGEC 1999). Upgrades to the Yonkers Joint Treatment plant in 1988 and the Rockland County Sewer District #1 in 1989 also resulted in improvements in water quality in the brackish portion of the Hudson River. In the mid-1990s, the Rockland County Sewer District #1 and Orangetown Sewer District plants were also upgraded(CHGEC 1999).

**Table 2-2. Facilities Discharging at Least 50 mgd (190,000 m<sup>3</sup>/day) into the Lower Hudson River**

Facility	Activity	Location			Discharge (mgd)
		Region	RM	RKM	
59 <sup>th</sup> Street Station	Power generation	Battery (BT)	7	11	70
North River	Wastewater discharge	Battery (BT)	10	16	170
Yonkers	Wastewater discharge	Yonkers (YK)	17	27	92
Bowline Point	Power generation	Croton-Haverstraw (CH)	37	60	912
Lovett	Power generation	Indian Point	42	68	496
Indian Point	Power generation	Indian Point	43	69	2,800
Westchester Resource Recovery	Power generation	Indian Point	43	69	55
Danskammer Point	Power generation	Poughkeepsie (PK)	66	106	457
Roseton <sup>a</sup>	Power generation	Poughkeepsie (PK)	67	108	926
Bethlehem	Power generation	Albany (AL)	140	225	515
Empire State Plaza	Power generation	Albany (AL)	146	235	108

<sup>a</sup> Roseton currently operates intermittently based on availability and cost of oil and natural gas.

Adapted from: Entergy 2007a

A review of long-term trends in DO and total coliform bacteria concentrations by Brosnan and O’Shea (1996) has shown that improvements to water treatment facilities have improved water quality. The authors noted that, between the 1970s and 1990s, DO concentrations in the Hudson River generally increased. The increases coincided with the upgrading of the North River plant to secondary treatment in spring 1991. DO, expressed as the average percent saturation, exceeded 80 percent in surface waters and 60 percent in bottom waters during summers in the early 1990s. DO minimums also increased from less than 1.5 mg/L in the early 1979s to greater than 3.0 mg/L in the 1990s, and the duration of low DO (hypoxia) events was also reduced (Brosnan and O’Shea 1996). Similar trends showing improvements in DO were noted by Abood et al. (2006) from an examination of two long-term data sets collected by NYCDEP in the lower reaches of the river. Brosnan and O’Shea (1996) also noted a strong

1 decline in total coliform bacteria concentrations that began in the 1970s and continued into the  
2 1990s, coinciding with sewage treatment plant upgrades.

### 3 Chemical Contaminants

4 The lower Hudson River currently appears on the EPA 303-d list as an impaired waterway  
5 because of the presence of polychlorinated biphenyls (PCBs) and the need for fishing  
6 restrictions (EPA 2004). The following is a description of the chemical contaminants in the river.

7 Chemical contaminants in the Hudson River and surrounding watershed generally fall into three  
8 major categories—(1) pesticides and herbicides, including dichloro-diphenyl-trichloroethane  
9 (DDT) and its metabolites, aldrin, lindane, chlordane, endrin, heptachlor, and toxaphene, (2)  
10 heavy metals, including arsenic, cadmium, chromium, copper, inorganic and methylated  
11 mercury, lead, and zinc, and (3) other organic contaminants, including PCBs, and polycyclic  
12 aromatic hydrocarbons (PAHs) (CHGEC 1999). In addition, there is a growing concern that the  
13 discharge of pharmaceuticals and hormones via wastewater may pose a risk to aquatic biota  
14 and human communities (NOAA 2008b). There is also a concern that waste products or  
15 residuals associated with the emerging nanotechnology market could create a new source of  
16 environmental risk (EPA 2007b).

17 Pesticides and herbicides generally enter the Hudson River via runoff from agricultural activities  
18 in the upper watershed and have a high affinity to binding with organic carbon. In the Hudson  
19 and Raritan River basins, the use of DDT, once a common pesticide, peaked in 1957 and  
20 subsequently decreased until the compound was banned in the early 1970s (Phillips and  
21 Hanchar 1996). Sediment contaminant trends suggest that the concentration of DDT in  
22 sediment has generally decreased since the 1970s and is currently at or near the effects-range-  
23 median (ER-M), which is the median sediment concentration for a particular chemical or  
24 contaminant at which adverse biological effects have been observed (Steinberg et al. 2004). In  
25 the lower Hudson River, comparison of the EPA-sponsored regional environmental monitoring  
26 and assessment program (R-EMAP) results from 1993 to 1994 and 1998 show that the  
27 concentrations of the metals cadmium, nickel, lead, and silver have generally declined and are  
28 at or below ER-M. The concentrations of mercury, however, continue to be above ER-M at  
29 many locations in the lower river (Steinberg et al. 2004).

30 Contamination of the sediment, water, and biota of the Hudson River estuary resulted from the  
31 manufacture of capacitors and other electronic equipment in the towns of Fort Edward and  
32 Hudson Falls, New York, from the 1940s to the 1970s. Investigations conducted by EPA and  
33 others over the past 25 years have delineated the extent and magnitude of contamination, and  
34 numerous cleanup plans have been devised and implemented. Recently, EPA Region 2  
35 released a “Fact Sheet” describing a remedial dredging program designed to remove over  
36 1.5 million cubic yards (1.15 million m<sup>3</sup>) of contaminated sediment covering 400 acres (160 ha)  
37 extending from the Fort Edwards Dam to the Federal Dam at Troy (EPA 2008a). Phase 1 of the  
38 project was completed in October 2009, and resulted in the removal of 293,000 cubic yards of  
39 PCB-contaminated sediment from the river. While this volume exceeded established goals for  
40 Phase 1, removal was completed for only 10 of 18 targeted areas due to the presence of  
41 contamination in some areas that was deeper than expected, and the presence of woody debris  
42 and PCB oil in the sediment that complicated the removal effort. Phase 2 of the project will  
43 begin with removal actions at areas that were not completed under Phase 1 (EPA 2009).  
44 Concentrations of PCBs in river sediments below the Troy Dam are much lower. Work

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1 summarized by Steinberg et al. (2004) suggests that the sediment-bound concentrations of  
2 PCBs and dioxins have generally declined in the lower Hudson River since the 1970s and are  
3 now at or below ER-M limits.

4 Chemical contaminants present in the tissues of fish in the Hudson River estuary have been  
5 extensively studied for many years and resulted in the posting of consumption advisories by the  
6 States of New York and New Jersey. Current information summarized in Steinberg et al. (2004)  
7 suggests that many recreationally and important fish and shellfish still contain levels of metals,  
8 pesticides, PCB, and dioxins above U.S. Food and Drug Association (FDA) guidance values for  
9 commercial sales. Tissue concentrations of mercury were of concern only for striped bass;  
10 other fish and shellfish, including flounder, perch, eels, blue crab, and lobster, contained  
11 concentrations of mercury in their tissues well below the FDA limit for commercial sale of 2 parts  
12 per million (ppm). Concentrations of chlordane in white perch, American eels, and the  
13 hepatopancreas (green gland) of blue crab were also above FDA guidelines. Concentrations of  
14 DDT in the tissues of most recreationally and commercially valuable fish and shellfish in the  
15 estuary were below the 2 ppm FDA limit with the exception of American eel. The concentrations  
16 of 2,3,7,8-TCDD (commonly referred to as dioxin) and total PCBs in fish and shellfish tissues  
17 were often above FDA guidance limits, suggesting that fish and shellfish obtained from some  
18 locations within the estuary should be eaten in moderation or not at all. A detailed list of fish  
19 consumption advisories for both New York and New Jersey may be found in the *Health of the*  
20 *Harbor* report published by the Hudson River Foundation in 2004 (Steinberg et al. 2004).

21 Steinberg et al (2004) found that although a wide variety of contaminants still exists in sediment,  
22 water, and biota in the lower Hudson River, the overall levels appear to be decreasing because  
23 of the imposition of strict discharge controls by Federal and State regulatory agencies and  
24 improvements in wastewater treatment. These trends appear to be confirmed by the results of  
25 a NOAA-sponsored toxicological evaluation of the estuary in 1991, as described in Wolfe et al.  
26 (1996). Employing a combination of bioassay tests using amphipods, bivalve larvae, and  
27 luminescent bacteria and measurements of contaminants in a variety of environmental media,  
28 the NOAA study showed that spatial patterns of toxicity generally corresponded to the  
29 distributions of toxic chemicals in the sediments. Areas that exhibited the greatest sediment  
30 toxicity were the upper East River, Arthur Kill, Newark Bay, and Sandy Hook Bay. The lower  
31 Hudson River adjacent to Manhattan Island, upper New York Harbor, lower New York Harbor off  
32 Staten Island, and parts of western Raritan Bay generally showed lower toxicity. The supporting  
33 sediment chemistry, including acid-volatile sulfide and simultaneously extracted metals,  
34 suggests that metals were generally not the cause of the observed toxicity, with the possible  
35 exception of mercury. Among all contaminants analyzed, toxicity was most strongly associated  
36 with PAHs, which were substantially more concentrated in toxic samples than in nontoxic  
37 samples, and which frequently exceeded sediment quality criteria (Wolfe et al. 1996).

38 There is continuing concern, however, that legacy PCB waste may still pose a threat to  
39 invertebrate, fish, and human populations. A study by Achman et al. (1996) suggests that PCB  
40 concentrations in sediment measured at several locations in the lower Hudson River from the  
41 mouth to Haverstraw Bay are above equilibrium with overlying water and may be available for  
42 transfer within the food web. The authors concluded in some locations within the lower Hudson  
43 River, the sediments could act as a source of PCBs and pose a long-term chronic threat, but  
44 that fate and transport modeling would be required to fully understand the implications of this  
45 potential contaminant source.

## 1 Nonpoint Pollution

2 Nonpoint pollution can include the intentional or unintentional discharges of chemicals and  
3 constituents into rivers, streams, and estuaries. This section briefly summarizes three types of  
4 nonpoint pollution that may affect fish and shellfish resources in the Hudson River estuary—  
5 coliform bacteria that affect shellfish resources or swimmers, floatable debris, and surface  
6 slicks. All information is derived from Steinberg et al. (2004).

7 Levels of coliform bacteria in the Hudson River estuary have generally decreased from 1974 to  
8 1998, primarily in response to wastewater treatment improvements. At present, only stretches  
9 of the river near the southern end of the island of Manhattan have geometric mean coliform  
10 concentrations of 201–2000 coliform cells/100 mL. The incidence of shellfish-related illness in  
11 New York State has also decreased from a high of over 100 reported cases per year in 1982 to  
12 only a few in 1999. Steinberg et al. (2004) caution, however, that the incidence of shellfish-  
13 related illness is probably underreported and likely misdiagnosed when reported.

14 Common floatable debris found on New York beaches includes cigarette butts, food containers  
15 and wrappings, plastic and glass, and medical waste. The amount of debris removed from New  
16 York Harbor annually has generally exceeded 5000 t (4500 MT) since 1988, with no apparent  
17 downward trend. The presence of surface slicks in the harbor has appeared to decline since  
18 1994.

## 19 Invasive or Exotic Species

20 The presence of invasive or exotic species in the Hudson River estuary has been documented  
21 for over 200 years and probably began occurring after the Wisconsin-stage ice sheet receded  
22 over 10,000 years ago. In a compilation of information concerning the distribution of exotic  
23 organisms in the freshwater portions of the Hudson River basin, Mills et al. (1996) determined  
24 that at least 113 nonindigenous species of vertebrates, plants, and invertebrates have  
25 established populations in the Hudson River Basin. The list would undoubtedly be larger if  
26 better information was available concerning the historical populations of small invertebrates and  
27 algae. Most invasive species arrive through unintentional releases (e.g., from ship ballast water  
28 or agricultural cultivation activities) or via vectors introduced by the construction of canals.

29 While the presence of new or exotic species can result in a benefit (e.g., the largemouth and  
30 smallmouth bass recreational fishery), many have had a negative impact on their new  
31 environment. A classic example of the latter is the appearance of the zebra mussel in the  
32 freshwater portion of the Hudson River in 1991. Beginning in early fall 1992, zebra mussels  
33 have been dominant in the freshwater tidal Hudson, constituting more than half of heterotrophic  
34 biomass and filtering a volume of water equal to all of the water in the estuary every 1–4 days  
35 during the summer (Strayer 2007). The impacts of this species on the freshwater portions of the  
36 Hudson River are presented in Section 2.2.5.6.

37 The impacts of other invasive aquatic species are discussed elsewhere in this chapter. The  
38 issue is of magnitude significant enough to result in Federal actions to control future  
39 introductions. In 1992, the U.S. Congress passed an amendment to Public Law 101-646, the  
40 “Nonindigenous Aquatic Nuisance Species Act,” extending some of the Great Lakes-oriented  
41 provisions of that Act and the regulations that followed from it to the Hudson River. In particular,  
42 as of late 1994, vessels entering the Hudson River with foreign ballast water must have  
43 exchanged that water in midocean and must arrive with a salinity of at least 30 ppt (Mills et al.  
44 1996).

1 **2.2.5.3 Regulatory Framework and Monitoring Programs**

2 The regulatory framework, actions, and authorities governing environmental permitting and  
3 monitoring on the Hudson River are complex and have evolved significantly over time. The  
4 following is a chronological description of the major activities that have occurred over the past  
5 four decades.

6 Early Environmental Investigations

7 Early biological studies of the Hudson River began as a river survey program known as the  
8 Hudson River Fisheries Investigation (HRFI) which occurred from 1965 to 1968 under the  
9 direction of the Hudson River Policy Committee (HRPC) (Barnthouse and Van Winkle 1988).  
10 The investigations were intended to address the potential entrainment impacts of the proposed  
11 Cornwall pumped storage facility on striped bass. The objective of the HRFI program was to  
12 define the spatial and temporal distribution of striped bass eggs, larvae, and juveniles in relation  
13 to the intake to better understand the potential impacts of facility operation. The summary  
14 report produced by HRPC concluded that entrainment impacts associated with the operation of  
15 the Cornwall facility would be negligible, and this conclusion formed the basis of the decision by  
16 the Federal Power Commission (FPC) to license the facility in 1971. These conclusions were  
17 challenged on the grounds that an erroneous method had been used to estimate striped bass  
18 entrainment. This challenge ultimately resulted in a halt to the construction of the Cornwall  
19 facility in 1974 pending resolution of this issue (Barnthouse and Van Winkle 1988; Christensen  
20 and Englert. 1988).

21 During this period, IP1 was in operation, IP2 and IP3 were under construction, and a modest  
22 fish sampling program was being conducted in the area of Indian Point by New York University  
23 and Raytheon (Barnthouse and Van Winkle 1988). The enactment of the National  
24 Environmental Policy Act of 1969 (NEPA) on January 1, 1970, and the interpretation that it  
25 required the Atomic Energy Commission (AEC) to explicitly consider nonradiological impacts in  
26 its licensing decisions had immediate and dramatic impacts on IP2 and IP3. During the  
27 permitting process for IP2, the major point of contention again centered on whether facility  
28 operation would significantly affect striped bass eggs, larvae, and juveniles because of  
29 entrainment. The Consolidated Edison Company of New York, the owner of IP2 at the time,  
30 concluded in its ER that entrainment impacts would be insignificant. The environmental impact  
31 statement (EIS) prepared by the AEC staff in 1972 expressed concern about the impacts of  
32 thermal discharges, entrainment, and impingement associated with cooling system operation  
33 and concluded that “The operation of IP1 and IP2 with the present once-through cooling system  
34 has the potential for a long-term environmental impact on the aquatic biota inhabiting the  
35 Hudson River which [sic] would result in permanent damage to and severe reduction in the fish  
36 population, particularly striped bass, in the Hudson River, Long Island Sound, the adjacent New  
37 Jersey coast, and the New York Bight” (USAEC 1972). The final conclusion reached by AEC  
38 for IP2 was a recommendation that an operating license be issued with the following conditions  
39 to protect the environment—(1) once-through cooling was permitted only until January 1, 1978,  
40 and thereafter a closed-cycle system would be required, (2) the applicant would evaluate the  
41 economic and environmental impacts of an alternative closed-cycle system and submit this  
42 evaluation to AEC by July 1, 1973, (3) after approval by AEC, the required closed-cycle system  
43 would be designed, built, and placed in operation no later than January 1, 1978 (USAEC 1972).

1 The USAEC results published in 1972 were influenced to a great extent by the results of an  
2 entrainment model developed by C.P. Goodyear of the Oak Ridge National Laboratory  
3 (described in Hall 1977), and during subsequent years, the use of numerical simulation models  
4 to assess the impacts of entrainment from once-through facilities received a great deal of  
5 attention. As the models were developed, there was much debate concerning the assumptions  
6 used by the modelers, and the predictive ability of the models was the subject of numerous  
7 scientific symposia, peer-reviewed journal articles, and hearings. This information formed the  
8 basis of the decisions handed down by the Atomic Safety and Licensing Board in 1973 and the  
9 Atomic Safety and Licensing Appeals Board in 1974. These decisions stipulated that IP2 would  
10 be allowed to operate using once-through cooling but only until May 1, 1979. Unless the  
11 operator of the facility could demonstrate through new studies that the environmental impacts of  
12 once-through cooling were negligible, cooling towers would have to be installed (Barnthouse et  
13 al. 1984).

14 In late 1974, FPC held hearings to reconsider the Cornwall facility application. Recent data and  
15 numerical models that had been developed for IP2 were also evaluated. Because the  
16 information and assessment presented at the hearings provided conflicting conclusions  
17 concerning impacts, FPC was unable to determine the magnitude of potential environmental  
18 impacts, and the hearings were adjourned without resolution concerning plant licensing. In  
19 1975, the NRC, the successor agency to AEC, published an EIS for IP3 that once again  
20 expressed concern associated with the impacts of the once-through cooling system, including  
21 impacts associated with entrainment, impingement, and thermal releases. Using a combination  
22 of entrainment modeling and an improved striped bass life-cycle model, the NRC concluded that  
23 impingement and entrainment impacts were "likely to result in a substantial decrease in the  
24 Hudson River spawned striped bass population" (NRC 1975). The NRC indicated that the  
25 applicant, who had used different parameters in its impingement and entrainment simulation  
26 modeling, did not share this conclusion. The NRC agreed to allow IP3 to operate as a once-  
27 through facility but required the applicant to comply with a variety of technical specifications  
28 including the collection of additional environmental data to evaluate the impact of entrainment,  
29 impingement, and thermal discharges. The applicant was also required to comply with the  
30 license conditions agreed to in 1974 that required a cessation of once-through cooling by 1979  
31 unless new evidence demonstrated that environmental impacts were negligible (NRC 1975;  
32 Barnthouse et al. 1984).

### 33 Pollutant Discharge Elimination System Permitting

34 On October 28, 1975, EPA gave its approval to NYSDEC to issue SPDES permits in the State  
35 of New York. Before that time, national pollutant discharge elimination system (NPDES) (the  
36 federally administered analog to SPDES for States in which EPA has not granted authority to  
37 discharge to waters of the United States) permits were issued directly by EPA. Issues  
38 considered by EPA before the issuance of the 1975 permits included the thermal impacts of  
39 once-through cooling and fish mortalities associated with the cooling water intakes. During this  
40 time, scientists representing both the applicants and the regulatory agencies had embarked on  
41 ambitious programs to better understand the impacts of once-through cooling systems on  
42 sensitive fish species. This included a large-scale field program and the use and refinement of  
43 numerical simulation models to better understand entrainment impacts.

44 Depending on the model used and the assumptions employed, the impacts of once-through  
45 cooling ranged from negligible to catastrophic (Barnthouse et al. 1984). Further, although field

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1 collections were occurring, the amount of information available to be used as input data or to  
2 calibrate model output was limited. As a result, the EPA deemphasized the use of simulation  
3 modeling to estimate entrainment impacts and, in 1975, issued permits for IP2 and IP3, Bowline  
4 Units 1 and 2, and Roseton Unit 1 that required the construction of cooling towers. The utility  
5 companies contested the permits and requested adjudicatory hearings. In 1977, the owners of  
6 IP2 and IP3, Bowline, and Roseton facilities sought an administrative adjudicatory hearing  
7 against the EPA NPDES permits issued in 1975 to overturn the cooling water intake conditions  
8 and other requirements. The EPA hearings began in 1977 and ended in 1980 with the Hudson  
9 River Settlement Agreement (HRSA).

### 10 Hudson River Settlement Agreement

11 After a number of years of adjudicatory proceedings, the owners of IP2 and IP3, Roseton, and  
12 Bowline facilities signed the HRSA. The 10-year agreement was intended to resolve the  
13 disputes related to the issuance of the 1975 NPDES permits and provide the necessary funding  
14 to support a long-term investigation of the lower Hudson River estuary. Parties to the  
15 agreement, which was effective for the 10-year period from May 10, 1981, to May 10, 1991,  
16 included EPA, the New York State Attorney General, NYSDEC, the Scenic Hudson  
17 Preservation Conference (Scenic Hudson), the Hudson River Fishermen's Association (the  
18 predecessor to Riverkeeper), and the Natural Resources Defense Council (NYSDEC 2003a).  
19 HRSA provided for mitigative measures to reduce fish mortalities at each generation station  
20 from impingement and entrainment during once-through cooling operation, seasonal outages  
21 during sensitive aquatic life stages, and the installation of variable speed pumps at IP2 and IP3  
22 within 3½ years of the effective date of the agreement to allow for more efficient use of cooling  
23 water. In addition, HRSA established a biological monitoring program of fish species at various  
24 life stages within the lower Hudson River to better understand spatial and temporal trends.

25 In 1982, NYSDEC, under authority from EPA, issued SPDES permits to each of the facilities  
26 covered by HRSA. The permits included limitations on thermal releases and incorporated the  
27 terms of HRSA in the permit language to ensure that the environmentally protective mitigative  
28 measures stipulated in the agreement were included as conditions. These permits expired in  
29 1987, and NYSDEC issued SPDES permit renewals to each of the three HRSA facilities.  
30 Permits for IP2 and IP3, Bowline Point 1 and 2, and Roseton 1 and 2 became effective on  
31 October 1, 1987, and have been administratively continued by the NYSDEC since  
32 October 1, 1992 (NYSDEC 2003a). HRSA conditions were incorporated into the permit  
33 language as before. Before the permits expired in 1992, NYSDEC received timely renewal  
34 applications, and the department and the applicants executed an agreement on May 15, 1991,  
35 to continue the mitigative measures described in HRSA until the SPDES renewal permits were  
36 issued. The agreement also stipulated that the parties would negotiate in good faith to resolve  
37 issues associated with impingement, entrainment, and thermal discharges, and to resolve  
38 issues associated with mitigation and alternatives (NYSDEC 2003a).

39 In response to a lawsuit filed in 1991 by Riverkeeper, Scenic Hudson, and the Natural  
40 Resources Defense Council, a consent order was signed by all parties on March 23, 1992,  
41 which stipulated that the operators of IP2 and IP3, Roseton, and Bowline would continue the  
42 HRSA mitigative measures, such as timed outages to reduce impacts to fish, and continue to  
43 fund the ongoing environmental studies of the lower Hudson River. The 1992 consent order  
44 was extended by the parties on four separate occasions, with the fourth extension expiring on  
45 February 1, 1998. At present, there has been no agreement on a fifth consent order because of



1 the ongoing SPDES renewal process, but the operators of IP2 and IP3, Roseton, and Bowline  
2 have agreed to continue the mitigative measures included in their existing SPDES permit and to  
3 follow the provisions of the fourth consent order until new SPDES permits are issued (NYSDEC  
4 2003b). The major monitoring and assessment programs conducted under HRSA that form the  
5 basis for the staff's assessment of impacts are discussed below.

#### 6 Environmental Studies in the Lower Hudson Estuary

7 Numerous environmental studies were conducted in the Hudson River in support of HRSA and  
8 by other organizations to develop a baseline and to assess changes to key components of the  
9 ecosystem over time. A general description of the studies evaluated during the development of  
10 this SEIS is presented in Table 2-3. Other studies are cited throughout the description and  
11 historical assessment of impacts; however, only the data obtained from these studies were  
12 made available for further analysis.

13 Impingement losses associated with IP2 and IP3 were studied annually from 1975 to 1990.  
14 Data from 1975 to 1980 provided for analysis were weekly estimates of the total number  
15 impinged, organized by operating unit and taxon. From 1979 to 1980, estimates were further  
16 delineated by life stage (young of the year, yearling, yearling or older). Data from 1981 to 1990  
17 included seasonal estimates of the total number impinged by operating unit, taxon, and life  
18 stage.

19 As a part of the HRSA, IP2 and IP3 were required to replace the existing debris screens in 12 of  
20 the intake bays with angled screens and fish bypass systems. A subsequent analysis, however,  
21 showed that the angled screen system did not significantly reduce impingement mortality, and  
22 so the HRSA settlement parties rejected this mitigation option (Fletcher 1990). Con Edison and  
23 the New York Power Authority elected to install and test a Ristroph screen system at IP2 and  
24 IP3. The trial machine, referred to as "screen version 1" by Fletcher (1990), was installed in a  
25 single intake bay of IP2 and IP3 and evaluated from January 16 to April 19, 1985. At the  
26 request of the Hudson River Fishermen's Association, Fletcher (1990) evaluated the design of  
27 the trial machine, conducted flume tests, and suggested improvements to the design that were  
28 incorporated into "screen version 2." This final design, also known as a modified Ristroph  
29 screen, was installed in all intake bays of IP2 and IP3. As it was not required by the NYSDEC,  
30 no further studies were conducted after the installation of the modified Ristroph system at  
31 IP2 and IP3 to determine actual mortality of key species, and no additional impingement  
32 monitoring was conducted.

33 Ichthyoplankton entrainment losses associated with IP2 and IP3 were studied between May and  
34 August in 1981, 1983 through 1985, and in 1987, as well as between January and August 1986.  
35 Data provided for this analysis were the combined IP2 and IP3 weekly mean densities  
36 (number/1000 m<sup>3</sup>) of each life stage (egg, yolk-sac larvae, post-yolk-sac larvae, and juvenile) by  
37 taxon.

38 Data from the three field surveys from the Hudson River Estuary Monitoring Program were also  
39 provided for this analysis (Long River Survey (LRS), Fall Juvenile Survey (FJS), and the Beach  
40 Seine Survey (BSS)). All three data sets include the annual total catch and volume sampled per  
41 taxon from 1974 through 2005, the annual abundance index per taxon and life stage from 1974  
42 through 2005, and the weekly regional density of each life stage by taxon from 1979 through  
43 2005.

44

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**Table 2-3. Hudson River Environmental Studies Table  
(Information used in SEIS to assess impacts; data provided by Entergy)**

Study	Study Dates	Information Available
Impingement Abundance <sup>1</sup>	1975–1990	Number of fish impinged at IP2 and IP3.
Entrainment Abundance Studies	1981 1983–1987	Entrainment density by species and life stage for IP2 and IP3 combined.
Longitudinal River Ichthyoplankton Surveys	1974–2004	Standing crop, temporal and geographic distributions, and growth rates for ichthyoplankton forms of fish species, with an emphasis on Atlantic tomcod, American shad, striped bass, white perch, and bay anchovy. Sampling generally occurred in spring, summer, and fall.
Fall Juvenile Surveys	1974–2005	Standing crop and temporal and geographic indices for young-of-the-year fish in shoal, bottom, and channel habitats in the estuary with an emphasis on Atlantic tomcod, American shad, striped bass, and white perch. Surveys generally conducted in midsummer and fall.
Beach Seine Surveys	1974–2005	Abundance and distribution of young-of-the-year fish in the shore-zone habitat in the estuary, with an emphasis on American shad, Atlantic tomcod, striped bass, and white perch. Surveys generally conducted in summer and fall.

3 **2.2.5.4 Potentially Affected Fish and Shellfish Resources**

4 The Hudson River estuary is home to a large and diverse assemblage of fish and shellfish.  
 5 Species richness and abundance vary according to season and location and can be influenced  
 6 by climatological changes that affect water temperature, salinity, and sediment load. Waldman  
 7 et al. (2006) report that 212 species of fish have been recorded north of the southern tip of  
 8 Manhattan Island, with the largest contributions associated with temperate marine strays (65),  
 9 introduced species (28), and freshwater species surviving the Pleistocene glaciations in the  
 10 Atlantic coast refugia (21). The authors also note that only 10 diadromous (traveling between  
 11 fresh- and salt-water) species are known to occur in the Hudson River Estuary.

12 The NRC staff identified 18 aquatic representative important species (RIS) to use in assessing  
 13 the impacts of IP2 and IP3 (Table 2-4). This list contains RIS identified in past analyses  
 14 conducted by NYSDEC, the NRC, and the current and past owners of IP2 and IP3. The aquatic  
 15 RIS identified in this section are meant to represent the overall aquatic resource and reflect the

<sup>1</sup> Entergy re-submitted this data to NRC on November 24, 2009, because the data Entergy initially provided to NRC staff contained errors that caused some impingement numbers to appear artificially high. The new data are publicly available through ADAMS at ML093420528. NRC staff relied on the new impingement data – along with the other data listed in Table 2-3 – for its analysis in this SEIS.

1 complexity of the Hudson River ecosystem by encompassing a broad range of attributes, such  
 2 as biological importance, commercial or recreational value, trophic position, commonness or  
 3 rarity, interaction with other species, vulnerability to cooling system operation, and fidelity or  
 4 transience in the local community. Table 2-5 provides the locations in the Hudson River estuary  
 5 where specific RIS and life stages represented at least 10 percent of the total number collected  
 6 in reference surveys or studies.

7 What follows is a discussion of life histories, abundance data, and other information for each  
 8 aquatic RIS. Unless otherwise noted, information on impingement or entrainment trends are  
 9 from electronic data provided to NRC staff by Entergy or its contractors. The significance of  
 10 impingement and entrainment, and the presence of other potential environmental stressors on  
 11 aquatic RIS is discussed in Chapter 4 and Appendixes H and I.

12 **Table 2-4. Aquatic Representative Important Species**

Common Name	Scientific Name	Occurrence and Status	Predator/Prey Relationships
Alewife	<i>Alosa pseudoharengus</i>	Anadromous	Juveniles eat insect larvae and amphipods; adults eat zooplankton, small fish, and fish eggs. Species is prey of bluefish, weakfish, and striped bass.
Atlantic menhaden	<i>Brevoortia tyrannus</i>	Permanent or seasonal resident	Juveniles and adults eat phytoplankton, zooplankton, copepods, and detritus. Species is prey of bluefish and striped bass.
American shad	<i>Alosa sapidissima</i>	Anadromous	Juveniles and adults primarily eat zooplankton, small crustaceans, copepods, mysids, small fish, and fish eggs. Species is prey of oceanic species.
Atlantic sturgeon	<i>Acipenser oxyrinchus</i>	Candidate for Federal endangered status; Anadromous	Juveniles and adults are bottom feeders, subsisting on mussels, worms, shrimp, and small fish.
Atlantic tomcod	<i>Microgadus tomcod</i>	Anadromous permanent or seasonal resident	Diet includes crustaceans, polychaete worms, mollusks, and small fish. Juveniles are prey of striped bass when anchovies are scarce.
Bay anchovy	<i>Anchoa mitchilli</i>	Estuarine	Species primarily eats zooplankton and is prey of YOY bluefish and striped bass.
Blueback herring	<i>Alosa aestivalis</i>	Anadromous	Species' diet includes insect larvae and copepods. It is prey of bluefish, weakfish, and striped bass.
Bluefish	<i>Pomatomus saltatrix</i>	Permanent or seasonal resident	Juveniles eat bay anchovy, Atlantic silverside, striped bass, blueback herring, Atlantic tomcod, and American shad. Species is prey of a variety of birds.

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Gizzard shad	<i>Dorosoma cepedianum</i>	Freshwater	Juveniles eat daphnids, cladocerans, adult copepods, rotifers, algae, phytoplankton, and detritus; adults eat phyto- and zooplankton. Species is prey of striped bass, other bass species, and catfish.
Hogchoker	<i>Trinectes maculatus</i>	Estuarine	Adults are generalists and eat annelids, arthropods, and tellinid siphons. Species is prey of striped bass.
Rainbow smelt	<i>Osmerus mordax</i>	Anadromous	Larval and juvenile smelt eat planktonic crustaceans; larger juveniles and adults feed on crustaceans, polychaetes, and fish. Adults eat anchovies and alewives. Species is prey of striped bass and bluefish.
Shortnose sturgeon	<i>Acipenser brevirostrum</i>	Federally endangered; permanent or seasonal resident	Juveniles feed on benthic insects and crustaceans.
Spottail shiner	<i>Notropis hudsonius</i>	Freshwater	Species eats aquatic insect larvae, zooplankton, benthic invertebrates, and the eggs and larvae of fish, including their own species. Species is prey of striped bass.
Striped bass	<i>Morone saxatilis</i>	Anadromous	Species eats menhaden, river herring, tomcod, and smelt. Larvae are prey of spottail shiner, white perch, striped bass, bluegill, and white catfish.
Weakfish	<i>Cynoscion regalis</i>	Permanent or seasonal resident	Small weakfish feed primarily on crustaceans, while larger weakfish feed primarily on anchovies, herrings, spot. Species is prey of bluefish, striped bass, and other weakfish.
White catfish	<i>Ameiurus catus</i>	Freshwater	Juveniles eat midge larvae. Adults are omnivores, feeding on anything from fish to insects to crustaceans.
White perch	<i>Morone americana</i>	Estuarine	Species eat eggs of other fish and larvae of walleye and striped bass. Prey of larger piscivorous fish and terrestrial aquatic vertebrates.
Blue Crab	<i>Callinectes sapidus</i>	Estuarine	Zoea eat phytoplankton, and dinoflagellates; adults opportunistic. Larval crabs are the prey of fish, shellfish, jellyfish; juvenile and adult blue crabs are prey of a wide variety of fish, birds, and mammals.

1

1 **Table 2-5. Locations in the Hudson River Estuary (see Figure 2-10) Where the Presence**  
 2 **of Aquatic RIS Life Stages Represented at Least 10 Percent of the Total Number**  
 3 **Collected in Referenced Surveys or Studies (adapted from ASA 2007; river segment**  
 4 **abbreviations from Figure 2-10)**

Species	Lifestage	River Segments													
		BT	YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL	
Alewife	Eggs												LRS <sup>(c)</sup>		
	YSL <sup>(d)</sup>												LRS		
	PYSL <sup>(e)</sup>									LRS					
	YOY <sup>(f)</sup>			BSS <sup>(g)</sup>				BSS				BSS			
	Year + <sup>(g)</sup>														
Atlantic menhaden <sup>(h)</sup>	Eggs														
	YSL														
	PYSL														
	YOY	ASMFC 2006a													
	Year +														
American shad	Eggs												LRS		
	YSL												LRS		
	PYSL										LRS				
	YOY								BSS	LRS		LRS/BSS		BSS	
	Year +														
Atlantic sturgeon	Eggs														
	YSL														
	PYSL														
	YOY														
	Year +					FJS <sup>(b)</sup> : Only 12 fish caught 2005									
Atlantic tomcod	Eggs														
	YSL														
	PYSL		LRS												
	YOY		LRS/FJS			LRS/FJS		FJS							
	Year +		FJS			FJS									

5

1

Table 2-5 (continued)

Species	Lifestage	BT	YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
Bay anchovy	Eggs	LRS												
	YSL	LRS												
	PYSL	LRS												
	YOY	LRS/BSS												
	Year +		BSS											
Blueback herring	Eggs											LRS		
	YSL											LRS		
	PYSL							LRS						
	YOY						LRS/BSS							
	Year +													
Bluefish	Eggs													
	YSL													
	PYSL													
	YOY		BSS											
	Year +													
Gizzard shad	Eggs													
	YSL													
	PYSL													
	YOY							BSS			BSS			BSS
	Year +							BSS			BSS			

2

1

Table 2-5 (continued)

Species	Lifestage	BT	YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
Hogchoker	Eggs													
	YSL													
	PYSL													
	YOY			FJS				FJS						
	Year +				FJS									
Rainbow smelt	Eggs											LRS		
	YSL										LRS			
	PYSL										LRS			
	YOY										LRS/FJS			
	Year +								FJS					
Shortnose sturgeon	Eggs													
	YSL													ER Text
	PYSL													
	YOY													
	Year +													FJS/LRS: Only 32 fish caught in 2005
Spottail shiner	Eggs													
	YSL													
	PYSL													
	YOY									BSS			BSS	
	Year +									BSS			BSS	
Striped bass	Eggs											LRS		
	YSL											LRS		
	PYSL											LRS		
	YOY											LRS/BSS		LRS
	Year +					BSS							BSS	

2

1

Table 2-5 (continued)

Species	Lifestage	BT	YK	TZ	CH	IP	WP	CW	PK	HP	KG	SG	CS	AL
Weakfish	Eggs													
	YSL													
	PYSL													
	YOY		FJS											
	Year +		FJS				FJS							
White catfish	Eggs													
	YSL													
	PYSL													
	YOY								FJS				FJS	
	Year +			FJS									FJS	
White perch	Eggs												LRS	
	YSL												LRS	
	PYSL												LRS	
	YOY				BSS				LRS				BSS	
	Year +				BSS								BSS	
Blue crab <sup>(1)</sup>	Eggs													
	Zoea													
	Megalops													
	Juvenile													
	Year +													

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(a) BSS: Beach Seine Survey (1974–2005)  
 (b) FJS: Fall Juvenile Survey (also known as Fall Shoals Survey) (1979–2004)  
 (c) LRS: Long River Survey (1974–2004)  
 (d) YSL: yolk-sac larvae  
 (e) PYSL: post-yolk-sac larvae  
 (f) YOY: young of year  
 (g) Year +: yearling and older  
 (h) Obtained from ASMFC 2006a distribution  
 (i) Obtained from ASMFC 2006a distribution  
 Source: NYSDEC 2004b



1 Alewife

2 The alewife (*Alosa pseudoharengus*, family Clupeidae) is a pelagic, anadromous species found  
3 in riverine and estuarine habitats along the Atlantic coast from Newfoundland to South Carolina;  
4 landlocked populations have also been introduced in the Great Lakes and Finger Lakes. The  
5 species is historically one of the most commercially important fish species in Massachusetts and  
6 continues to be harvested as a source of fish meal, fish oil, and protein for animal food  
7 industries (Fay et al. 1983). The commercial fishing industry does not differentiate between the  
8 alewife and the blueback herring (*Alosa aestivalis*) and refers to the two species collectively as  
9 river herring. Commercial landings of river herrings peaked in the 1950s at approximately  
10 34,000 MT (37,500 t) and then declined to less than 4000 MT (4400 t) in the 1970s (Haas-  
11 Castro 2006a). Between 1996 and 2005, landings of river herring ranged from 300 to 900 MT  
12 (330 to 990 t) annually, with 90 percent of landings in Maine, North Carolina, and Virginia  
13 (Haas-Castro 2006a). The river herring fishery is one of the oldest fisheries in the United  
14 States; however, no commercial fisheries for river herring exist in the Hudson River today.  
15 River herring are often taken as bycatch in the offshore mackerel fishery; within New York and  
16 New Jersey, river herring accounted for 0.3 percent of annual landings on the Atlantic coast  
17 (CHGEC 1999).

18 Spawning adults enter the Hudson River from the Atlantic Ocean in early spring and spawn  
19 once per year between late May and mid-July in shallow, freshwater tributaries with low current  
20 at temperatures between 11°C (52°F) and 27°C (81°F) (Everly and Boreman 1999; Fay et al.  
21 1983). Females first spawn at 3 to 4 years of age and produce 60,000 to 100,000 eggs.  
22 Alewives spawn 3 to 4 weeks before blueback herring in areas where the two species occur  
23 sympatrically, and the peak spawning of each species occurs 2 to 3 weeks apart from one  
24 another (Fay et al. 1983). Within the Hudson River estuary, peak abundance of river herring  
25 eggs generally occurs within the Catskill region of the upper estuary during mid-May (CHGEC  
26 1999). Incubation time varies inversely with water temperature and ranges from 2 to 15 days,  
27 and eggs are semidemersal and are easily carried by currents (Fay et al. 1983; CHGEC 1999).  
28 The yolk sac larvae (YSL) stage lasts approximately 2 to 5 days, and the post-yolk-sac larvae  
29 (PYSL) stage lasts until transformation to the juvenile stage at approximately 20 millimeters  
30 (mm) (0.78 in.). Full development occurs at approximately 45 mm (1.8 in.) at the age of about  
31 1 month (Fay et al. 1983; CHGEC 1999).

32 Young-of-the-year (YOY) have been found in both lower and upper regions of the river  
33 (Table 2-5). Juveniles migrate to the ocean between July and November of their first year. At  
34 sexual maturity, alewives weigh 153 to 164 grams (g) (0.34 to 0.36 pounds (lb)) and can weigh  
35 325 to 356 g (0.72 to 0.78 lb) by their seventh year; the average length for males is 29 cm and  
36 for females is 31 cm (Fay et al. 1983). Alewives in the Hudson River estuary have a life span of  
37 up to 9 years (Haas-Castro 2006a). Juveniles in the lower Hudson River have been reported to  
38 feed on chironomid larvae and amphipods, and the diet of adult alewives consists primarily of  
39 zooplankton, amphipods, mysids, copepods, small fish, and fish eggs. After spawning, alewives  
40 feed heavily on shrimp (Fay et al. 1983; CHGEC 1999). The species fulfills an important link in  
41 the estuarine food web between zooplankton and top piscivores. Juvenile and adult alewife is  
42 prey for gulls, terns, and other coastal birds, as well as bluefish (*Pomatomus saltatrix*), weakfish  
43 (*Cynoscion regalis*), and striped bass (*Morone saxatilis*) (CHGEC 1999).

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1 | The annual abundance in the Hudson River of YOY alewives has been estimated to range from  
2 | 110,000 to 690,000 individuals (CHGEC 1999). For each annual cohort, entrainment mortality  
3 | for the combined abundance of alewife and blueback herring for all water withdrawal locations  
4 | within the Hudson River varies widely, ranging from 8 to 41 percent for data taken between  
5 | 1974 and 1997, while impingement mortality of the alewife is low, ranging from 1.1 to  
6 | 1.9 percent for the same time period (CHGEC 1999). The Atlantic States Marine Fisheries  
7 | Commission (ASMFC) implemented a Fisheries Management Plan for the American shad and  
8 | river herring in 1985. Restoration efforts under the plan include habitat improvement, fish  
9 | passage, stocking, and transfer programs; however, the abundance of river herring still remains  
10 | well below historic estimates (Haas-Castro 2006a). River herring were present in both  
11 | impingement and entrainment samples obtained from IP2 and IP3.

### 12 | Atlantic Menhaden

13 | The Atlantic menhaden (*Brevoortia tyrannus*, family Clupeidae) is a euryhaline species found in  
14 | inland tidal waters along the Atlantic coast from Nova Scotia to Florida (MRC 2006). Menhaden  
15 | is commercially harvested as a high-grade source of omega-3 fatty acid, which is used in  
16 | pharmaceuticals and processed food production (ASMFC 2006a). Atlantic menhaden make up  
17 | between 25 and 40 percent of the combined annual landings of menhaden species along the  
18 | Atlantic coast and Gulf of Mexico (Rogers and Van Den Avyle 1989). The Atlantic menhaden  
19 | was first commercially fished in the late 1600s and early 1700s for use in agricultural fertilizer,  
20 | and the species was later harvested for oil beginning in the early 1800s (Rogers and Van Den  
21 | Avyle 1989). Fish meal from menhaden also became a staple component in swine and  
22 | ruminant feed beginning in the mid-1900s and began to be used in aquaculture feed in the  
23 | 1990s (ASMFC 2006a).

24 | Atlantic menhaden migrate seasonally and exhibit north-south and inshore-offshore movement  
25 | in large schools composed of individuals of a similar size and age (Rogers and Van Den Avyle  
26 | 1989). Migration patterns are linked to spawning habits, and the species spawns year-round  
27 | throughout the majority of its range, with spawning peaks in the spring and fall in mid-Atlantic  
28 | and northern Atlantic regions (MRC 2006). Menhaden reach sexual maturity at lengths of 18 to  
29 | 23 cm (7.1 to 9.1 in.), and female fecundity ranges from 38,000 eggs for a small female to  
30 | 362,000 eggs for a large female (ASMFC 2006a; MRC 2006). Eggs are pelagic and hatch  
31 | offshore in 2.5 to 2.9 days at an average temperature of 15.5°C (59.9°F) (ASMFC 2006a;  
32 | Rogers and Van Den Avyle 1989). Larvae absorb the yolk sac within approximately 4 days of  
33 | hatching and begin to feed on zooplankters (Rogers and Van Den Avyle 1989).

34 | The survival of larvae is a function of temperature and salinity, with the highest survival rates  
35 | occurring in laboratory experiments at temperatures greater than 4°C (39°F) and salinities of 10  
36 | to 20 ppt (ASMFC 2006a). Larvae migrate shoreward into estuaries at 1 to 3 months of age at a  
37 | size of 14 to 34 mm (0.55 to 1.3 in.) (ASMFC 2006a). Metamorphosis to the juvenile stage  
38 | occurs at approximately 38 mm (1.5 in.), and menhaden begin to filter feed on phytoplankton,  
39 | zooplankton, copepods, and detritus (MRC 2006). Juveniles move into shallow portions of  
40 | estuaries and are generally more abundant in areas of lower salinity (less than 5 ppt) and  
41 | waters above the brackish-freshwater boundary in rivers. Juveniles leave estuaries in dense  
42 | schools between August and November at lengths of 55 to 140 mm (2.2 to 5.5 in.) and migrate  
43 | southward along the North Carolina coast as far south as Florida in late fall and early winter  
44 | (Rogers and Van Den Avyle 1989). During the following spring and summer, menhaden move  
45 | northward, redistributing in schools consisting of similarly sized individuals (ASMFC 2006a).

1 Most menhaden reach maturity at 2 years of age, at which point approximately 90 percent of  
2 individuals are capable of spawning (Rogers and Van Den Avyle 1989). Menhaden lose their  
3 teeth as juveniles, and adults are strictly filter feeders, feeding on planktonic organisms (ASMFC  
4 2006a). Atlantic menhaden can live 8 to 10 years; however, fish over 4 years of age are  
5 uncommon in commercial catches. Maximum adult length is 500 mm (19.7 in.) and maximum  
6 weight is 1500 g (3.3 lb) (Rogers and Van Den Avyle 1989). Menhaden are prey for a number  
7 of piscivorous fish, including bluefish (*P. saltatrix*), striped bass (*M. saxatilis*), bluefin tuna  
8 (*Thunnus thynnus*), as well as birds and marine mammals because of their abundance in  
9 nearshore and estuarine waters (ASMFC 2006a; Rogers and Van Den Avyle 1989).

10 Atlantic menhaden were not a focus of the Hudson River monitoring programs; therefore,  
11 historical records for the Hudson River population trends are unavailable. However, based on  
12 tagging studies, the Atlantic menhaden population appears to be composed of a single  
13 population that undergoes extensive seasonal migration (ASMFC 2006a). Menhaden are  
14 primarily harvested via reduction purse-seine fishing, and Virginia and North Carolina are the  
15 only States that currently permit this type of fishing for this species (ASMFC 2006a). Menhaden  
16 landings peaked during the late 1950s at an annual average of over 600,000 t (544,000 MT)  
17 and then declined during the 1960s from 576,000 t (523,000 MT) in 1961 to 162,000 t  
18 (147,000 MT) in 1969. Landings rose in the 1970s as the stock rebuilt, maintained moderate  
19 levels during the 1980s, and declined again in the 1990s. Landings have varied in the 2000s  
20 with average annual landings of 184,900 t (168,000 MT) from 2000 to 2004, and 146,900 t  
21 (133,000 MT) landed in 2005. Landings from the reduction purse-seine fishery accounted for  
22 79 percent of total landings along the Atlantic coast in 2005 (ASMFC 2006a). Atlantic  
23 menhaden are also harvested for bait in many Atlantic coast States; however, no data are  
24 available for these landings as they are taken via cast net, pound net, gill net, and as bycatch.  
25 Atlantic menhaden were generally not present in entrainment samples from IP2 and IP3, but  
26 were present in impingement samples.

### 27 American Shad

28 The American shad (*Alosa sapidissima*, family Clupeidae) is the largest of the anadromous  
29 herring species found in the Hudson River estuary and ranges from Newfoundland to northern  
30 Florida. The species is most abundant between Connecticut and North Carolina. The stock  
31 was introduced along the Pacific coast in the Sacramento and Columbia Rivers in 1871, and the  
32 population is now established from Cook Inlet, Alaska, to southern California (Facey and Van  
33 Den Avyle 1986). American shad has been commercially harvested via gillnets for meat and  
34 roe since the late 17th century (Haas-Castro 2006b). Before World War II, American shad was  
35 the most valuable fish along the east coast (Facey and Van Den Avyle 1986).

36 American shad spend most of their life at sea and only return to their natal rivers at sexual  
37 maturity (at the age of about 5 years) to spawn. Adult American shad have an average length  
38 of 30 in. (76.2 cm), weigh up to 12 lb (5.4 kg), and have a life span in the Hudson River of about  
39 11 years (CHGEC 1999). Shad eggs have a high mortality rate, and fecundity of females  
40 changes with latitude, decreasing from south to north. Females in southern rivers produce  
41 300,000 to 400,000 eggs, and females in northern rivers produce an average of 125,000 eggs  
42 (Haas-Castro 2006b). Spawning occurs at night in shallow waters of moderate current in sand,  
43 gravel, or mud substrates (Facey and Van Den Avyle 1986). The species can repeat annual  
44 spawning up to five times within their lifetime in northeastern rivers; however, most shad from  
45 southeastern rivers die after spawning (Facey and Van Den Avyle 1986; CHGEC 1999). Egg

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1 abundance in the Hudson River peaks in May, and once hatched, YSL transform into PYSL  
2 within 4 days to 1 week in waters at a temperature of 17°C (63°F) (Everly and Boreman 1999;  
3 CHGEC 1999). Larvae inhabit riffle pools of moderate depth near spawning grounds and  
4 develop into juveniles 4 to 5 weeks after hatching when they are approximately 25 mm (1 in.) in  
5 length (Everly and Boreman 1999; Facey and Van Den Avyle 1986). American shad eggs, YSL,  
6 PYSL, and YOY are generally found between Kingston and Albany (Table 2-5), probably in  
7 response to food availability (Limburg 1996). Juveniles travel downriver in schools between  
8 June and July (Everly and Boreman 1999), utilize the middle estuary by September, and move  
9 to the lower estuary by late October (Limburg 1996). Adults spend the summer months in the  
10 northwestern Atlantic waters off the Gulf of Maine, the Bay of Fundy, and the coast of Nova  
11 Scotia. In the fall months, individuals migrate southward as far as North Carolina (CHGEC  
12 1999).

13 Shad stop eating before running and spawning and resume feeding after spawning during their  
14 downriver migration back to the Atlantic Ocean (Everly and Boreman 1999). Larvae feed on  
15 *Bosmina* spp., cyclopoid copepodites, and chironomid larvae. Juveniles are opportunistic  
16 feeders and consume free-swimming organisms at the surface as well as insects (CHGEC  
17 1999). The principal food source of the adult American shad is zooplankton, though the species  
18 also consumes small crustaceans, copepods, mysids, small fish, and fish eggs (Facey and Van  
19 Den Avyle 1986). The American eel (*Anguilla rostrata*) and catfish (*Ictalurus* spp.) prey upon  
20 American shad eggs, and bluefish (*Pomatomus saltatrix*) prey upon larvae (CHGEC 1999).  
21 Once juveniles migrate to the Atlantic Ocean, likely predators include sharks, tuna, and  
22 porpoises; adult shad are not thought to have many predators (Facey and Van Den Avyle  
23 1986).

24 | The estimated population of American shad in the Hudson River has declined from 2.3 million in  
25 1980 to 404,000 in 1996 (ASMFC 1998). The decline of the species in the Hudson and  
26 Connecticut Rivers in the past century is attributed to overfishing, degradation of riverine  
27 habitat, and dam construction (Haas-Castro 2006b). ASMFC implemented a Fisheries  
28 Management Plan for the American shad and river herring in 1985. Restoration efforts under  
29 the plan include habitat improvement, fish passage, stocking, and transfer programs; however,  
30 abundance of American shad remains well below historic estimates (Haas-Castro 2006b). Low  
31 DO conditions can affect the migration patterns of American shad and limit spawning.  
32 Improvements in sewage treatment facilities along the Hudson River in the late 1960s have  
33 eliminated the low DO conditions that were problematic in waters south of Albany and have  
34 allowed adult shad to spawn farther upriver (CHGEC 1999). According to CHGEC (1999),  
35 entrainment mortality has caused a 23.8 percent annual decrease in abundance of juvenile  
36 American shad, and impingement may reduce the population by an additional 1 percent  
37 annually. The majority of entrainment mortality is believed to occur in the Albany region as a  
38 result of the Albany Steam Station and Empire State Plaza (CHGEC 1999). American shad  
39 were present in both impingement and entrainment samples obtained from IP2 and IP3.

### 40 Atlantic Tomcod

41 The demersal, anadromous Atlantic tomcod (*Microgadus tomcod*, family Gadidae) is found in  
42 northwest Atlantic estuarine habitats, with a range extending from southern Labrador and  
43 northern Newfoundland to Virginia (Stewart and Auster 1987). The species is nonmigratory and  
44 inhabits brackish waters, including estuarine habitats, salt marshes, mud flats, eel grass beds,  
45 and bays. The species is short-lived, with an estimated mortality rate ranging from 81 to

1 98 percent by the age of 2 years (McLaren et al. 1988). Mean lifespan within the Hudson River  
2 is 3 years, though populations north of the Hudson River tend to be longer lived (Stewart and  
3 Auster 1987). Most tomcod within the Hudson River are thought to remain within the estuary for  
4 life; however, a small number of individuals have been marked and recaptured in the lower New  
5 York Bay, the East River, and western Long Island Sound (Klauda et al. 1988). The tomcod has  
6 not been a commercially important species in the northeast within the past century, and no  
7 catch statistics have been recorded since the 1950s, as the species is generally a target for  
8 winter sport fishing only along the New England coast (Stewart and Auster 1987). Tomcod are  
9 particularly vulnerable to impingement and entrainment because of their high concentration near  
10 the lower portion of the Hudson River estuary (Barnhouse and Van Winkle 1988; Boreman and  
11 Goodyear 1988) (Table 2-5).

12 Spawning occurs under ice between December and January in shallow stream mouths (Stewart  
13 and Auster 1987). In the Hudson River, tomcod aged 11 to 13 months contribute approximately  
14 85 to 97 percent of annual egg production, and the majority of tomcod in the Hudson River  
15 spawn only once in their lifetime (McLaren et al. 1988). Females produce an average of  
16 20,000 eggs, and incubation time correlates inversely with salinity and ranges from 24 to  
17 63 days (Dew and Hecht 1994; Stewart and Auster 1987). Once hatched, larvae float to the  
18 surface and are swept by currents into estuaries, where they develop into juveniles. YSL are  
19 found throughout the lower half of the estuary, and PYSL are concentrated in the Yonkers and  
20 Tappan Zee regions of the estuary (CHGEC 1999) (Table 2-5). Adults are found at all levels of  
21 salinity, but larvae and juvenile densities are highest within the 4.5 to 6.7 ppt salinity range  
22 (Stewart and Auster 1987). The Hudson River represents the southernmost major spawning  
23 area of the species, and the tomcod is the only major species within the freshwater region of the  
24 Hudson River to hatch between February and March (Dew and Hecht 1994). Because the  
25 species hatches earlier than herring species within the Hudson and larvae and juveniles are  
26 able to tolerate low temperatures, tomcod experience little interspecific competition for food until  
27 the fall of their first year (McLaren et al. 1988). Tomcod are found at temperatures as low as -  
28 1.2°C (30°F) and have not been observed to inhabit waters at temperatures higher than 26°C  
29 (79°F) (Stewart and Auster 1987). The species has also been observed at a wide range of  
30 depths varying from the surface to 69 m (226 ft) (Froese and Pauly 2007a). Tomcod have three  
31 visible stages of first year growth within the Hudson River population. Juveniles show rapid  
32 growth during the spring, little to no growth during the summer, and rapid growth again in the  
33 fall, which is highly correlated with prevailing water temperatures (McLaren et al. 1988). Growth  
34 has been found to slow at temperatures above 19°C (66°F), and growth essentially ceases at  
35 temperatures above 22°C (72°F) (CHGEC 1999).

36 The diet of tomcod consists primarily of small crustaceans but also may include polychaete  
37 worms, mollusks, and small fish. Because tomcod have a lipid-rich liver and prey on many  
38 benthic organisms, they are especially sensitive to contaminants in highly polluted waterways,  
39 including PCBs and other chlorinated hydrocarbons (Levinton and Waldman 2006). Recent  
40 work by Wirgin and Chambers (2006) has reported evidence of induction of hepatic expression  
41 of cytochrome P4501A1 and messenger ribonucleic acid (mRNA) in Hudson River tomcod,  
42 suggesting a potential for deoxyribonucleic acid (DNA) damage, somatic mutations, and  
43 initiation of carcinogenesis consistent with chemical exposure. Within the Hudson River  
44 estuary, juvenile tomcod serve as alternate prey in the summer months for yearling striped bass  
45 (*M. saxatilis*) during years when juvenile striped bass's main prey, the bay anchovy (*A. mitchilli*),

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1 is scarce (Dew and Hecht 1976 cited in Stewart and Auster 1987). Juvenile tomcod are also the  
2 | prey of large juvenile bluefish (*P. saltatrix*) (Juanes et al. 1993).

3 The Hudson River tomcod population exhibits wide fluctuations in annual abundance because  
4 the species is relatively short lived, and a yearly population is generally composed of only one  
5 age class (Levinton and Waldman 2006). The population of tomcod aged 11 to 13 months has  
6 been estimated to vary year-to-year between 2 to 5 million individuals, and numbers of tomcod  
7 aged 23 to 25 months may vary from 100,000 to 900,000 individuals. A combined abundance  
8 index suggests that a population decline has occurred since 1989 (CHGEC 1999). Recent  
9 information provided by Entergy (2006c) estimated the population of Atlantic tomcod spawning  
10 in the Hudson River during the winter of 2003–2004 to be 1.7 million fish, with 95 percent  
11 confidence limits of 1.0 and 2.9 million fish. This estimate, derived by a Petersen mark-  
12 recapture technique, is based on the number of tomcod caught and marked between RM 25  
13 and 76 (RKM 40 to 122) in box traps between December 15, 2003, and February 1, 2004, and  
14 recaptured in trawls in the Battery region from January 5 through April 11, 2004. The estimated  
15 2003–2004 Atlantic tomcod spawning population in the Hudson River is the ninth lowest  
16 observed among 20 recent years of Petersen estimates (Entergy 2006c). Atlantic tomcod were  
17 | present in both impingement and entrainment samples obtained from IP2 and IP3.

### 18 Bay Anchovy

19 The bay anchovy (*Anchoa mitchilli*, family Engraulidae) occurs along the Atlantic coastline from  
20 Maine to the Gulf of Mexico and the Yucatan Peninsula (Morton 1989) and is a common  
21 shallow-water fish in the Hudson River estuary. No commercial fishery for the bay anchovy  
22 exists on the Hudson River, but it is preyed upon by other fish, such as the striped bass (*M.*  
23 *saxatilis*), which is recreationally important on the Hudson River. Unless otherwise noted, the  
24 information below is from Morton (1989).

25 Considered a warm water migrant, the bay anchovy uses the Hudson River estuary for  
26 spawning and as a nursery ground. Adults are found in a variety of habitats, including shallow  
27 to moderately deep offshore waters, nearshore waters off sandy beaches, open bays, and river  
28 mouths. Studies conducted in the Hudson River from 1974–2005 suggest that eggs, YSL,  
29 PYSL, YOY, and older individuals occur in greatest abundance from the Battery to IP2 and IP3  
30 (Table 2-5, Figure 2-10). There is also evidence from recent work by Dunning et al. (2006a)  
31 that the peak standing crops of bay anchovy eggs and larvae in New York Harbor, the East  
32 River, and Long Island Sound are approximately eight times larger than the population  
33 estimates for the lower Hudson River, probably because of the larger water volumes in those  
34 areas and the salinity preference of the species. Spawning generally occurs at water  
35 temperatures between 9 and 31°C (48 and 88°F). The spawning period for the species is long,  
36 typically ranging from May through October. Spawning generally occurs in the late evening or  
37 at night, and the eggs are pelagic. Schultz et al. (2006) has reported that anchovies that spawn  
38 in the Hudson River are mostly 2 years old, whereas yearlings predominate in other locations,  
39 such as Chesapeake Bay. Eggs are usually concentrated in salinities of 8 to 15 ppt and, at  
40 temperatures around 27°C (81°F), hatch in 24 hours. At hatching, the YSL are about 1.8 to  
41 2.0 mm (0.07 to 0.08 in.) long. Within 24 hours of hatching, YSL consume the yolk sac and  
42 become PYSL. Fins begin to develop during the PYSL stage. Larvae are transparent and  
43 become darker as they develop into juveniles. PYSL eat copepod larvae and other small  
44 zooplankton.

1 Larvae metamorphose to juveniles at about a length of 16 mm (0.63 in.). Juveniles and adults  
2 travel and hunt in large schools. Juveniles acquire adult characteristics at about 60 mm (2.4 in.)  
3 in length and gain a silvery lateral band. Adults have a relatively high tolerance to fluctuations in  
4 both river temperature and salinity, and there is evidence in the Hudson River that early-stage  
5 anchovies migrate up-estuary at a rate of 0.6 km/day (0.4 mi/day) and are capable of periodic  
6 vertical migration (Schultz et al. 2006). Adult and juvenile bay anchovy feed primarily on mysid  
7 shrimp, copepods, other small crustaceans, small mollusks, other plankton, and larval fish  
8 (Hartman et al. 2004). Important predators include birds, bluefish (*P. saltatrix*), weakfish (*C.*  
9 *regalis*), summer flounder (*Paralichthys dentatus*), and striped bass (*M. saxatilis*) (CHGEC  
10 1999). The population trend in the Hudson River appears to show a population decline,  
11 although exact population counts are not available (Tipton 2003). Tipton (2003) also speculates  
12 that the reduction in bay anchovy may be linked to increased predation and overall populations  
13 of striped bass, bluefish, or other important commercial fish. Fishery statistics are not available  
14 for this species from National Marine Fisheries Service (NMFS) because of the lack of  
15 commercial and recreational fishing. The Mid-Atlantic Fishery Management Council has not  
16 identified bay anchovy as a managed species. Bay anchovy were present in impingement  
17 samples, and represented a sizable portion in entrainment samples obtained from IP2 and IP3  
18 during 1981, and 1983-1987.

#### 19 Blueback Herring

20 The blueback herring (*Alosa aestivalis*, family Clupeidae) is an anadromous species found in  
21 riverine and estuarine waters along the Atlantic coast ranging from Nova Scotia to St. Johns  
22 River, Florida. As noted in the life history of the alewife (*A. pseudoharengus*), commercial  
23 fisheries do not differentiate between the blueback herring (*A. aestivalis*) and alewife, and the  
24 two species are collectively referred to as river herring. River herring are harvested for fish  
25 meal, fish oil, and protein for animal food industries (Fay et al. 1983). Commercial landings of  
26 river herrings peaked in the 1950s at approximately 34,000 MT (37,000 t) and then declined to  
27 less than 4000 MT (4400 t) in the 1970s. Between 1996 and 2005, landings of river herring  
28 ranged from 300 to 900 MT (330 to 990 t) annually, with the majority of the landings in Maine,  
29 North Carolina, and Virginia (Haas-Castro 2006a). The river herring fishery is one of the oldest  
30 fisheries in the United States; however, no commercial fisheries for river herring exist in the  
31 Hudson River today. River herring are often taken as bycatch in the offshore mackerel fishery.  
32 Within New York and New Jersey, river herring accounted for 0.3 percent of annual landings on  
33 the Atlantic coast (CHGEC 1999).

34 Blueback herring spawn once per year between late May and mid-July in the main channels of  
35 estuaries or relatively deep freshwater with swift currents on sand or gravel substrate at  
36 temperatures between 14°C (57°F) and 27°C (81°F) (Everly and Boreman 1999; Fay et al.  
37 1983). Female egg production varies greatly, ranging from 46,000 to 350,000 eggs per female  
38 (Fay et al. 1983), and incubation time is approximately 6 days (Bigelow and Schroeder 1953).  
39 Blueback herring spawn 3 to 4 weeks after alewives in areas where the two species occur  
40 sympatrically, and the peak spawning of each species occurs 2 to 3 weeks apart from one  
41 another (Fay et al. 1983). In the Hudson, blueback herring spawn most commonly within the  
42 Mohawk River and upper Hudson River (CHGEC 1999). The YSL stage exists 2 to 3 days  
43 before yolk-sac absorption, and the PYSL stage lasts until larvae reach approximately 20 mm  
44 (0.79 in.), with full development occurring at 45 mm (1.8 in.) (Fay et al. 1983). Eggs, YSL,  
45 PYSL, and YOY are generally found between Poughkeepsie and Albany (Table 2-5). Juvenile

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1 blueback herring assume adult characteristics within a month of hatching, at which point growth  
2 slows. Peak abundance of juveniles occurs during late June within the upper estuary (CHGEC  
3 1999) (Table 2-5). Migration downriver to the Atlantic Ocean occurs in October, which is  
4 generally later than peak migration for both the American shad and the alewife within the  
5 Hudson River estuary (Fay et al. 1983). Some blueback herring do not migrate and tend to stay  
6 within the lower reaches of the estuary during their first 1 to 2 years (CHGEC 1999). Average  
7 length for males is 23 cm (9.1 in.) and for females is 26 cm (10 in.) (Collette and Klein-  
8 MacPhee 2002).

9 Adult blueback herring feed mainly on copepods but also eat amphipods, shrimp, fish eggs,  
10 crustacean eggs, insects, and insect eggs. The diet of blueback herring in the lower Hudson  
11 River consists primarily of chironomid larvae and copepods. As described for the alewife,  
12 blueback herring is an important link in the estuarine food web between zooplankton and top  
13 piscivores. The blueback herring is prey for gulls, terns, and other coastal birds, as well as for  
14 bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), and striped bass (*Morone*  
15 *saxatilis*) (CHGEC 1999).

16 Annual abundance of blueback herring YOY in the Hudson River estuary has been estimated to  
17 range from 1.2 million to 50.1 million individuals from sampling conducted with a Tucker trawl  
18 since 1979 (CHGEC 1999). According to CHGEC (1999), entrainment mortality for the  
19 combined abundance of blueback herring and alewife for all water withdrawal locations within  
20 the Hudson River varies widely, ranging from 8 to 41 percent in data taken between 1974 and  
21 1997, while impingement mortality of the two species was low, ranging from 0.2 to 0.7 percent  
22 for the same time period. Blueback herring were present in both impingement and entrainment  
23 samples obtained from IP2 and IP3.

## 24 Bluefish

25 The bluefish (*Pomatomus saltatrix*, family Pomatomidae) is a migratory, pelagic species that  
26 occurs in temperate and tropical waters worldwide on the continental shelf and in estuaries.  
27 Along the Atlantic coast, the bluefish ranges from Nova Scotia to the Gulf of Mexico (Pottern et  
28 al. 1989). Bluefish are a highly sought-after sport fish along the North Atlantic Coast, and State  
29 and Federal regulations on the commercial catch of the species began in the early 1970s  
30 (CHGEC 1999; Pottern et al. 1989). The majority of the Atlantic coast bluefish catch occurs  
31 between New York and Virginia, and recreational fishing has accounted for 80 to 90 percent of  
32 the total bluefish catch in the past, with a peak in 1981 and 1985 of over 43,000 MT (47,000 t).  
33 Landings have since decreased, reaching a low of 3300 MT (3600 t) in 1999; landings in 2005  
34 totaled 3500 MT (3300 t) (Shepherd 2006a). The bluefish is also harvested commercially for  
35 human consumption, and during peak years in 1981 to 1983, average annual landings were  
36 7.4 million kg (16.3 million lb), accounting for 0.5 percent of the total Atlantic coast commercial  
37 finfish and shellfish landings (Pottern et al. 1989).

38 North American bluefish populations range from New England to Cape Hatteras, North Carolina,  
39 in the summer, and migrate to Florida and the Gulf Stream during the winter. Fisheries data  
40 also indicate the existence of small nonmigratory populations in southern Florida waters and the  
41 Gulf of Mexico (Pottern et al. 1989). Bluefish are generally not found in waters colder than 14 to  
42 16°C (57.2 to 60.8°F) and exhibit signs of stress at temperatures below 11.8°C (53.2°F) and  
43 above 30.4°C (86.7°F) (Collette and Klein-MacPhee 2002).



1 Generally, bluefish have two major spawnings per year. The first spawning occurs during the  
2 spring migration as bluefish move northward to the South Atlantic Bight between April and May;  
3 the second spawning occurs in the summer in offshore waters of the Middle Atlantic Bight  
4 between June and August. Two distinct cohorts of juvenile bluefish in the fall result from the two  
5 spawning events, which mix during the year creating a single genetic pool (Shepherd 2006a).  
6 Females can produce 600,000 to 1.4 million eggs (CHGEC 1999). Larvae hatch in 46 to  
7 48 hours at temperatures of 18 to 22°C (64.4 to 71.6°F) (Collette and Klein-MacPhee 2002).  
8 Newly hatched larvae are pelagic and stay in offshore waters for the first 1 to 2 months of life  
9 before migrating shoreward to shallower waters (CHGEC 1999). Beach seine survey results  
10 indicate YOY bluefish are generally found between Yonkers and Croton-Haverstraw (Table 2-5).  
11 YSL typically consume the yolk sac by the time they reach 3 to 4 mm (0.12 to 0.16 in.) in length  
12 (Pottern et al. 1989). Bluefish larvae grow rapidly; spring-spawned juveniles reach lengths of 25  
13 to 50 mm (0.99 to 2 in.) once they move to mid-Atlantic bays in the summer, grow to lengths of  
14 175 to 200 mm (6.9 to 7.9 in.) by late September when migration begins, and reach lengths of  
15 about 260 mm (10.2 in.) by the following spring. Summer-spawned juveniles exhibit slower  
16 growth because they are unable to inhabit bays and estuaries until after their first migration,  
17 though summer-spawned juvenile growth rates exceed those of spring-spawned juveniles  
18 during the second year, at which point differences between the two stocks are less pronounced  
19 (Pottern et al. 1989). Adult bluefish can live up to 12 years and reach weights of 14 kg (31 lb)  
20 and lengths of 100 cm (39 in.) (Shepherd 2006a).

21 Bluefish are avid predators, and the Atlantic coast population is estimated to consume eight  
22 times its biomass in prey annually. Larvae feed on zooplankton and larvae of other pelagic-  
23 spawning fish (Pottern et al. 1989). In the Hudson River estuary, YOY feed on bay anchovy  
24 (*A. mitchilli*), Atlantic silverside (*M. menidia*), striped bass (*M. saxatilis*), blueback herring  
25 (*A. aestivalis*), Atlantic tomcod (*M. tomcod*), and American shad (*A. sapidissima*) (CHGEC  
26 1999; Juanes et al. 1993). Adult bluefish diets are dominated by squids, clupeids, and  
27 butterfish. YOY bluefish are prey for birds including Atlantic puffin (*Fratercula arctica arctica*),  
28 Arctic tern (*Sterna paradioaea*), and roseate tern (*Sterna dougalli dougalli*) (Collette and Klein-  
29 MacPhee 2002). Sharks also prey on bluefish; species include the bigeye thresher (*Alopias*  
30 *supercilius*), white shark (*Carcharodon carcharias*), shortfin mako (*Isurus oxyrinchus*), longfin  
31 mako (*I. paucus*), tiger shark (*Galeocerdo cuvier*), blue shark (*Prionace glauca*), sandbar shark  
32 (*Carcharhinus plumbeus*), smooth dogfish (*Mustelus canis*), spiny dogfish (*Squalus acanthias*),  
33 and angel shark (*Squatina* spp.) (Collette and Klein-MacPhee 2002).

34 The bluefish population data from the Hudson River estuary show a declining trend since the  
35 population peaked in 1981 and 1982 (CHGEC 1999). Bluefish populations along the east coast  
36 have historically fluctuated widely, though analysis by the National Marine Fisheries Service  
37 (NMFS) of data between 1974 and 1986 did not find evidence of a systematic decline of the  
38 species (CHGEC 1999). According to CHGEC (1999), bluefish have not been found in  
39 entrainment samples from power plants along the Hudson River, which include Roseton Units 1  
40 and 2, IP2 and IP3, or Bowline Point Units 1 and 2 (CHGEC 1999). CHGEC (1999) also stated  
41 that juvenile bluefish may be impinged, but the numbers are estimated to be relatively small.  
42 Electronic data obtained from Entergy (Entergy 2007b) showed that bluefish eggs and larvae  
43 were infrequently observed in entrainment samples, but were common in impingement samples  
44 from IP2 and IP3 (NL-09-160).

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### 1 Gizzard Shad

2 The gizzard shad (*Dorosoma cepedianum*, family Clupeidae) is a pelagic herring species that is  
3 found in the waters of the Atlantic and Gulf coastal plains streams as well as in freshwater lakes  
4 and reservoirs ranging from New York to Mexico (MDNR 2007a). Gizzard shad are found  
5 mainly in freshwater rivers, reservoirs, lakes, and swamps, and in slightly brackish waters of  
6 estuaries and bays (Froese and Pauly 2007b). The gizzard shad is a relatively recent immigrant  
7 to the Hudson River estuary, though it is now considered a permanent resident, and the species  
8 is continuing to expand its range throughout the northeastern United States (CHGEC 1999;  
9 Levinton and Waldman 2006). No commercial or sport fishery for gizzard shad exists on the  
10 Hudson River (CHGEC 1999). Larvae have been observed in the tidal waters of the Hudson  
11 River since 1989 (Levinton and Waldman 2006). A spawning population is believed to exist in  
12 the Mohawk River, but no spawning has been observed in the Hudson River (CHGEC 1999).

13 Adult gizzard shad grow to 23 to 36 cm (9 to 14 in.) in length with an average weight of 907 g  
14 (2 lb) and an average life span of 7 years in northern populations (CHGEC 1999; Morris 2001).  
15 Both males and females mature between 2 and 3 years of age, and females spawn between  
16 April and June in shallow waters between 10 and 21°C (50 and 70°F) (CHGEC 1999; MDNR  
17 2007a). Fecundity is thought to be highly variable but does appear to increase with size of the  
18 female (CHGEC 1999). Females can produce between 50,000 and 379,000 eggs (MDNR  
19 2007a). Eggs hatch in 1.5 to 7 days, depending on water temperature (CHGEC 1999). YSL  
20 transform into PYSL within 5 days of hatching and begin to feed on microzooplankton until they  
21 reach 2.5 cm (1 in.) in length. At this point, development of the digestive system supports a diet  
22 including plant material; juveniles eat a variety of daphnids, cladocerans, adult copepod, rotifers,  
23 algae, phytoplankton, and detritus (CHGEC 1999). Gizzard shad grow rapidly during the first 5  
24 to 6 weeks of life, at which point growth slows; individuals reach a length of 10 to 25 cm (4 to  
25 10 in.) by their first summer (CHGEC 1999). Adults are filter feeders, eating a variety of  
26 phytoplankton and zooplankton. Larvae are not an important prey species because of their  
27 size, but age 0 gizzard shad are consumed by a number of species including striped bass,  
28 largemouth bass (*Micropterus salmoides*), white crappie (*Pomoxis annularis*), black crappie  
29 (*Pomoxis nigromaculatus*), white bass (*Morone chrysops*), and spotted bass (*Micropterus*  
30 *punctulatus*) (CHGEC 1999). Predators of adult gizzard shad include catfish (order  
31 Siluriformes) and striped bass (*M. saxatilis*) (Morris 2001).

32 | Abundance data are not available for the gizzard shad from the Hudson River sampling  
33 programs because of the low capture rate of the species in these programs (CHGEC 1999).  
34 Beach seine surveys from 1974 to 2005 suggest YOY and older gizzard shad occur primarily  
35 from Cornwall north to Albany (Table 2-5). Impingement data are available at three power  
36 stations along the Hudson River (Danskammer, Roseton Units 1 and 2, and the now-shuttered  
37 Lovett Generating Station) and indicate year-to-year fluctuations with a general trend of  
38 increasing impingement and peak adult impingement during the winter months. According to  
39 | CHGEC (1999), entrainment of early life stages is thought to be low, and small gizzard shad are  
40 rare in utility ichthyoplankton surveys. Gizzard shad eggs and larvae were not observed in  
41 entrainment samples from IP2 and IP3 during evaluations in 1981 and 1983-1987, but were  
42 commonly observed in impingement samples.

1 Hogchoker

2 The hogchoker (*Trinectes maculatus*, family Soleidae) is a right-eyed flatfish species found  
3 along the Atlantic coast in bays and estuaries from Maine to Panama (Dovel et al. 1969). The  
4 hogchoker is common in the Hudson River estuary and surrounding bays and coastal waters,  
5 and abundance indices from the annual Fall Juvenile Survey (also known as the Fall Shoals  
6 Survey) channel sampling in the Hudson River from 1974 to 1997 indicate that the hogchoker  
7 population has remained relatively stable with a nonsignificant 1 percent increase per year  
8 (CHGEC 1999). Because of its small size (adults range from 6 to 15 cm (2.4 to 5.9 in.) with a  
9 maximum size of 20 cm (7.9 in.)), the hogchoker is not commercially harvested in any area  
10 within its geographic range (Collette and Klein-MacPhee 2002). CHGEC (1999) indicates that  
11 hogchoker larvae are found mainly within deeper channel waters and are not often captured  
12 during the Longitudinal River Survey; low numbers of juveniles are captured during the Beach  
13 Seine and Fall Juvenile Surveys, and yearlings and adults are generally not exposed to Hudson  
14 River generating stations because they remain in the waters below RM 34 (CHGEC 1999).  
15 However, the Fall Juvenile Survey information reviewed by the NRC staff suggests that YOY  
16 and older hogchokers have been collected from Tappan Zee to Poughkeepsie—an area that  
17 includes IP2 and IP3 (Table 2-5).

18 The majority of hogchokers in the Hudson River reach sexual maturity at the age of 2 years,  
19 though some faster growing males have been observed to spawn at age 1 year (Koski 1978).  
20 Spawning occurs in estuaries between May and October in the Hudson River estuary, which is  
21 a 5-week longer spawning period than that of the Chesapeake Bay population (Collette and  
22 Klein-MacPhee 2002; Koski 1978). Spawning occurs in waters 20 to 25°C (68 to 77°F) and a  
23 salinity of 10 to 16 ppt (Collette and Klein-MacPhee 2002). Eggs are observed in greatest  
24 numbers from the last week in May through July in lower estuary waters. Egg production is  
25 positively correlated with size, and females can produce between 11,000 and 54,000 eggs.  
26 Within the Hudson River, eggs are most common between RM 12 and 24 (RKM 19 and 39).  
27 Eggs hatch in 24 to 36 hours at temperatures between 23.3 and 24.5°C (73.9 and 76.1°F).  
28 YSL absorb the yolk sac within 48 hours of hatching, and eye migration occurs within 34 days of  
29 hatching or at lengths of 0.2 to 0.4 in. (0.51 to 0.02 cm) (Collette and Klein-MacPhee 2002;  
30 CHGEC 1999). Larvae have been observed to congregate upstream in waters with lower  
31 salinity than their hatching ground (Dovel et al. 1969). Within the Hudson River, YSL are most  
32 abundant between RM 24 and 33 (RKM 39 and 53), and PYSL are most abundant from RM 24  
33 through RM 55 (RKM 39 and 89). Juveniles are found above RM 39 (RKM 63), while yearling  
34 and older individuals are found below RM 34 (RKM 55) (CHGEC 1999). Adult individuals  
35 inhabit nonvegetated waters with sandy or silty bottoms (Whiteside and Bonner 2007).

36 Adult hogchokers feed mainly on annelids, arthropods, and tellinid siphons (Derrick and  
37 Kennedy 1997). The species is a generalist and may also prey on midges, ostracods, aquatic  
38 insects, annelids, crustaceans, and foraminiferans (Whiteside and Bonner 2007). Larger striped  
39 bass (*M. saxatilis*) prey on yearling and older hogchokers within the Hudson River estuary,  
40 which may affect the abundance of those age groups (CHGEC 1999). The Northeast Fisheries  
41 Science Center also found the smooth dogfish (*Mustelus canis*) to be a predator of hogchoker  
42 (Roundtree 1999 as cited in Collette and Klein-MacPhee 2002). Hogchokers were observed in  
43 both impingement and entrainment samples from IP2 and IP3.

44

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### 1 Rainbow Smelt

2 Rainbow smelt (*Osmerus mordax*, family Osmeridae) is an anadromous species once found  
3 along the Atlantic coast from Labrador to the Delaware River, although the southern end of the  
4 range is now north of the Hudson River. NOAA (2007) lists rainbow smelt as a Species of  
5 Concern. Unless otherwise noted, information below comes from Buckley (1989).

6 Adult rainbow smelt along the east coast move into saltwater in summer, where they are found  
7 in waters less than 1 mi (1.6 km) from shore and usually no deeper than 6 m (20 ft). In spring,  
8 spawning adults typically move up the estuaries before ice breaks up to spawn above the head  
9 of tide in water temperatures of 4.0 to 9.0°C (39 to 48°F). They have been found to run up into  
10 coastal streams to spawn at night and then return to the estuary during the day. Females,  
11 depending on size, produce about 7,000 to 75,000 eggs (summarized in NOAA 2007a), which  
12 are from 1.0 to 1.2 mm (about 0.04 in.) in diameter. Eggs are typically deposited over gravel,  
13 and egg survival appears to be influenced by water flow, substrate type, and egg density.  
14 Exposure to salt or brackish water can cause egg mortality, as can sudden increases in  
15 temperature, diseases, parasites, contaminant exposure, and predation by other fish species.  
16 Incubation times can be 8 to 29 days and decrease with increasing water temperature.  
17 Common mummichog (*Fundulus heteroclitus*) and fourspine stickleback (*Apeltes quadracus*)  
18 are reported to be major predators of smelt eggs.

19 YSL are 5 to 6 mm (0.20 to 0.24 in.) long at hatching. The yolk sac is absorbed by the time the  
20 larvae reach 7 mm (0.28 in.) and enter the PYSL stage. The larvae initially concentrate near the  
21 surface and drift downstream. As they grow, they seek deeper water and congregate near the  
22 bottom. Vertical migration begins, and they move to the surface to feed during the day and  
23 deeper at night. The vertical migration patterns may maintain their position in two-layered  
24 estuarine systems. Larval and small juvenile smelt eat copepods and other small planktonic  
25 crustaceans as well as fish. In turn, larval and juvenile smelt are probably eaten by most  
26 estuarine piscivores.

27 Smelt grow fairly rapidly and begin to school when they reach a length of 19 mm (0.75 in.). As  
28 the smelt grow, they move down estuaries into higher salinity and, as adults, migrate to sea.  
29 They are mature and participate in spawning runs at age 1. Adults grow to average  
30 approximately 25.4 cm (10 in.) in length. Larger juveniles and adults feed on euphausiids,  
31 amphipods, polychaetes, and fish such as anchovies (family Engraulidae) and alewives (*A.*  
32 *pseudoharengus*). Adults also eat other fish species, including common mummichog, cunner  
33 (*Tautoglabrus adspersus*), and Atlantic silversides (*Menidia menidia*). Bluefish (*P. saltatrix*),  
34 striped bass (*M. saxatilis*), harbor seals (*Phoca vitulina*), and other large piscivores eat adult  
35 smelt.

36 Once a prevalent fish in the Hudson River, an abrupt smelt population decline in the Hudson  
37 River was observed from 1994 to , and the species may now have no viable population within  
38 the Hudson River. The last tributary run of rainbow smelt was recorded in 1988, and the  
39 Hudson River Utilities' Long River Ichthyoplankton Survey show that PYSL essentially  
40 disappeared from the river after 1995 (Daniels et al. 2005). When present, the largest  
41 abundances of eggs and YSL occurred from Poughkeepsie to the Catskills, and the largest  
42 abundances of PYSL, YOY, and older individuals were distributed from approximately Yonkers  
43 to Hyde Park (Table 2-5, Figure 2-6). Rainbow smelt runs in the coastal streams of western  
44 Connecticut declined at about the same time as in the Hudson River (Daniels et al. 2005).

1 Smelt landings in waters south of New England have dramatically decreased, although the  
2 reasons for this are unknown. Daniels et al. (2005) note slowly increasing water temperatures  
3 in the Hudson River and suggest that the disappearance of rainbow smelt from the Hudson  
4 River may be a result of global warming. Rainbow smelt were observed in both impingement  
5 and entrainment samples obtained from IP2 and IP3.

#### 6 Spottail Shiner

7 The spottail shiner (*Notropis hudsonius*, family Cyprinidae) is a freshwater species which occurs  
8 across much of Canada, south to the Missouri River drainage, and in Atlantic States from New  
9 Hampshire to Georgia, with habitat ranging from small streams to large rivers and lakes,  
10 including Lake Erie (Smith 1985a). One of the most abundant fishes in the Hudson River,  
11 spottail shiners are commonly 3.9 in. (100 mm) in length, which is large for shiner species  
12 (Smith 1985a). The maximum length is approximately 5.8 in. (147 mm) (Schmidt and Lake  
13 2006; Smith 1985a; Marcy et al. 2005a).

14 Spottail shiners spawn from May to June or July (typically later for the northern populations)  
15 over sandy bottoms and stream mouths (Smith 1985a; Marcy et al. 2005a); water chestnut  
16 (*Trapa natans*) beds provide important spawning habitat (CHGEC 1999). Individuals older than  
17 3 years are seldom found, but there is evidence of individuals living up to 4 or 5 years (Marcy et  
18 al. 2005a). Fecundity is a factor of age: the ovaries of younger females contain 1400 eggs, and  
19 ovaries of older females contain from 1300 to 2600 eggs; a correlation between fecundity and  
20 size does not appear to exist (Marcy et al. 2005a). In the Hudson River Estuary, beach seine  
21 survey data from 1974 to 2005 showed the largest abundances of YOY and Year 1+ individuals  
22 occurred from Poughkeepsie north to Albany (Table 2-5).

23 Spottail shiners are opportunistic feeders, typically eating insects, bivalve mollusks, and  
24 microcrustaceans throughout the water column (Marcy et al. 2005a). Aggregations of spottail  
25 shiners have been observed preying on eggs of alewives (*Alosa pseudoharengus*) and mayflies  
26 (Marcy et al. 2005a). Striped bass (*M. saxatilis*) larvae are also prey for spottail shiners  
27 (McGovern and Olney 1988), as are spottail eggs and larvae (Smith 1985a). Spottail shiners  
28 are frequently used as bait (Smith 1985a), and they are an important prey species for some fish,  
29 including walleye (*Sander vitreus*), channel catfish (*I. punctatus*), northern pike (*Esox lucius*),  
30 and smallmouth bass (*Micropterus dolomieu*) (IDFG 1985). The Hudson River population of  
31 spottail shiners is known to be susceptible to impingement and entrainment at water intakes,  
32 and this could be affecting the survivorship of most life stages (CHGEC 1999). Eggs and larval  
33 forms of spottail shiner were infrequently observed in entrainment samples from IP2 and IP3,  
34 but were commonly impinged.

#### 35 Striped Bass

36 The striped bass (*Morone saxatilis*, family Moronidae) is an anadromous species, with a range  
37 extending from St. Johns River, Florida, to St. Lawrence River, Canada (ASMFC 2006b).  
38 Individual stocks of striped bass spawn in rivers and estuaries from Maine to North Carolina.  
39 When adults leave the estuaries to go to the Atlantic, the stocks mix; striped bass return to their  
40 natal rivers and estuaries to spawn. The Atlantic coast striped bass fishery has been one of the  
41 most important commercial fisheries on the east coast for centuries and has been regulated  
42 since European settlement in North America (ASMFC 2006b). In 1982, overfishing depleted the  
43 striped bass population to fewer than 5 million fish. Since that time, the Atlantic coast  
44 population has been restored to 65 million in 2005 (ASMFC 2006b). Striped bass have been

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1 important in both commercial and recreational fisheries, and while the majority of the stock  
2 spawns in the Chesapeake Bay, the Hudson River contributes to the stock as well. Fabrizio  
3 (1987) reported that of the age 2–5 individuals sampled from the Rhode Island commercial trap-  
4 net fishery in November 1982, 54 percent were from the Chesapeake Bay stock and 46 percent  
5 were from the Hudson River stock. Wirgin et al. (1993) estimated that the Chesapeake Bay and  
6 Hudson River stocks combined contributed up to 87 percent of the mixed fishery stock on the  
7 Atlantic coast.

8 The striped bass is a long-lived species, reaching 30 years of age, and spends the majority of  
9 its life in coastal estuaries and the ocean. Females reach maturity between 6 and 9 years, and  
10 then produce between 0.5 million and 3 million eggs per year, which are released into riverine  
11 spawning areas (ASMFC 2006b). The males, reaching maturity between 2 and 3 years, fertilize  
12 the eggs as they drift downstream (ASMFC 2006b). The eggs hatch into larvae, which absorb  
13 their yolk and then feed on microscopic organisms. PYSL mature into juveniles in the nursery  
14 areas, such as river deltas and inland portions of coastal sounds and estuaries, where they  
15 remain for 2 to 4 years, before joining the coastal migratory population in the Atlantic (ASMFC  
16 2006b). Recent field investigations by Dunning et al. (2006b) have suggested that dispersal of  
17 age 2+ striped bass out of the Hudson River may be influenced by cohort abundance. In the  
18 spring or summer, adults migrate northward from the mouth of their spawning rivers up the  
19 Atlantic coast, and in the fall or winter they return south, in time to spawn in their natal rivers  
20 (Berggren and Lieberman 1978; ASMFC 2006b). Work by Wingate and Secor (2007), using  
21 remote biotelemetry on a total of 12 fish, suggested that specific homing patterns are possible  
22 for this species, and these patterns may influence their susceptibility to localized natural and  
23 anthropogenic stressors. Based on long-term monitoring data, various life-stages associated  
24 with this species are found in the Hudson River from Tappan Zee to Albany (Table 2-5).

25 Several factors play a role in spawning, including water temperature, salinity, total dissolved  
26 solids concentration, and water velocity and flow. Peak spawning occurs in water temperatures  
27 of 15 to 20°C (59 to 68°F) but can occur between 10 and 23°C (50 and 73°F) (Shepherd  
28 2006b). Striped bass reach 150 cm (59 in.) in length and 25 to 35 kg (55 to 77 lb) in weight  
29 (Shepherd 2006b). Adult striped bass are omnivores and prey on invertebrates and fish,  
30 especially clupeids, including menhaden (*B. tyrannus*) and river herring (*Alosa* spp.) (Shepherd  
31 2006b). Diets vary by season and location, typically including whatever species are available  
32 (Bigelow and Schroeder 1953). YOY striped bass diet is made up of fish and mysid shrimp  
33 (Walter et al. 2003).

34 Compared to other anadromous species, striped bass appear to spend extended periods in the  
35 Hudson River, contributing to their PCB body burdens. In 1976, the Hudson River commercial  
36 fishery was closed because of PCB contamination, although shad fishermen continue to catch  
37 striped bass in their nets (CHGEC 1999). Commercial restrictions on harvesting the Atlantic  
38 coastal fishery, in part supported by the Atlantic Striped Bass Conservation Act of 1984  
39 (16 U.S.C. 5151–5158), which allows coastal States to cooperatively regulate and manage the  
40 stock, have led to the declaration of full recovery of the population in 1995 (ASMFC 2006b).  
41 Abundance levels have continued to increase in the Atlantic population. Restrictions on both  
42 commercial and recreational fisheries have been relaxed because of the recovery of the  
43 population (ASMFC 2006b), but the fisheries continue to be limited to State waters (within  
44 3 nautical miles of land), and New York State's commercial fishery remains completely closed.  
45 While commercial landings have remained lower than the levels seen in the early 1970s,

1 recreational landings have increased, and in 2004 made up 72 percent of the total weight  
2 harvested from the Atlantic stock (Shepherd 2006b). Recreational fishing in the Hudson River  
3 during the spring generally occurs north of the Bear Mountain Bridge (RKM 75 (RM 46)) (Euston  
4 et al. 2006). Striped bass were commonly found in entrainment and impingement samples  
5 obtained from IP2 and IP3.

#### 6 Weakfish

7 The weakfish (*Cynoscion regalis*, family Sciaenidae) is a demersal species found along the  
8 Atlantic coast ranging from Massachusetts Bay to southern Florida and is occasionally found as  
9 far north as Nova Scotia and as far south as the eastern Gulf of Mexico (Mercer 1989). The  
10 weakfish is one of the most abundant fish species along the Atlantic coast and is fished  
11 recreationally as well as commercially via gill-net, pound-net, haulseine, and trawl (Mercer  
12 1989). ASMFC considers weakfish to be composed of one stock based on genetic analysis;  
13 however, more recent tagging studies have indicated that weakfish may return to their natal  
14 estuary to spawn (ASMFC 2006c). The stock as a whole is thought to be declining as  
15 evidenced by decreased landings in recent years. Landings peaked in 1981 and 1982 at  
16 12,500 MT (13,800 t), declined from 1989 through 1993, peaked again in 1998 at over 5000 MT  
17 (5500 t), and then declined from 1999 through 2004, at which point a record low of less than  
18 1000 MT (1100 t) was reported (ASMFC 2006c). Entrainment of eggs and larvae at power  
19 plants within the Hudson River is not common because weakfish spawn in waters with higher  
20 salinity, though movement of juveniles into the Hudson River estuary during late winter and  
21 early spring results in some entrainment of young juveniles and impingement of larger juveniles  
22 (CHGEC 1999).

23 Weakfish are found at a depth range of 10 to 26 m (33 to 85 ft) and temperatures between  
24 17 and 27°C (63 and 81°F) (Froese and Pauly 2007c). Adults favor shallow coastal waters with  
25 sandy substrate and a salinity of 10 ppt or higher, though they are found in a variety of estuarine  
26 environments (CHGEC 1999). Adult weakfish vary greatly in size, ranging from 6 to 31 in. (15  
27 to 79 cm) in length, with a maximum weight of 20 lb (9.1 kg), and can live up to 11 years  
28 (CHGEC 1999). Most weakfish mature at the age of 2 during the late summer months, and  
29 almost all weakfish are mature by the end of their third summer (CHGEC 1999). Size at  
30 maturity varies with latitude: in northern populations, females have been observed to mature at  
31 256 mm (10.1 in.) and males at 251 mm (9.9 in.), while in North Carolina populations, females  
32 have been observed to spawn at 230 mm (9.1 in.) and males at 180 mm (7.1 in.) (Mercer 1989).  
33 Weakfish migrate southward in the fall to the coastal waters of North Carolina and Virginia and  
34 then move northward in the spring to spawn (ASMFC 2006c).

35 Spawning takes place along the northeastern coast of the Atlantic between the Chesapeake  
36 Bay and Montauk, Long Island, New York, in nearshore coastal and estuarine waters during the  
37 spring and summer (CHGEC 1999). Within the New York Bight, two spawning peaks occur in  
38 mid-May, consisting of larger individuals that migrate northward earlier, and in June, consisting  
39 of smaller individuals (Mercer 1989). Fecundity estimates vary widely, though fecundity can be  
40 generally correlated with size and geographic area (from 4593 eggs for a 203-mm (8-in.) female  
41 to 4,969,940 eggs for a 569-mm (22.4-in.) female and from 306,159 eggs for a northern female  
42 to 2,051,080 eggs for a similarly sized female in North Carolina) (Collette and Klein-MacPhee  
43 2002). Eggs can tolerate a temperature range of 12 to 31.5°C (53.6 to 88.7°F) and a salinity  
44 range of 10 to 33 ppt (Collette and Klein-MacPhee 2002). Larvae hatch within 36 to 40 hours at  
45 temperatures of 20 to 21°C (68 to 69.8°F) (Mercer 1989). Larvae move into bays and estuaries

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1 after hatching; in the Hudson River estuary, larvae are rarely observed north of the George  
2 Washington Bridge because of the lower salinity of these waters (CHGEC 1999). Larvae feed  
3 primarily on cyclopoid copepods, as well as calanoid copepods, tintinnids, and polychaete  
4 larvae (Collette and Klein-MacPhee 2002). Weakfish juveniles grow rapidly during their first  
5 year and reach lengths of 7.6 to 15.2 cm (3 to 6 in.) by the end of the summer (CHGEC 1999).  
6 Juveniles are typically distributed from Long Island to North Carolina in late summer and fall in  
7 waters of slightly higher salinity, sand or sand-grass substrates, and depths of 9 to 26 m (30 to  
8 85 ft) (Mercer 1989). Juveniles are considered adults at approximately 30 mm (1.2 in.) (Collette  
9 and Klein-MacPhee 2002).

10 Adult weakfish feed on a variety of organisms, and their diet varies with locality and availability  
11 of food sources. Smaller weakfish (less than 20 cm (7.9 in.)) feed primarily on crustaceans,  
12 while larger weakfish feed primarily on anchovies, herrings, spot, and other fish (CHGEC 1999;  
13 Mercer 1989). Adult weakfish of all sizes also prey on decapod shrimps, squids, mollusks, and  
14 annelid worms (CHGEC 1999; Mercer 1989). Bluefish (*P. saltatrix*), striped bass (*M. saxatilis*),  
15 and older weakfish prey on younger weakfish, while weakfish of larger size are preyed on by  
16 dusky sharks (*Carcharhinus obscurus*), spiny dogfish (*Squalus acanthias*), smooth dogfish  
17 (*Mustelus canis*), clearnose skate (*Raja eglanteria*), angel sharks (*Squatina* spp.), goosefish  
18 (family Lophiidae), and summer flounder (*Paralichthys dentatus*) (Collette and Klein-MacPhee  
19 2002).

20 YOY and older weakfish are generally found from Yonkers to West Point (Table 2-5). Weakfish  
21 abundance fluctuated from 1979 to 1990, and abundance was relatively low between 1990 and  
22 1997; overall, abundance declined 6 percent between 1979 and 1997 (CHGEC 1999). The  
23 weakfish stock as a whole declined suddenly in 1999 and approached even lower levels by  
24 2003, which ASMFC determined to be the result of higher natural mortality rates rather than the  
25 result of fishing mortality (ASMFC 2007b). A leading hypothesis suggests that insufficient prey  
26 species and increased predation by striped bass may contribute significantly to rising natural  
27 mortality rates in the weakfish population (ASMFC 2007b). Weakfish were commonly found in  
28 both impingement and entrainment samples obtained from IP2 and IP3.

### 29 White Catfish

30 The white catfish (*Ictalurus catus*, family Ictaluridae) is a demersal species found in estuarine  
31 and freshwater habitats along the Atlantic coast from the lower Hudson River to Florida, though  
32 it has been introduced in other areas, including Ohio and California (Smith 1985b). The natural  
33 distribution of the species is thought to be in coastal streams from the Chesapeake Bay to  
34 Texas; limited recreational fishing for this species occurs in the Hudson River (CHGEC 1999).  
35 White catfish are the least common species of catfish in New York waters (NYSDEC 2008a).  
36 The New York State Department of Health has issued a fish advisory for the species because of  
37 the potential for elevated levels of PCBs (NYSDOH 2007). Additionally, the New Jersey  
38 Department of Environmental Protection (NJDEP) has issued a health advisory for the white  
39 catfish downstream of the New York-New Jersey border, which includes portions of the Hudson  
40 River and Upper New York Bay (NJDEP and NJDHSS 2006).

41 The white catfish is of intermediate size compared with other species in the family; adults grow  
42 to lengths of 8.3 to 24 in. (21 to 62 cm) and reach weights of 0.6 to 2.2 lb (0.25 to 1.0 kg) (Marcy  
43 et al. 2005b). The species has been reported to live 11 or more years as evidenced by  
44 individuals observed in South Carolina (Marcy et al. 2005b). White catfish prefer fresh or



1 brackish water and, in the upper Hudson River, are most commonly found in channel borders,  
2 shoals, and vegetated backwaters (Marcy et al. 2005b). Though the white catfish is more salt  
3 tolerant than most catfish species, it is not typically found in waters with salinities above 8 ppt  
4 (CHGEC 1999; NJDEP 2005). Fall Juvenile Survey data from 1979 to 2004 suggests that YOY  
5 and older individuals were generally found from the Saugerties to Albany segments of the  
6 Hudson River (Figure 2-10, Table 2-5).

7 White catfish are sexually mature between 3 to 4 years of age at the size of 7 to 8 in. (18 to  
8 20 cm). Adults move upstream for spawning between late June and early July when Hudson  
9 River water temperatures reach approximately 70°F (21°C) (CHGEC 1999). Before spawning,  
10 both males and females construct nests on sand or gravel bars, and males protect the nest  
11 once females lay eggs. Females that are 11 to 12 in. (28 to 30 cm) can lay 3200 to 3500 eggs.  
12 Eggs hatch in 6 to 7 days at temperatures between 75 to 85°F (24 to 29°C) (CHGEC 1999;  
13 Smith 1985b). Males continue to protect young until the juveniles form large schools and  
14 disperse from the nest (MDNR 2007b). YOY migrate downstream to deeper waters in  
15 September and October, and generally, yearling and older white catfish move out of the upper  
16 Hudson River estuary once the water temperatures drop below 59°F (15°C) to overwinter in the  
17 lower estuary. (Smith 1985b, CHGEC 1999).

18 White catfish have an especially varied diet. Adults collected from the North Newport River in  
19 Georgia were found to consume over 50 different species of prey (Marcy et al. 2005b).  
20 Juveniles and smaller adults feed primarily on midge larvae and macroinvertebrates, while  
21 larger adults have a more diverse diet, which may consist of midge larvae, crustaceans, algae,  
22 fish eggs, and a number of fish species, including herring (*Clupea* spp.), menhaden (*Brevoortia*  
23 spp.), gizzard shad (*Dorosoma cepedianum*), and bluegills (*Lepomis macrochirus*) (CHGEC  
24 1999; Smith 1985b). Amphipods are widely consumed by adult catfish and make up a large  
25 percentage (up to 80 percent) of the volume of food eaten (CHGEC 1999).

26 The white catfish population is considered stable throughout the majority of its range, though the  
27 Hudson River population appears to have been in decline since 1975 (CHGEC 1999). The  
28 decline may partially be a result of food-limited growth and survival of larvae and YOY as a  
29 result of resource depletion by PYSL and YOY striped bass (*Morone saxatilis*) (CHGEC 1999).  
30 According to CHGEC (1999), early life stages of this species are generally not at risk of  
31 entrainment because spawning and early development occurs upstream near nests, which adult  
32 white catfish guard. CHGEC (1999) also states that juvenile and adult white catfish are  
33 infrequently impinged; the species has been recorded to consist of 0.42 percent of total fish  
34 impinged at IP2 and IP3. White catfish were not commonly observed in entrainment samples  
35 but were common in impingement samples obtained from IP2 and IP3.

### 36 White Perch

37 White perch (*Morone americana*) is endemic to the North American eastern coastal areas and  
38 range from Nova Scotia to South Carolina. It is not actually a perch, but a member of the  
39 temperate bass family Percichthyidae, along with striped bass (*M. saxatilis*). White perch are  
40 year-round residents in the Hudson River between New York City and the Troy Dam near  
41 Albany. They have never been a recreationally or commercially important resource for the  
42 Hudson River, and commercial fishing was closed in 1976 because of PCB contamination, but  
43 they are well represented in impingement collections of Hudson River power plants. In other  
44 parts of its range, white perch is intensively fished (Klauda et al. 1988).

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1 Spawning habitats vary and can be clear or turbid, fast or slow, in water less than 7 m (23 ft)  
2 deep (Stanley and Danie 1983). In the Hudson River, most spawning occurs in the upper  
3 reaches (RKM 138 to 198 (RM 86 to 123)) in shallow embayments and tidal creeks, and adults  
4 move offshore and downriver after spawning (Klauda et al. 1988). Spawning in the Hudson  
5 River begins in late April when water temperatures reach 10 to 12°C (50 to 54°F) and can  
6 continue until late May or early June when temperatures reach 16 to 20°C (61 to 68°F) (Klauda  
7 et al. 1988). Fecundity depends on age and size of the females and ranges from about 5,000 to  
8 over 300,000 eggs (Stanley and Danie 1983). The eggs are adhesive and sink and may stick to  
9 the substrate or each other.

10 Hatching takes place between 1 and 6 days following fertilization, and the incubation period is  
11 inversely related to water temperature but relatively unaffected by salinity and silt levels  
12 (Collette and Klein-MacPhee 2002; Stanley and Danie 1983). Newly hatched YSL are about  
13 2 mm (0.08 in.) long, and after 5 to 6 days, the yolk sac is absorbed (Collette and Klein-  
14 MacPhee 2002). The YSL generally remain in the same area where they hatched for 4 to  
15 13 days (Stanley and Danie 1983). PYSL eat zooplankton and grow rapidly. Juveniles eat  
16 larger zooplankton. In the spring as water temperature rises, adults, which can reach maximum  
17 lengths of 495 mm (19.5 in.), begin their spawning migration and start to move upstream into  
18 shallower, fresher waters and into tidal streams.

19 Juveniles tend to stay in inshore areas of the estuary and in creeks until they are about a year  
20 old and 20 to 30 cm (8 to 12 in.) in length and then tend to move downstream to brackish areas  
21 (Stanley and Danie 1983). Although they may move offshore during the day, they tend to return  
22 to shoal areas at night. Most males and females mature at 2 years. After spawning, they return  
23 to deeper waters. In summer, large schools of white perch tend to move slowly without  
24 direction, and they tend not to travel very far. (Stanley and Danie 1983)

25 White perch are opportunistic feeders and have a broad range of prey. Young adults in  
26 freshwater environments feed on aquatic insects, crustaceans, and other smaller fishes (Stanley  
27 and Danie 1983). In brackish and estuarine environments, the white perch feed on fish eggs,  
28 the larvae of walleye (*Sander vitreus*) and striped bass, and other smaller adult fish  
29 (Chesapeake Bay Program 2006). Young adult white perch also consume amphipods, snails,  
30 crayfish, crabs, shrimp, and squid where available. White perch larger than 22 cm (9 in.) feed  
31 almost exclusively on other fish. White perch are consumed by many larger predatory fish  
32 species. White perch were commonly observed in both entrainment and impingement samples  
33 obtained from IP2 and IP3.

### 34 Blue Crab

35 Blue crab (*Callinectes sapidus*, family Portunidae) is an important commercial and recreational  
36 resource throughout much of its range, which in the western Atlantic is from Nova Scotia  
37 through the Gulf of Mexico to northern Argentina. The life history of blue crab in the Hudson  
38 River estuary is largely based on the Delaware and Chesapeake Bays, where the most relevant  
39 information in the United States has been gathered. Unless otherwise noted, information below  
40 is from Perry and McIlwain (1986).

41 Spawning and mating in blue crabs occur at different times. Mating takes place when female  
42 crabs are in the soft condition after their terminal, or last, molt. Males then carry the soft-shelled  
43 females until their shell hardens. Females store the sperm, which is used to fertilize the eggs  
44 for repeated spawnings. After the shell hardens, the females move downstream to the mouths

1 of estuaries to spawn. Females extrude fertilized eggs and attach them on the underside of  
2 their bodies as a bright orange “sponge” consisting of up to 2 million eggs. The eggs become  
3 darker as they mature, and the sponge is almost black at the time of hatching. The eggs hatch  
4 and release the first zoea stage after about 2 weeks.

5 Larval crabs go through seven zoeal stages (and sometimes eight) in 31 to 49 days, depending  
6 on temperature and salinity. The zoeae are planktonic and live in the ocean near shore. Zoeae  
7 eat small zooplankton, such as rotifers. The last zoeal stage metamorphoses with its molt to a  
8 megalops larva, which persists from 6 to 20 days. Megalops larvae have more crab-like  
9 features than zoeae and are initially planktonic but gradually become more benthic. Megalops  
10 larvae inhabit the lower estuary and nearshore areas (ASMFC 2004) and have been found as  
11 far as 40 mi (64 km) offshore. Winds, tides, and storms transport the larvae back in towards  
12 shore (Kenny 2002). Among others, jellyfish are predators on crab larvae.

13 The megalops larvae molt and metamorphose into the first crab stage, which has all the  
14 features of a blue crab, and, like all crustaceans, grows by molting. The early crab stages,  
15 which are 10 to 20 mm (0.4 to 0.8 in.) carapace width in size, migrate to fresher water.  
16 Although benthic, blue crabs are good swimmers. They feed less and cease molting as winter  
17 nears and bury themselves in the mud in winter. Because the Hudson River is at the northern  
18 end of the blue crab’s range, severe winters may affect over-winter survival (Kenney 2002).

19 In the Chesapeake Bay, blue crabs mature in 18 to 20 molts, at which time females undergo a  
20 final, or terminal, molt, and males continue to grow and molt (Kenney 2002). In the Hudson  
21 River, most females make the terminal molt before they reach a carapace width of about  
22 125 mm (4.92 in.) (Kenney 2002). Adult males prefer the low salinity areas of upper estuaries,  
23 while females, after mating, move to and remain in the higher salinity areas of the lower estuary.  
24 Blue crabs can live about 3 or 4 years, although most probably do not live past the age of 2.  
25 Adult blue crabs are benthic predators that will lie in wait to catch small fish. They also eat other  
26 crabs and crustaceans, mollusks, dead organisms, zebra mussels, aquatic plants, and organic  
27 debris. They will also eat other blue crabs. Young and adult blue crabs are prey for many  
28 predators, including a variety of birds, including herons and diving ducks; humans; raccoons;  
29 and fish, including various members of the sciaenid (drum) family, American eel, and striped  
30 bass. Cannibalism is thought to be a major source of mortality. Environmental factors thought  
31 to affect juvenile and adult blue crab populations include drought, winter mortality, hypoxia,  
32 hurricanes, and the effects of human development (ASMFC 2004).

33 New York has a relatively small blue crab fishery, which reported a large decrease in landings in  
34 1997; since then, the harvest has been about a million pounds a year (ASMFC 2004). Blue  
35 crab fishing in the Hudson River Estuary occurs mostly in the summer and fall (Kenney 2002).  
36 Egg-bearing females are returned to the river to help protect spawning stock (Kenney 2002).  
37 Blue crab have been impinged on the screens of IP2 and IP3.

#### 38 **2.2.5.5 Special Status Species and Habitats**

##### 39 Atlantic Sturgeon

40 The Atlantic sturgeon (*Acipenser oxyrinchus*, family Acipenseridae) is an anadromous  
41 species, with a range extending from St. Johns River, Florida, to Labrador, Canada.  
42 Considered the “cash crop” of Jamestown before tobacco, the Atlantic sturgeon has been  
43 harvested for its flesh and caviar, as well as its skin and swim bladder. A long-lived, slowly  
44 maturing species, the Atlantic sturgeon can reach 60 years of age (ASMFC 2007c; Gilbert

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1 1989). Maturity is reached at 7 to 30 years for females, and 5 to 24 for males, with fish in the  
2 southern range maturing earlier than those inhabiting the northern range (ASMFC 2007c).  
3 Fecundity is correlated with age and size, ranging from 400,000 to 8 million eggs per female  
4 (NMFS 2007). Individuals reach lengths of about 79 in. (200 cm), while the largest recorded  
5 sturgeon was 15 ft (4.5 m) and 811 lb (368 kg) (ASMFC 2007c).

6 In the spring, adult Atlantic sturgeons migrate to freshwater to spawn, with males arriving a few  
7 weeks before the females. In the Hudson River, the males' migration occurs when water  
8 temperatures reach 5.6 to 6.1°C (42 to 43°F); the females appear when water temperatures  
9 warm to 12.2 to 12.8°C (54 to 55°F). Spawning occurs a few weeks later (Gilbert 1989). Eggs  
10 are deposited on hard surfaces on the river bottom, and hatch after 4 to 6 days (Shepherd  
11 2006c). Individuals do not spawn annually—spawning intervals range from 1 to 5 years for  
12 males and 2 to 5 years for females (NMFS 2007). Females typically leave the estuary 4 to  
13 6 weeks after spawning, but the males can remain in the estuary until the fall. Larvae feed from  
14 their yolk sac for 9 to 10 days, and then the PYSL begin feeding on the river bottom (Gilbert  
15 1989). In the fall, the juveniles move downstream from freshwater to the estuaries, where they  
16 remain for 3 to 5 years, and then migrate to the ocean as adults (Shepherd 2006c). Individuals  
17 return to their natal river for spawning, and so the species is divided into five distinct population  
18 segments (ASSRT 2007). Juveniles and adults are bottom feeders, subsisting on mussels,  
19 worms, shrimp, and small fish (Gilbert 1989; ASMFC 2007c).

20 Before 1900, landings of Atlantic sturgeon reached 3500 MT (3860 t) per year. This number  
21 dropped in the 20<sup>th</sup> century, and from 1950 to 1990, landings ranged from 45 to 115 MT (50 to  
22 127 t) per year (Shepherd 2006c). ASMFC placed a moratorium on harvesting wild Atlantic  
23 sturgeon for the entire coast in 1997, in an attempt to allow the population to recover. In 1999,  
24 the Federal Government banned the possession and harvest of sturgeon in the Exclusive  
25 Economic Zone (Shepherd 2006c; ASMFC 2007c). Using a Petersen mark-recapture  
26 population estimator, Peterson et al. (2000) estimated that the Hudson River population of age 1  
27 Atlantic sturgeon had declined about 80 percent between 1977 and 1985. The authors  
28 suggested that the then-current recruitment could be too low to sustain the population. As of  
29 October 2006, NMFS has listed Atlantic sturgeon as a candidate species for listing under the  
30 Endangered Species Act (71 *Federal Register* (FR) 61022). Threats such as bycatch, water  
31 quality, and dredging continue to affect Atlantic sturgeon (ASMFC 2007c). In the Hudson River,  
32 the Federal Dam (the southernmost obstruction in the river) is upstream of the northern extent  
33 of the Atlantic sturgeon spawning habitat and therefore is not a limiting factor (ASSRT 2007).

34 Average levels of PCBs in Hudson River sturgeon tissue exceeded FDA guidelines for human  
35 consumption in the 1970s and 1980s; since then, levels of PCBs have dropped below FDA  
36 guidelines (ASSRT 2007). Although the State placed a moratorium on harvesting Atlantic  
37 sturgeon in 1996 when it became apparent that the Hudson River stock was overfished, the  
38 American shad gill net fishery continues to take subadult sturgeon as bycatch. The Review  
39 Team for Atlantic Sturgeon concluded in 2007 (ASSRT 2007) that the Hudson River  
40 subpopulation has a moderate risk (less than 50 percent) of becoming endangered in the next  
41 20 years as a result of the threat of commercial bycatch. Despite this, the Hudson River  
42 supports the largest subpopulation of spawning adults and juveniles, and some long-term  
43 surveys indicate that the abundance has been stable since 1995 or is even increasing (ASSRT  
44 2007). Recent work by Sweka et al. (2007) has suggested that a substantial population of  
45 juvenile Atlantic sturgeon are present in Haverstraw Bay and that future population monitoring

1 should focus on this area to obtain the greatest statistical power for assessing population  
2 trends. Eggs and larval forms of Atlantic sturgeon were not observed in entrainment samples  
3 collected from IP2 and IP3 in 1981 and 1983-1987, but sturgeon were present in impingement  
4 samples.

#### 5 Shortnose Sturgeon

6 The shortnose sturgeon (*Acipenser brevirostrum*, family Acipenseridae) is amphidromous, with  
7 a range extending from St. Johns River, Florida, to St. John River, Canada. Unlike anadromous  
8 species, shortnose sturgeons spend the majority of their lives in freshwater, moving to saltwater  
9 periodically, without relation to spawning (Collette and Klein-MacPhee 2002). From colonial  
10 times, shortnose sturgeons have rarely been the target of commercial fisheries but have  
11 frequently been taken as incidental bycatch in Atlantic sturgeon and shad gillnet fisheries  
12 (Shepherd 2006c; Dadswell et al. 1984). The shortnose sturgeon was listed on March 11, 1967,  
13 as endangered under the Endangered Species Act of 1973, as amended. In 1998, a recovery  
14 plan for the shortnose sturgeon was finalized by NMFS (NMFS 1998). The threats to the  
15 species include dams, water pollution, and destruction or degradation of habitat (Shepherd  
16 2006c).

17 Shortnose sturgeon can grow up to 143 cm (56 in.) in total length, and can weigh up to 23 kg  
18 (51 lb). Females are known to live up to 67 years, while males typically do not live beyond  
19 30 years (Dadswell et al. 1984). As young adults, the sex ratio is 1:1; however, among fish  
20 larger than 90 cm (35 in.), measured from nose to the fork of the tail, the ratio of females to  
21 males increases to 4:1. Throughout the range of the shortnose sturgeon, males and females  
22 mature at 45 to 55 cm (18 to 22 in.) fork length, but the age at which this length is achieved  
23 varies by geography. At the southern extent of the sturgeon's range, males reach maturity at  
24 age 2, and females reach maturity at 6 years or younger; in Canada, males can reach maturity  
25 as late as age 11, and females at age 13 (Dadswell et al. 1984; OPR undated). One to two  
26 years after reaching maturity, males begin to spawn at 2-year intervals, while females may not  
27 spawn for the first time until 5 years after maturing, and thereafter spawn at 3- to 5-year  
28 intervals (Dadswell et al. 1984; OPR undated). Shortnose sturgeon migrate into freshwater to  
29 spawn during late winter or early summer. Eggs adhere to the hard surfaces on the river bottom  
30 before hatching after 4 to 6 days. Larvae consume their yolk sac and begin feeding in 8 to 12  
31 days, as they migrate downstream away from the spawning site (Kynard 1997; Collette and  
32 Klein-MacPhee 2002). The juveniles, who feed on benthic insects and crustaceans, do not  
33 migrate to the estuaries until the following winter, where they remain for 3 to 5 years. As adults,  
34 they migrate to the nearshore marine environment, where their diet consists of mollusks and  
35 large crustaceans (Shepherd 2006c; OPR undated).

36 In the Hudson River, shortnose sturgeon use the lower Hudson and are dispersed throughout  
37 the river estuary from late spring to early fall and then congregate to winter near Sturgeon Point  
38 (RKM 139 (RM 86)). They then spawn in the spring, just downstream of the Federal Dam at  
39 Troy. The population of shortnose sturgeons in the Hudson River has increased 400 percent  
40 since the 1970s, according to Cornell University researchers (Bain et al. 2007). Recent work by  
41 Woodland and Secor (2007) estimates a fourfold increase in sturgeon abundance over the past  
42 three decades, but reports that the population growth slowed in the late 1990s, as evidenced by  
43 the nearly constant recruitment pattern at depressed levels relative to the 1986–1992 year  
44 classes. Although the Hudson River appears to support the largest population of shortnose  
45 sturgeons, Bain et al. (2007) report that other populations along the Atlantic coast are also

1 increasing, and some appear to be nearing safe levels, suggesting that the overall population  
2 could recover if full protection and management continues. NMFS (2009) recently suggested to  
3 NRC Staff that the shortnose sturgeon population estimates for the Hudson River of 60,000 fish  
4 presented in Bain et al. (2007) are likely overestimates, and that 30,000 is a more appropriate  
5 estimate. Eggs and larval forms of shortnose sturgeon were not observed in entrainment  
6 samples from IP2 and IP3 in 1981 and 1983-1987, but sturgeon were present in impingement  
7 samples.

#### 8 **2.2.5.6 Other Potentially Affected Aquatic Resources**

##### 9 Phytoplankton and Zooplankton

10 Phytoplankton and zooplankton communities often form the basis of the food web in rivers and  
11 estuaries. The phytoplankton in the Hudson River generally fall into three major categories—  
12 diatoms, green algae, and blue-green algae. Diatoms are abundant through most of the year,  
13 but reach peak densities when water temperatures are low and watershed runoff and river flows  
14 are high. Green algae are present in highest abundances during the summer, when river flows  
15 are low and water temperatures are relatively high. Blue-green algae are generally present in  
16 late summer and early fall (CHGEC 1999).

17 Zooplankton populations in the Hudson River are divided into two major categories—  
18 holoplankton, which spend their entire live cycle as plankton, and meroplankton, which include  
19 the eggs and larvae of fish and shellfish that spend only a part of their life cycle in the planktonic  
20 community. Holoplankton in the brackish areas of the Hudson River from approximately IP2  
21 and IP3 downstream (RM 40 (RKM 64)) are generally dominated by marine species;  
22 holoplankton from Poughkeepsie north (RM 68 (RKM 109)) are generally dominated by  
23 freshwater forms (Figure 2-10). Zooplankton sampling from Haverstraw Bay to Albany from  
24 April to December 1987–1989 identified five numerically dominant taxa—the cyclopoid copepod,  
25 *Diacyclops bicuspidatus thomasi*; the cladoceran, *Bosmina longirostris*; and the rotifers  
26 *Keratella* spp., *Polyarthra* spp., and *Trichocera* spp. (CHGEC 1999). Work by Lonsdale et al.  
27 (1996) suggests that larger (greater than 64 microns (0.0025 in.)) zooplankton species that  
28 include both mesozooplankton and micrometazoa have a minimal role in controlling total  
29 phytoplankton biomass in the lower Hudson River estuary. Grazing pressure sufficient to  
30 contribute to the decline of the phytoplankton standing crop occurred only during the month of  
31 October.

32 Phytoplankton communities in the freshwater portion of the Hudson River are susceptible to  
33 predation by the zebra mussel, *Dreissena polymorpha*. Work by Roditi et al. (1996) suggests  
34 that the mussels are able to remove Hudson River phytoplankton effectively in the presence of  
35 sediment and can do so at rapid rates. The authors indicate that, based on their measurements  
36 and unpublished estimates of the size of the zebra mussel population, the mussels present in  
37 the upper stretches of the river can filter a volume equivalent to the entire freshwater portion of  
38 the Hudson River every 2 days. Strayer suggests that they filter a volume of water equal to all  
39 of the water in the estuarine Hudson every 1–4 days during the summer (2007). Significant  
40 declines in zooplankton biomass were also reported after the introduction of the mussel (Pace  
41 et al. 1998). Work by Strayer et al. (2004) suggests that the long-term impacts of zebra mussel  
42 removal of phytoplankton and zooplankton have profoundly affected the food web in the Hudson  
43 River, resulting in a shift of open-water species to downriver locations away from the mussels  
44 and a shift of littoral species upriver. The resulting changes affected a variety of commercially

1 and recreationally important species, including American shad and black bass, illustrating the  
2 importance of zooplankton and phytoplankton in food webs associated with the freshwater  
3 portion of the Hudson River (Strayer et al. 2004).

#### 4 Aquatic Macrophyte Communities

5 Aquatic macrophyte communities provide food and shelter to a variety of fish and invertebrate  
6 communities and are an important component of the Hudson River ecosystem. Macrophyte  
7 communities are generally divided into three broad groups that include emergent macrophytes,  
8 floating-leaved macrophytes, and submerged macrophytes (also known as SAV). Emergent  
9 macrophytes in the Hudson River generally occur near the shoreline to a water depth of about  
10 5 ft (1.5 m) and have leaves that rise out of the water. Floating leaved macrophytes are  
11 attached to the bottom and have floating leaves and long, flexible stems. Submerged  
12 macrophytes are found beneath the water surface at a depth related to the clarity of the water  
13 (CHGEC 1999). The composition and distribution of aquatic macrophyte communities vary  
14 along the river and are controlled by physical characteristics and season. Work by Findlay et al.  
15 (2006) shows that the densities of macroinvertebrates in SAV beds were more than three times  
16 as high as densities on unvegetated sediments, suggesting that SAV beds may be the richest  
17 feeding grounds in the Hudson River estuary for fish. Further, the authors also noted that many  
18 species of macroinvertebrates that are common in aquatic macrophyte beds are rare or absent  
19 from unvegetated sites.

20 SAV beds in the Hudson are represented by two predominant species—the native submerged  
21 eel grass, *Vallisneria americana* and the introduced water chestnut, *Trapa natans* (Findlay et al.  
22 2006). CHGEC (1999) identified 18 species of submergent aquatic vegetation between  
23 Kingston and Nyack, including nine species of *Potamogeton* (pondweed), and *Elodea* sp.  
24 (common pondweeds used in aquaria), and a variety of other species. Historical and recent  
25 work has shown that SAV occupies major portions of some reaches of the Hudson River, when  
26 present, and can cover as much as 25 percent of the river bottom (Findlay et al. 2006). New  
27 York State has been studying the SAV in the Hudson River estuary from the Troy Dam south to  
28 Yonkers since 1995. Using true color aerial photography, researchers from Cornell University  
29 and the New York Sea Grant Extension inventoried the spatial extent of the SAV and water  
30 chestnut beds from 1995 to 1997 and in 2002. They determined that vegetated area constitutes  
31 roughly 8 percent of total river surface area with eel grass three times as abundant as water  
32 chestnut. Plant coverage over the entire study area from the Troy Dam to Yonkers was about  
33 6 percent of the river bottom area for eel grass and 2 percent for water chestnut, although the  
34 distribution of both plants varies greatly among reaches of the tidal freshwater Hudson River  
35 (Nieder et al. 2004). According to NYSDEC (2007a), there has been a 9-percent decline in all  
36 SAV and a 7-percent gain in water chestnut.

#### 37 Coastal Marshes, Wetlands, and Riparian Zones

38 Coastal marshes, tidal wetlands, and associated riparian zones are found along the lower  
39 Hudson River. Vegetation in these areas includes emergent grasses, sedges, and other plants  
40 adapted to nearshore conditions that often experience changes in runoff, salinity, and  
41 temperature. FWS has identified the area extending from the Battery north to Stony Point at the  
42 northern end of Haverstraw Bay as Lower Hudson River Estuary Complex #21 (FWS 2008a).  
43 Within this complex there are many significant wetland habitats, including a regionally significant

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1 nursery and wintering habitat for a variety of anadromous, estuarine, and marine fish, as well as  
2 a migratory area for birds and fish that feed on abundant prey items.

3 Recognizing the importance of coastal wetlands, tidal marshes, and riparian zones, NOAA,  
4 partnering with NYSDEC, identified four locations along the lower Hudson River estuary for  
5 inclusion in the National Estuarine Research Reserve System in 1982 (NOAA 2008a). The  
6 areas, from north to south, are Stockport Flats, Tivoli Bay, Iona Island, and Piermont Marsh;  
7 they collectively represent over 4800 acres (1900 ha) of protected habitat.

8 Stockport Flats is the northernmost site in the Hudson River Reserve and is located on the east  
9 shore of the river in Columbia County near the city of Hudson. This site is a narrow, 5-mi-long  
10 landform that includes Nutten Hook, Gay's Point, Stockport Middle Ground Island, the Hudson  
11 River Islands State Park, a portion of the upland bluff south of Stockport Creek, and dredge  
12 spoils and tidal wetlands between Stockport Creek and Priming Hook. The dominant features of  
13 Stockport Flats include freshwater tidal wetlands that contain subtidal shallows, intertidal  
14 mudflats, intertidal shores, tidal marshes, and floodplain swamps (NOAA 2008a).

15 Tivoli Bay extends for 2 mi along the east shore of the Hudson River between the villages of  
16 Tivoli and Barrytown, in the Dutchess County town of Red Hook. The site includes two large  
17 coves on the east shore—Tivoli North Bay, a large intertidal marsh, and Tivoli South Bay, a  
18 large, shallow cove with mudflats. The site also includes an extensive upland buffer area  
19 bordering North Tivoli Bay. Habitats at this site include freshwater intertidal marshes, open  
20 waters, riparian areas, shallow subtidal areas, mudflats, tidal swamps, and mixed forest uplands  
21 (NOAA 2008a).

22 Iona Island is located near the Town of Stony Point in Rockland County, 6 mi south of West  
23 Point. This bedrock island is located in the vicinity of the Hudson Highlands and is bordered to  
24 the west and the southwest by Salisbury and Ring Meadows. In the early 20<sup>th</sup> century, filling  
25 activities connected Round Island to the south end of Iona Island. There is approximately 1 mi  
26 of marsh and shallow water habitat between Iona Island and the west shore of the Hudson  
27 River, and the area includes brackish intertidal mudflats, brackish tidal marsh, freshwater tidal  
28 marsh, and deciduous forested uplands.

29 Piermont Marsh lies at the southern edge of the village of Piermont, 4 mi south of Nyack. The  
30 marsh is located on the west shore of the Tappan Zee region near the town of Orangetown in  
31 Rockland County. The site includes 2 mi of shoreline south of the mile-long Erie Pier and the  
32 mouth of Sparkill Creek. Habitats at this location include brackish tidal marshes, shallows, and  
33 intertidal mud flats.

### 34 **2.2.5.7 Nuisance Species**

#### 35 Zebra Mussel

36 | In the early 1990s, the nonnative zebra mussel, *Dreissena polymorpha*, made its first  
37 appearance in the freshwater portions of the Hudson River estuary. Beginning in early fall  
38 1992, zebra mussels have been dominant in the freshwater tidal Hudson, constituting more than  
39 half of heterotrophic biomass, and filtering a volume of water equal to all of the water in the  
40 estuary every 1-4 days during the summer (Strayer 2007). The mussel's range extends from  
41 Poughkeepsie to the Troy Dam, with the highest densities occurring between Saugerites and  
42 Albany (CHGEC 1999; Strayer et al. 2004; Caraco et al. 1997). The presence of the mussels  
43 resulted in a decrease in phytoplankton biomass of 80 percent (Caraco et al. 1997) and a



1 decrease of zooplankton abundance of 70 percent (Pace et al. 1998). Water chemistry was  
2 also altered, as phosphate and nitrate concentrations increased and DO concentrations  
3 decreased after the mussels were established (CHGEC 1999; Caraco et al. 2000). Caraco et  
4 al. (2000) indicated that these effects fundamentally changed food web relationships in the river  
5 and may have had a significant impact on many fish species.

6 Work by Strayer et al. (2004) found that open-water species such as *Alosa* spp. (shad and  
7 herring) exhibited a decreased abundance in response to Zebra mussel introduction, while the  
8 abundance of littoral species such as centrarchids (sunfish) increased. The median decrease in  
9 abundance of open-water species was 28 percent, and the median increase in abundance of  
10 littoral species was 97 percent. The authors also noted that populations of open-water species  
11 shifted downriver, away from the zebra mussel population, while littoral species shifted upriver.

12 Growth rates of open-water and littoral species were also affected by the mussels. Strayer and  
13 Smith (1996) found impacts to unionid bivalve mussels (*Elliptio complanata*, *Anodonta imbecilis*,  
14 *Leptodea ochracea*) such as decreasing densities and incidences of infestations. After the  
15 arrival of the zebra mussel, the authors reported that densities of these three unionid clam  
16 species fell by 56 percent, recruitment of YOY unionids fell by 90 percent, and the biological  
17 condition of unionids fell by 20–50 percent, with *E. complanata* less severely affected than the  
18 other two. Strayer and Smith (1996) suggest that the impacts to these species may be  
19 associated with both competition for food and biofouling by zebra mussels.

20 The work of Strayer, Caraco, Pace, and others has raised important questions and issues  
21 concerning the nature of impacts to fish communities from exotic or introduced species, the  
22 management of fish populations affected by these species, and the need to carefully consider  
23 all potential environmental stressors present when assessing the reasons for fish or invertebrate  
24 population declines. Changes in abundance and distribution in the freshwater portion of the  
25 Hudson River estuary involved many recreationally and commercially important species,  
26 including striped bass (*M. saxatilis*), American shad (*A. sapidissima*), redbreast sunfish, and  
27 black bass (*Micropterus* spp.). The changes Strayer et al. (2004) documented since 1992  
28 include overall decreases in abundance, redistribution of species up- or downriver in relation to  
29 the mussels and fundamental changes to food webs because of the physical presence of the  
30 mussels and their filtration activity.

31 Recent work by Strayer and Malcom (2006) suggests that there are still significant gaps in  
32 understanding about the biology and life cycle of the zebra mussel in the Hudson River. The  
33 researchers used a combination of long-term data and simulation modeling. The authors  
34 evaluated mussel population size, adult growth, and body condition and found considerable  
35 interannual variation in these factors that was not strongly correlated with phytoplankton  
36 population. The data suggested a 2- to 4-year population cycle that was driven by large  
37 interannual variations in recruitment. Strayer and Malcolm's (2006) work indicates that a  
38 complete understanding of the potential effects of this species on aquatic food webs, and thus  
39 recreationally, commercially, or ecologically important fish and invertebrate species and  
40 communities requires a better understanding of the factors affecting the zebra mussel life cycle  
41 in the Hudson River than currently exists.

#### 42 Water Chestnut

43 The water chestnut was first observed in North America in 1859 near Concord, Massachusetts  
44 (FWS 2004). Currently, the plant is found in Maryland, Massachusetts, New York, and

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1 Pennsylvania. The most problematic populations are found in the Connecticut River Valley,  
2 Lake Champlain region, and the Hudson, Potomac and Delaware Rivers (FWS 2004). Water  
3 chestnut impacts to water bodies can include increasing sedimentation and reducing Dissolved  
4 Oxygen (DO), as well as developing dense mats that cause competition for nutrients and space  
5 with other species (IPCNYS 2008).

6 According to CHGEC (1999), the water chestnut was introduced into the upper Hudson River in  
7 the late 1880s and was established by the 1930s. An eradication program was begun by the  
8 NYSDEC using the herbicide 2,4-D, but the program was discontinued in 1976. Since 1976, the  
9 water chestnut beds have expanded into dense stands in available habitat in the fresh and low-  
10 salinity brackish areas of the estuary, and as of 1999, the exotic water chestnut was the  
11 dominant form of rooted vegetation in shallow areas of the estuary upstream of Constitution  
12 Island (RM 53 (RKM 85)). CHGEC (1999) indicates that water chestnut beds in some parts of  
13 the Hudson River are now so dense that they have adversely affected water circulation, lowered  
14 DO concentrations, and altered fish communities.

### 15 Ctenophores

16 Members of the phylum Ctenophora, variously known as comb jellies, sea gooseberries, sea  
17 walnuts, or Venus's girdles, are gelatinous marine carnivores that are present in marine and  
18 estuarine waters from the sea surface to depths of several thousand meters. Ctenophores are  
19 characterized by eight rows of cilia that are used for locomotion. Cilia rows are organized into  
20 stacks of "combs" or "ctenes"; hence the name comb jellies. Ctenophore morphology can range  
21 from simple sac-like shapes without tentacles, to large, multilobed individuals equipped with  
22 adhesive cells called colloblasts. Worldwide, there are probably 100 to 150 species, but most  
23 are poorly known and are challenging to collect and study because of their fragility (Haddock  
24 2007).

25 As members of the zooplankton community, ctenophores influence marine and estuarine food  
26 webs by preying on a variety of eggs and larvae. Predator-prey relationships between the  
27 ctenophore *Mnemiopsis leidyi* and eggs of the bay anchovy (*A. mitchelli*) have been described  
28 by Purcell et al. (1994) in the Chesapeake Bay, and Deason (1982) described a similar  
29 relationship between *M. leidyi* and *Acartia tonsa*, a copepod prey species. Similarly, the NRC  
30 staff finds it possible that during certain times of the year, ctenophore predation may influence  
31 zooplankton abundance in the higher salinity portions of the Hudson River. Laboratory studies  
32 evaluating the feeding and functional morphology of *M. mccradyi* by Larson (1988) provided  
33 new information concerning how prey are captured by ctenophores, but there is little field  
34 information available on predator-prey dynamics in natural systems, primarily because of the  
35 difficulties associated with field collections. At present, the impact of ctenophores on  
36 zooplankton, eggs, and larvae in the lower portions of the Hudson River is unknown.

### 37 **2.2.6 Terrestrial Resources**

38 This section describes the terrestrial resources of the IP2 and IP3 site and its immediate vicinity,  
39 including plants and animals of the upland areas, an onsite freshwater pond, and riparian areas  
40 along the river shoreline.

### 1 2.2.6.1 Description of Site Terrestrial Environment

2 As mentioned at the beginning of this chapter, the IP2 and IP3 site includes 239 acres (96.7 ha)  
3 on the east bank of the Hudson River. The property is bordered by the river on the west and the  
4 north (Lents Cove), a public road (Broadway) on the east, and privately owned industrial  
5 property on the south. The site is hilly, with elevations rising to about 150 ft (46 m) above the  
6 level of the river at the highest point. The site is enclosed by a security fence that follows the  
7 property line. Developed areas covered by facilities and pavement occupy over half of the site  
8 (134 acres (54.2 ha)), predominantly in the central and southern portions. Outside the central  
9 portion of the site where the reactors and associated generator buildings are located, small  
10 tracts of forest totaling approximately 25 acres (10 ha) are interspersed among the paved areas  
11 and facilities. Maintained areas of grass cover about 7 acres (2.8 ha) of the site. The northern  
12 portion of the site is covered by approximately 70 acres (28 ha) of forest (Entergy 2007a).  
13 Within this forested area is a 2.4-acre (0.97-ha) freshwater pond (Entergy 2007a; NRC 1975).  
14 The New York State Freshwater Wetlands Map for Westchester County indicates that there are  
15 no streams or wetlands on the site (NYSDEC 2004c).

16 The site is within the northeastern coastal zone of the eastern temperate forest ecoregion (EPA  
17 2007a). The forest vegetation of the site and adjacent areas was characterized by a survey  
18 performed in the early 1970s, before the completion of construction of IP3 (NRC 1975). At that  
19 time, the canopy of this forest included a mixture of hardwoods such as red oak (*Quercus*  
20 *rubra*), white oak (*Q. alba*), black oak (*Q. velutina*), chestnut oak (*Q. prinus*), shagbark hickory  
21 (*Carya ovata*), black cherry (*Prunus serotina*), tulip tree (*Liriodendron tulipifera*), river birch  
22 (*Betula nigra*), and maple (*Acer* spp.), as well as conifers such as eastern hemlock (*Tsuga*  
23 *canadensis*) and white pine (*Pinus strobus*). The subcanopy included sassafras (*Sassafras*  
24 *albidum*) and sumac (*Rhus* spp.). The shrub layer included swamp juneberry (*Amelanchier*  
25 *intermedia*), summer grape (*Vitis aestivalis*), poison ivy (*Toxicodendron radicans*), and Virginia  
26 creeper (*Parthenocissus quinquefolia*); and the herbaceous layer included forbs such as  
27 wildflowers and ferns (NRC 1975). This forest community covers the riverfront north of the  
28 reactor facilities, surrounds the pond in the northeast corner of the site, and exists in fragmented  
29 stands in the eastern and southern areas of the site. The vegetation in the developed areas of  
30 the site consists mainly of turf grasses and planted shrubs and trees around buildings, parking  
31 areas, and roads.

32 The animal community of the site has not been surveyed but likely consists of fauna typical of  
33 mixed hardwood forest habitats in the region. Birds that have been observed breeding in the  
34 area of northwestern Westchester County and that utilize habitats such as the forest, pond, and  
35 riverfront habitats present on and adjacent to the site include the great blue heron (*Ardea*  
36 *herodias*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), wood duck (*Aix*  
37 *sponsa*), wild turkey (*Meleagris gallopavo*), Cooper's hawk (*Accipiter cooperii*), pileated  
38 woodpecker (*Dryocopus pileatus*), blue jay (*Cyanocitta cristata*), American robin (*Turdus*  
39 *migratorius*), and scarlet tanager (*Piranga olivacea*) (NYSDEC 2005, Dunn and Alderfer 2006).  
40 Numerous waterfowl utilize the lower Hudson River in winter. In the region of southeastern New  
41 York that includes Westchester County, waterfowl counts in January 2007 identified at least 22  
42 species of ducks and geese, as well as loons, grebes, and cormorants (NYSOA 2007). In  
43 addition to the waterfowl that use the Hudson River, raptors also forage and nest along the river.  
44 For example, the bald eagle (*Haliaeetus leucocephalus*), which preys on fish and waterfowl,  
45 congregates along the lower Hudson River in winter (NYSDEC 2008b, 2008c), and the

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1 peregrine falcon (*Falco peregrinus*), which preys on waterfowl and other birds, nests on bridges  
2 over the lower Hudson (NYSDEC 2008d, 2008e).

3 Mammals likely to occur in the forest habitats on and adjacent to the site include the gray fox  
4 (*Urocyon cinereoargenteus*), mink (*Mustela vison*), raccoon (*Procyon lotor*), Virginia opossum  
5 (*Didelphis virginiana*), white-tailed deer (*Odocoileus virginianus*), red squirrel (*Tamiasciurus*  
6 *hudsonicus*), white-footed mouse (*Peromyscus leucopus*), and northern short-tailed shrew  
7 (*Blarina brevicauda*). Aquatic mammals that may occur along and within the river include the  
8 river otter (*Lutra canadensis*) and muskrat (*Ondatra zibethicus*) (NYSDEC 2007b; Whitaker  
9 1980).

10 Reptiles and amphibians likely to occur on and in the vicinity of the site include species that  
11 typically inhabit upland forest habitats of the region, including the black rat snake (*Elaphe*  
12 *obsoleta*), eastern box turtle (*Terrapene carolina*), and American toad (*Bufo americanus*).  
13 Species likely to inhabit aquatic habitats such as the 2.4-acre (0.97-ha) pond and river shoreline  
14 include the northern water snake (*Nerodia sipedon*) and bullfrog (*Rana catesbeiana*) (NYSDEC  
15 2007b, Conant and Collins 1998). The pond historically was used for fishing and is likely to  
16 contain minnows (family Cyprinidae) and sunfishes (family Centrarchidae).

17 There are no State or Federal parks, wildlife refuges, wildlife management areas, or other State  
18 or Federal lands adjacent to the site. The closest such lands to the site are two State parks,  
19 Bear Mountain State Park and Harriman State Park, which are located across the Hudson River  
20 approximately 1 mi and 2 mi, respectively, northwest of the site at their closest points (Entergy  
21 2007a). In addition, a Significant Coastal Fish and Wildlife Habitat, referred to as "Hudson RM  
22 44–56," begins approximately 1 mi north of the site and extends upriver. Significant Coastal  
23 Fish and Wildlife Habitats are designated by the New York Department of State, Division of  
24 Coastal Resources. Hudson RM 44–56 provides important habitat for wintering bald eagles as  
25 well as waterfowl (NYSDOS 2004).

26 Of the total 4000 ft (1220 m) of transmission line, approximately 3500 ft (1070 m) traverses  
27 buildings, roads, parking lots, and other developed areas. As a result, the total length of the  
28 ROWs that is vegetated is only about 500 ft (150 m). The ROWs are approximately 150 ft  
29 (46 m) wide, and the vegetation within the ROWs is mainly grasses and forbs. The  
30 transmission lines included in this SEIS are those that were originally constructed for the  
31 purpose of connecting IP2 and IP3 to the existing transmission system. These two lines are  
32 described in more detail in Section 2.1.7. Each line is approximately 2000 ft (610 m) in length,  
33 all of which is within the site except for a terminal, 100-ft (30-m) segment of each that crosses  
34 the facility boundary and Broadway to connect to the Buchanan substation (Entergy 2005b;  
35 NRC 1975).

### 36 2.2.6.2 Threatened and Endangered Terrestrial Species

37 Two species that are federally listed as threatened or endangered, and one candidate species,  
38 have been identified by FWS as known or likely to occur in Westchester County. These are the  
39 endangered Indiana bat (*Myotis sodalis*), the threatened bog turtle (*Clemmys muhlenbergii*),  
40 and the candidate New England cottontail (*Sylvilagus transitionalis*) (FWS 2008b). In addition,  
41 194 species that are listed by the State of New York as endangered, threatened, species of  
42 special concern (animals), or rare (plants) have a potential to occur in Westchester County  
43 based on recorded observations or their geographic ranges. The identities, listing status, and  
44 preferred habitats of these federally and State-listed species are provided in Table 2-6.

## 1 Federally Listed Species

2 The three federally listed and candidate species are discussed below. In addition to these  
3 species that currently have a Federal listing status, a recently delisted species, the bald eagle,  
4 also occurs in Westchester County. On July 9, 2007, FWS issued a rule in the *Federal Register*  
5 (72 FR 37346) removing the bald eagle from the Federal List of Endangered and Threatened  
6 Wildlife, effective August 8, 2007. As discussed in Section 2.2.6.1, bald eagles winter in  
7 substantial numbers in the vicinity of the site, particularly in a Significant Coastal Fish and  
8 Wildlife Habitat area upstream of the site from RM 44 to 56 (RKM 70 to 90) (NYSDOS 2004).  
9 Bald eagles also have nested in recent years at locations along the Hudson River in the vicinity  
10 of the site. In New York, the breeding season generally extends from March to July, and in the  
11 southeastern part of the state, wintering eagles begin to arrive in November and congregate in  
12 greatest numbers in February. Adult bald eagles are dark brown with a white head and tail and  
13 a yellow bill. Juveniles are completely brown with a gray bill until they are mature at about  
14 5 years of age. The bald eagle feeds primarily on fish but also preys on waterfowl, shorebirds,  
15 small mammals, and carrion (NYSDEC 2008b).

## 16 Indiana Bat

17 The Indiana bat (*Myotis sodalis*) currently is listed as endangered under the Endangered  
18 Species Act of 1973 as amended (16 U.S.C. 1531 *et seq.*). Critical habitat for the Indiana bat  
19 was designated in 1976 (41 FR 41914) at eleven caves and two mines in six States (Missouri,  
20 Illinois, Indiana, Kentucky, Tennessee, and West Virginia). There is no designated critical  
21 habitat in New York.

22 The Indiana bat is a medium-sized bat with a head and body length slightly under 2 in. (5.1 cm),  
23 a wing span of 9 to 11 in. (23 to 28 cm), a weight of approximately 0.3 ounces (8.5 g), and a life  
24 span of about 10 years (FWS 2002, FWS 2007a). It feeds on flying insects captured in flight at  
25 night as it forages in forested areas, forest edges, fields, riparian areas, and over water. Indiana  
26 bats are migratory and hibernate in large colonies in caves or mines (hibernacula). Hibernacula  
27 may support from fewer than 50 to more than 10,000 Indiana bats (FWS 2007a). In New York,  
28 hibernation may last from September to May. After emerging in spring, the bats may migrate  
29 hundreds of miles to summer habitats, where they typically roost during the day under bark  
30 separating from the trunks of dead trees or in other tree crevices (FWS 2007a). Reproductive  
31 females congregate in maternity colonies of up to 100 or more bats, where they give birth and  
32 care for their single young until it can fly, usually at 1 to 2 months of age (FWS 2007a). Males  
33 and nonreproductive females generally roost individually or in small colonies and may remain  
34 near their hibernaculum rather than migrating (FWS 2007a).

35 The Indiana bat may occur in 20 States in the eastern United States from New England to the  
36 Midwest, mainly within the central areas of this region from Vermont to southern Wisconsin,  
37 eastern Oklahoma, and Alabama. In summer, Indiana bat maternity colonies and individuals  
38 may occur throughout this range. In winter, populations are distributed among approximately  
39 280 hibernacula in 19 States (FWS 2007a). New York has a total of 10 known hibernacula in  
40 caves and mines in Albany, Essex, Jefferson, Onondaga, Ulster, and Warren Counties (NYNHP  
41 2008a). The nearest of these counties to the site is Ulster County, which is about 20 mi (32 km)  
42 to the north of the site at its closest point. The two largest hibernating colonies in New England  
43 (estimated populations in 2005 of over 11,300 and 15,400) are in two abandoned mines located  
44 in Ulster County approximately 45 mi (72 km) north of the site near the Town of Rosendale

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1 (FWS 2007a; Sanders and Chengler 2001). The larger of these is among the 10 largest Indiana  
2 bat hibernacula in the country (NYNHP 2008a). There are 13 general areas in the State where  
3 maternity and bachelor colonies are known to occur in summer. Hibernacula, maternity  
4 colonies, and bachelor colonies are not known to be present in Westchester County or the  
5 vicinity of the site, although Westchester County is within the potential range of the Indiana bat  
6 in New York (NYNHP 2008a). Given the presence of large hibernacula within migration  
7 distance of the site and the presence of suitable foraging habitat and possible roosting trees in  
8 the forest at the north end of the site, the NRC staff finds it possible that Indiana bats may use  
9 this area as summer habitat.

## 10 Bog Turtle

11 The northern population of the bog turtle (*Clemmys muhlenbergii*), which occurs in Connecticut,  
12 Delaware, Maryland, Massachusetts, New Jersey, New York, and Pennsylvania, was federally  
13 listed as threatened in 1997 under the ESA (16 U.S.C. 1531 *et seq.*). The southern population  
14 was listed as threatened because of its similarity of appearance to the northern population. The  
15 two populations are discontinuous. The southern population occurs mainly in the Appalachian  
16 Mountains from southern Virginia through the Carolinas to northern Georgia and eastern  
17 Tennessee (FWS 2001). In New York, the bog turtle occurs in the central and southeastern  
18 parts of the State, primarily in the Hudson Valley region (NYSDEC 2008f, 2008g).

19 The bog turtle is one of the smallest turtles in North America. Its upper shell is 3 to 4 in. (7.6 to  
20 10 cm) long and light brown to black in color, and each side of its black head has a distinctive  
21 patch of color that is bright orange to yellow. Its life span may be 40 years or longer. The bog  
22 turtle is diurnal and semiaquatic; it forages on land and in water for its varied diet of insects and  
23 other invertebrates, frogs, plants, and carrion (FWS 2001; NYNHP 2008b). In southeastern  
24 New York, the bog turtle usually is active from the first half of April to the middle of September,  
25 and hibernates the remainder of the year underwater in soft mud and crevices (FWS 2001).

26 Northern bog turtles primarily inhabit wetlands fed by groundwater or associated with the  
27 headwaters of streams and dominated by emergent vegetation. These habitats typically have  
28 shallow, cool water that flows slowly and vegetation that is early successional, with open  
29 canopies and wet meadows of sedges (*Carex* spp.). Other herbs commonly present include  
30 spike rushes (*Eleocharis* spp.) and bulrushes (*Juncus* spp. and *Scirpus* spp.) (FWS 2001). Bog  
31 turtle habitats in the Hudson River Valley also frequently include sphagnum moss (*Sphagnum*  
32 spp.) and horsetail (*Equisetum* spp.) (NYNHP 2008b). Commonly associated woody plants  
33 include alders (*Alnus* spp.) and willows (*Salix* spp.) (FWS 2001; NYNHP 2008b).

34 Of the 74 historic bog turtle locations recorded in New York, over half still may provide suitable  
35 habitat. However, populations are known to exist currently at only one-fourth of these locations,  
36 principally in southeastern New York (NYSDEC 2008f). The New York Natural Heritage  
37 Program (NYNHP) database contains locations in northwestern Westchester County where the  
38 bog turtle has been recorded as occurring historically. Although there were a few records  
39 during the 1990s of bog turtles in Westchester County, the NYNHP states that "it is not known if  
40 any extant populations remain in this county" (NYNHP 2008b). According to the data collected  
41 for the New York State Reptile and Amphibian Atlas for the period 1990 to 2007, the only  
42 reported occurrence of the bog turtle in Westchester County was near the eastern border of the  
43 State (NYSDEC 2008g). The New York State Freshwater Wetlands Map for Westchester  
44 County (NYSDEC 2004c) indicates that there are no wetlands on the IP2 and IP3 site. The  
45 nearest offsite wetland, which is adjacent to the north end of the site, is located on the east side

1 of Broadway and drains under the roadway to Lent's Cove. Its potential to provide bog turtle  
2 habitat was not evaluated. The 2.4-acre (0.97-ha) pond in the northern portion of the site is  
3 surrounded by mature forest with a closed canopy and does not provide the highly specialized  
4 wetland habitat (early successional wet meadows) required by the bog turtle.

5 While acknowledging that the wetland nearest to the site has not been evaluated for the  
6 presence of the bog turtle, the NRC staff notes that there is no suitable habitat on the site and  
7 there are no recently recorded occurrences of the bog turtle in portions of Westchester County  
8 near the plant site. Thus, the NRC staff finds that the bog turtle is unlikely to occur on the site or  
9 in the immediate vicinity of the site.

#### 10 New England Cottontail Rabbit

11 The New England cottontail rabbit (*Sylvilagus transitionalis*) is a Federal candidate for listing as  
12 an endangered or threatened species (72 FR 69034) and is State-listed as a species of special  
13 concern in New York (NYSDEC 2008h). It is similar in appearance to the more common and  
14 widespread eastern cottontail (*S. floridanus*). The New England cottontail can often be  
15 distinguished from the eastern cottontail by its slightly smaller size, shorter ears, darker fur,  
16 black spot between the ears, and black line at the front edge of the ears (NYNHP 2008c).  
17 Cottontails have short life spans and reproduce at an early age. Breeding season for the New  
18 England cottontail typically is from March to September (NYNHP 2008c). There may be two to  
19 three litters per year, with a usual litter size of five young and a range from three to eight (FWS  
20 2007b). The diet of the species consists mainly of grasses and other herbaceous plants in  
21 spring and summer and the bark, twigs, and seedlings of shrubs and other woody plants in  
22 autumn and winter (NYNHP 2008c).

23 The New England cottontail is native only to the northeastern United States. Populations  
24 historically were found throughout New England. The range of this species has become  
25 fragmented and currently is approximately 14 percent of its historical extent (72 FR 69034). In  
26 New York, the New England cottontail currently is thought to occur only in separate populations  
27 east of the Hudson River within Columbia, Dutchess, Putnam, and Westchester Counties  
28 (NYNHP 2008c). The dramatic decreases in population and range are primarily the result of  
29 loss of suitable habitat. The New England cottontail requires a specialized habitat of early  
30 successional vegetative growth such as thickets, open wooded areas with a dense understory,  
31 and margins of agricultural fields (NYNHP 2008c). Land development associated with the  
32 growth of urban and suburban areas and the maturation of early successional forests have been  
33 the primary causes of the loss of these types of habitat (69 FR 39395).

34 The known locations of the New England cottontail in Westchester County are in the central and  
35 northeastern areas of the county (NYNHP 2008c), not in the northwestern area where the IP2  
36 and IP3 site is located. The forests on the site consist mainly of mature hardwoods and do not  
37 contain early successional habitats, such as thickets, that are required by the New England  
38 cottontail. Therefore, the New England cottontail is considered unlikely to occur on or in the  
39 immediate vicinity of the site.

#### 40 State-Protected Species

41 The only State-listed terrestrial species identified by NYNHP as currently occurring in the vicinity  
42 of the IP2 and IP3 site is the bald eagle (NYSDEC 2007c). The only other documented  
43 occurrences in the NYNHP database for the site vicinity were historical records for four plant  
44 species that have not been documented in the site vicinity since 1979 or earlier (NYSDEC

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1 2007c). None of the State-listed species potentially occurring in Westchester County  
 2 (Table 2-6) are on the site or have been found there.

3 **Table 2-6. Federally and State-Listed Terrestrial Species Potentially**  
 4 **Occurring in Westchester County**

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<b>Amphibians</b>				
<i>Ambystoma jeffersonianum</i>	Jefferson salamander	-	SSC	Deciduous woodlands with a closed canopy and riparian habitats <sup>(1)</sup>
<i>Ambystoma laterale</i>	blue-spotted salamander	-	SSC	Marshes, swamps, and adjacent upland areas with loose soils <sup>(1)</sup>
<i>Ambystoma opacum</i>	marbled salamander	-	SSC	Near swamps and shallow pools, rocky hillsides and summits, and wooded sandy areas <sup>(1)</sup>
<i>Rana sphenoccephala utricularus</i>	southern leopard frog	-	SSC	Wet, open areas such as grasslands, marshes, and swales with slow-flowing water <sup>(2)</sup>
<b>Reptiles</b>				
<i>Carphophis amoenus</i>	eastern worm snake	-	SSC	Mesic, wooded or partially wooded areas, often near wetlands or farm fields <sup>(1)</sup>
<i>Clemmys guttata</i>	spotted turtle	-	SSC	Small ponds surrounded by undisturbed vegetation, marshes, swamps, and other small bodies of water <sup>(1)</sup>
<i>Clemmys insculpta</i>	wood turtle	-	SSC	Hardwood forests, fields, wet pastures, woodland marshes, and other areas adjacent to streams <sup>(1)</sup>
<i>Clemmys muhlenbergii</i>	bog turtle	FT	SE	Wet meadows with an open canopy or open boggy areas <sup>(2)</sup>
<i>Crotalus horridus</i>	timber rattlesnake	-	ST	Mountainous or hilly areas with rocky outcrops and steep ledges in deciduous or deciduous-coniferous forests <sup>(2)</sup>
<i>Heterodon platyrhinos</i>	eastern hognose snake	-	SSC	Open woods and margins, grasslands, agricultural fields, and other habitats with loose soils <sup>(1)</sup>
<i>Sceloporus undulatus</i>	northern fence lizard	-	ST	Open, rocky areas on steep slopes surrounded by oak-dominated forests <sup>(2)</sup>

5



1

Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Terrapene carolina</i>	eastern box turtle	-	SSC	Forests, grasslands, and wet meadows <sup>(1)</sup>
<b>Birds</b>				
<i>Accipiter cooperii</i>	Cooper's hawk	-	SSC	Mixed hardwood-coniferous forests, commonly near water <sup>(1)</sup>
<i>Accipiter gentilis</i>	northern goshawk	-	SSC	Mature mixed hardwood-coniferous forests <sup>(1)</sup>
<i>Accipiter striatus</i>	sharp-shinned hawk	-	SSC	Forests, open woods, and old fields <sup>(1)</sup>
<i>Ammodramus maritimus</i>	seaside sparrow	-	SSC	Coastal tidal marshes with emergent vegetation <sup>(2)</sup>
<i>Ammodramus savannarum</i>	grasshopper sparrow	-	SSC	Grasslands and abandoned fields <sup>(1)</sup>
<i>Buteo lineatus</i>	red-shouldered hawk	-	SSC	Open, moist forests and swamp margins <sup>(3)</sup>
<i>Caprimulgus vociferous</i>	whip-poor-will	-	SSC	Dry to moist open forests <sup>(1)</sup>
<i>Chordeiles minor</i>	common nighthawk	-	SSC	Open coniferous woods, grasslands, and near populated areas <sup>(1)</sup>
<i>Circus cyaneus</i>	northern harrier	-	ST	Salt and freshwater marshes, shrubland, and open grassy areas <sup>(2)</sup>
<i>Cistothorus platensis</i>	sedge wren	-	ST	Moist meadows with small bushes, boggy areas, and coastal brackish marshes <sup>(2)</sup>
<i>Dendroica cerulea</i>	cerulean warbler	-	SSC	Wet, mature hardwood forests with a dense canopy <sup>(1)</sup>
<i>Falco peregrinus</i>	peregrine falcon	-	SE	Holes or ledges in the rock on cliff faces, and on top of bridges or tall buildings in urban areas <sup>(2)</sup>
<i>Haliaeetus leucocephalus</i>	bald eagle	-	ST	Shorelines of large water bodies, such as lakes, rivers, and bays <sup>(2)</sup>

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**Table 2-6. (continued)**

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Icteria virens</i>	yellow-breasted chat	-	SSC	Thickets, overgrown pastures, woodland understory, margins of ponds and swamps, and near populated areas <sup>(1)</sup>
<i>Ixobrychus exilis</i>	least bittern	-	ST	Large marshes with stands of emergent vegetation <sup>(2)</sup>
<i>Melanerpes erythrocephalus</i>	red-headed woodpecker	-	SSC	Open forests and developed areas with trees, such as parks and gardens <sup>(1)</sup>
<i>Pandion haliaetus</i>	Osprey	-	SSC	Large bodies of water such as lakes, rivers, and seacoasts <sup>(1)</sup>
<i>Podilymbus podiceps</i>	pie-billed grebe	-	ST	Marshes and shorelines of ponds, shallow lakes or slow-moving streams in areas with emergent vegetation and open water <sup>(2)</sup>
<i>Rallus elegans</i>	king rail	-	ST	Shallow fresh to salt marshes with substantial emergent vegetation <sup>(2)</sup>
<i>Vermivora chrysoptera</i>	golden-winged warbler	-	SSC	Recently abandoned agricultural fields surrounded by trees, open areas of dense herbaceous vegetation <sup>(1)</sup>
<b>Mammals</b>				
<i>Myotis sodalis</i>	Indiana bat	FE	SE	Wooded areas with living, dying, and dead trees during the summer; caves and mines in the winter <sup>(2)</sup>
<i>Sylvilagus transitionalis</i>	New England cottontail rabbit	FC	SSC	Disturbed areas, open woods, areas with shrubs and thickets, marshes <sup>(2)</sup>
<b>Insects</b>				
<i>Callophrys henrici</i>	Henry's elfin	-	SSC	Borders and clearings of pine-oak woods <sup>(4)</sup>
<i>Erynnis persius</i>	Persius duskywing	-	SE	Stream banks, marshes, bogs, mountain prairies, and sand plains <sup>(4)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Pontia protodice</i>	checkered white	-	SSC	Dry, open habitats such as fields, roads, railroad tracks, weedy vacant lots, and sandy areas <sup>(4)</sup>
<i>Speyeria idalia</i>	regal fritillary	-	SE	Wet fields and meadows, marshes <sup>(4)</sup>
<i>Tachopteryx thoreyi</i>	gray petaltail	-	SSC	Rocky gorges in forests with small streams fed by seepage areas or fens <sup>(2)</sup>
<b>Plants</b>				
<i>Acalypha virginica</i>	Virginia three-seeded mercury	-	SE	Dry upland forests, thickets, and prairies <sup>(5)</sup>
<i>Agastache nepetoides</i>	yellow giant hyssop	-	ST	Open wooded areas, roadsides, railroads, thickets, and fencerows <sup>(2)</sup>
<i>Ageratina aromatica</i> var. <i>aromatica</i>	small white snakeroot	-	SE	Upland forests, roadsides, fencerows, and old fields <sup>(6)</sup>
<i>Agrimonia rostellata</i>	woodland agrimony	-	ST	Slopes, streambanks, and thickets in rich, mesic forests and wooded pastures <sup>(2)</sup>
<i>Amaranthus pumilus</i>	seabeach amaranth	-	SE	Sparsely vegetated areas of barrier island beaches and inlets <sup>(1)</sup>
<i>Aplectrum hyemale</i>	Puttyroot	-	SE	Upland to swampy forests <sup>(2)</sup>
<i>Arethusa bulbosa</i>	dragon's mouth orchid	-	ST	Sphagnum swamps and wet meadows <sup>(2)</sup>
<i>Aristolochia serpentaria</i>	Virginia snakeroot	-	SE	Well-drained, rocky slopes of rich wooded areas <sup>(2)</sup>
<i>Asclepias variegata</i>	white milkweed	-	SE	Open wooded areas and thickets <sup>(7)</sup>
<i>Asclepias viridiflora</i>	green milkweed	-	ST	Dry, rocky hillsides, grasslands, and open areas <sup>(2)</sup>
<i>Bidens beckii</i>	water marigold	-	ST	Slow-moving or still waters <sup>(6)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Bidens bidentoides</i>	Delmarva beggar-ticks	-	SR	Borders of freshwater tidal marshes and mudflats <sup>(2)</sup>
<i>Bidens laevis</i>	smooth bur-marigold	-	ST	Freshwater to brackish tidal marshes and mudflats <sup>(2)</sup>
<i>Blephilia ciliata</i>	downy wood mint	-	SE	Shallow soils of disturbed areas such as fields and powerline ROWs <sup>(2)</sup>
<i>Bolboschoenus maritimus paludosus</i>	seaside bulrush	-	SE	Alkaline or saline marshes, pond edges, and transient wet areas <sup>(8)</sup>
<i>Bolboschoenus novae-angliae</i>	saltmarsh bulrush	-	SE	Brackish tidal marshes <sup>(2)</sup>
<i>Botrychium oneidense</i>	blunt-lobe grape fern	-	SE	Rich, moist soils of deciduous forests <sup>(2)</sup>
<i>Bouteloua curtipendula</i> var. <i>curtipendula</i>	side-oats grama	-	SE	Dry, open areas and disturbed lands such as powerline ROWs, pastures, and bluffs along rivers <sup>(2)</sup>
<i>Callitriche terrestris</i>	terrestrial starwort	-	ST	Exposed, muddy ground in pastures, forests, and on the banks of ponds <sup>(2)</sup>
<i>Cardamine longii</i>	Long's bittercress	-	ST	Shady tidal creeks, swamps, and mudflats <sup>(2)</sup>
<i>Carex abscondita</i>	thicket sedge	-	ST	Swamps, wooded streambanks, mesic forests, and shrublands <sup>(2)</sup>
<i>Carex arcta</i>	northern clustered sedge	-	SE	Edges of reservoirs and rivers, wooded swamps, swales, and wet meadows <sup>(2)</sup>
<i>Carex bicknellii</i>	Bicknell's sedge	-	ST	Open woods, dry to mesic prairies, rocky areas with sparse vegetation <sup>(6)</sup>
<i>Carex conjuncta</i>	soft fox sedge	-	SE	Edges of streams, thickets, swales, and wet meadows <sup>(2)</sup>
<i>Carex cumulata</i>	clustered sedge	-	ST	Open rocky areas with shallow soils, such as powerline ROWs, recently burned areas, or other successional habitats <sup>(2)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Carex davisii</i>	Davis' sedge	-	ST	Near rivers, on open gravel bars of large rivers, in wet meadows, and disturbed areas <sup>(2)</sup>
<i>Carex hormathodes</i>	marsh straw sedge	-	ST	Coastal salt and brackish tidal marshes, swales on beaches, edges of swamps, and wet forests near the coast <sup>(2)</sup>
<i>Carex lupuliformis</i>	false hop sedge	-	SR	Swamps, marshes, and floodplain forests <sup>(2)</sup>
<i>Carex mesochorea</i>	midland sedge	-	SE	Dry prairies, oak forests, and roadsides <sup>(2)</sup>
<i>Carex mitchelliana</i>	Mitchell's sedge	-	ST	Edges of streams and ponds, swamps, and wet meadows <sup>(2)</sup>
<i>Carex molesta</i>	troublesome sedge	-	ST	Open wooded areas and fields <sup>(2)</sup>
<i>Carex nigromarginata</i>	black edge sedge	-	SE	Dry to mesic rocky areas in deciduous forests <sup>(2)</sup>
<i>Carex retroflexa</i>	reflexed sedge	-	SE	Rocky ledges, openings and edges of dry to mesic deciduous forests, and along paths and railroads <sup>(2)</sup>
<i>Carex seorsa</i>	weak stellate sedge	-	ST	Hardwood or conifer swamps and thickets <sup>(6)</sup>
<i>Carex straminea</i>	straw sedge	-	SE	Edges of swamps and marshes <sup>(2)</sup>
<i>Carex styloflexa</i>	bent sedge	-	SE	Wet areas of streambanks, thickets, and pine barrens; swampy woods <sup>(2)</sup>
<i>Carex typhina</i>	cattail sedge	-	ST	Wetlands, floodplain forests, sedge meadows, and flats along rivers <sup>(2)</sup>
<i>Carya laciniosa</i>	big shellbark hickory	-	ST	Rich soils in floodplains and along the banks of rivers and marshes <sup>(2)</sup>
<i>Castilleja coccinea</i>	scarlet Indian paintbrush	-	SE	Open areas, including on limestone bedrock in prairies, and fields with moist, sandy soils <sup>(2)</sup>
<i>Ceratophyllum echinatum</i>	prickly hornwort	-	ST	Quiet lakes, ponds, streams, and swamps <sup>(1)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Chamaelirium luteum</i>	fairy wand	-	ST	Moist woodlands, thickets, meadows, and swamps <sup>(2)</sup>
<i>Cheilanthes lanosa</i>	woolly lip fern	-	SE	Dry areas on rock outcrops and ledges <sup>(2)</sup>
<i>Chenopodium berlandieri</i> var. <i>macrocalycium</i>	large calyx goosefoot	-	SE	Coastal sands and beaches <sup>(6)</sup>
<i>Chenopodium rubrum</i>	red pigweed	-	ST	Brackish marshes and developed lands <sup>(5)</sup>
<i>Crassula aquatica</i>	water pigmyweed	-	SE	Rocky shores of rivers, marshes, and tidal mudflats <sup>(2)</sup>
<i>Crotalaria sagittalis</i>	Rattlebox	-	SE	Sandy soils in pastures and pine plantations <sup>(2)</sup>
<i>Cyperus echinatus</i>	globose flatsedge	-	SE	Inland disturbed areas such as roadsides and pastures <sup>(6)</sup>
<i>Cyperus flavescens</i>	yellow flatsedge	-	SE	Wet, sandy soils of roadsides, coastal pond margins, and salt marshes <sup>(2)</sup>
<i>Cyperus retrorsus</i> var. <i>retrorsus</i>	retrorse flatsedge	-	SE	Moist to dry sandy soils in open woods and thickets <sup>(6)</sup>
<i>Cypripedium parviflorum</i> var. <i>parviflorum</i>	small yellow ladyslipper	-	SE	Rich humus and decaying leaves on wooded slopes and river bluffs, moist swales, and creek margins <sup>(1)</sup>
<i>Desmodium ciliare</i>	little leaf tick-trefoil	-	ST	Dry upland forests and glades <sup>(5)</sup>
<i>Desmodium humifusum</i>	spreading tick-trefoil	-	SE	Dry, sandy soils in open pine and oak forests <sup>(9)</sup>
<i>Desmodium laevigatum</i>	smooth tick-trefoil	-	SE	Dry, upland forests <sup>(5)</sup>
<i>Desmodium nuttallii</i>	Nuttall's tick-trefoil	-	SE	Dry, upland forests; acidic gravel seeps; and dry to mesic grasslands <sup>(5)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Desmodium obtusum</i>	stiff tick-trefoil	-	SE	Open woods, old fields, and grasslands <sup>(2)</sup>
<i>Desmodium pauciflorum</i>	small-flowered tick-trefoil	-	SE	Upland forests <sup>(5)</sup>
<i>Dichanthelium oligosanthes</i> var. <i>oligosanthes</i>	few-flowered panic grass	-	SE	Upland forests, prairies, lake margins, and glades <sup>(5)</sup>
<i>Digitaria filiformis</i>	slender crabgrass	-	ST	Sandy soils in dry forests and prairies, sandstone glades, and agricultural fields <sup>(5)</sup>
<i>Diospyros virginiana</i>	Persimmon	-	ST	Rocky slopes, dry woodlands, open pastures, and swamp margins <sup>(8)</sup>
<i>Draba reptans</i>	Carolina whitlow grass	-	ST	Open areas with limestone outcrops, dry sandy soils, and cedar glades <sup>(2)</sup>
<i>Eclipta prostrata</i>	false daisy	-	SE	Lake margins, mesic to wet prairies, and fields and other developed lands <sup>(5)</sup>
<i>Eleocharis equisetoides</i>	knotted spikerush	-	ST	Shallow ponds in coastal areas <sup>(2)</sup>
<i>Eleocharis ovata</i>	blunt spikerush	-	SE	Marshy areas near rivers, shallow ponds <sup>(2)</sup>
<i>Eleocharis quadrangulata</i>	angled spikerush	-	SE	Lake margins and shallow ponds <sup>(2)</sup>
<i>Eleocharis tricostata</i>	three-ribbed spikerush	-	SE	Wet depressions, edges of ponds, pine barrens, and grasslands <sup>(6)</sup>
<i>Eleocharis tuberculosa</i>	long-tubercled spikerush	-	ST	Lake margins, ponds, streams, marshes, grasslands, and disturbed lands <sup>(6)</sup>
<i>Equisetum palustre</i>	marsh horsetail	-	ST	Wet areas such as marshes, stream margins, meadows, and wooded areas <sup>(2)</sup>
<i>Equisetum pratense</i>	meadow horsetail	-	ST	Rocky soils, riverbanks, roadsides, and railroad ditches <sup>(2)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Euonymus americanus</i>	American strawberry bush	-	SE	Wooded areas, stream banks, and thickets in sandy soils <sup>(8)</sup>
<i>Fimbristylis castanea</i>	marsh fimbry	-	ST	Brackish and salt marshes <sup>(6)</sup>
<i>Fuirena pumila</i>	dwarf umbrella sedge	-	SR	Pond margins, seeps, and wet grasslands and swales <sup>(6)</sup>
<i>Gamochaeta purpurea</i>	purple everlasting	-	SE	Open, disturbed areas such as fields, roadsides, and edges of forests <sup>(6)</sup>
<i>Geranium carolinianum</i> var. <i>sphaerospermum</i>	Carolina cranesbill	-	ST	Dry upland forests and prairies, limestone glades, agricultural fields, and pastures <sup>(5)</sup>
<i>Geum vernum</i>	spring avens	-	SE	Organic soils of forested hillsides, thickets, and floodplains <sup>(1)</sup>
<i>Geum virginianum</i>	rough avens	-	SE	Hardwood forests, roadsides, wooded swamps, and riverbanks <sup>(2)</sup>
<i>Hottonia inflata</i>	Featherfoil	-	ST	Ponds and swales in coastal areas <sup>(2)</sup>
<i>Houstonia purpurea</i> var. <i>purpurea</i>	purple bluets	-	SE	Well-drained hillsides in mesic forests <sup>(10)</sup>
<i>Hylotelephium telephioides</i>	live forever	-	SE	Rocky cliffs and outcrops <sup>(7)</sup>
<i>Hypericum prolificum</i>	shrubby St. John's wort	-	ST	Disturbed areas such as roadsides and powerline ROWs, fields, thickets, and margins of swamps <sup>(2)</sup>
<i>Iris prismatica</i>	slender blue flag	-	ST	Rich, mucky soils <sup>(6)</sup>
<i>Jeffersonia diphylla</i>	twin leaf	-	ST	Calcareous soils in mesic forests, semishaded rocky hillsides, and exposed limestone <sup>(2)</sup>
<i>Lechea pulchella</i> var. <i>moniliformis</i>	bead pinweed	-	SE	Dry to mesic upland forests <sup>(5)</sup>
<i>Lechea racemulosa</i>	Illinois pinweed	-	SR	Infertile or sandy soils <sup>(11)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Lechea tenuifolia</i>	slender pinweed	-	ST	Dry, open, grassy areas, wooded areas with pines or oaks, rocky hillsides, and disturbed areas <sup>(2)</sup>
<i>Lemna perpusilla</i>	minute duckweed	-	SE	Still waters in ponds and lakes <sup>(6)</sup>
<i>Lespedeza angustifolia</i>	narrow-leaved bush clover	-	SR	Dry sandy soil <sup>(12)</sup>
<i>Lespedeza repens</i>	trailing bush clover	-	SR	Dry upland forests and dry to mesic grasslands <sup>(5)</sup>
<i>Lespedeza stuevei</i>	velvety bush clover	-	ST	Dry, rocky areas in woodlands and clearings, old fields, and roadsides <sup>(1)</sup>
<i>Lespedeza violacea</i>	violet bush clover	-	SR	Dry to mesic grasslands, thickets, and upland forests <sup>(5)</sup>
<i>Liatris scariosa</i> var. <i>novae-angliae</i>	northern blazing star	-	ST	Dry, sandy grasslands, rocky hilltops, and sandy roadsides <sup>(2)</sup>
<i>Lilaeopsis chinensis</i>	eastern grasswort	-	ST	Margins of peaty or rocky intertidal and brackish marshes <sup>(2)</sup>
<i>Limosella australis</i>	Mudwort	-	SR	Edges of freshwater pools and intertidal fresh to brackish water bodies <sup>(1)</sup>
<i>Linum striatum</i>	stiff yellow flax	-	SR	Sandy soils in mesic to wet forests, swamps, seeps, and lake margins <sup>(5)</sup>
<i>Liparis liliifolia</i>	large twayblade	-	SE	Peaty soils in hardwood swamps, dry wooded slopes, and railroad ditches <sup>(2)</sup>
<i>Lipocarpa micrantha</i>	dwarf bulrush	-	SE	Sandy soils along pond margins and riverbanks <sup>(2)</sup>
<i>Listera convallarioides</i>	broad-lipped twayblade	-	SE	Wet sandy soils in white cedar swamps <sup>(2)</sup>
<i>Ludwigia sphaerocarpa</i>	globe-fruited ludwigia	-	ST	Margins of shallow ponds and wetland channels in pine barrens, clearings in shrub swamps <sup>(2)</sup>
<i>Lycopus rubellus</i>	gypsy wort	-	SE	Marshes and inundated swamps <sup>(2)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Lysimachia hybrida</i>	lance-leaved loosestrife	-	SE	Wet upland and floodplain forests, wet prairies, lake margins, swamps, and seeps <sup>(5)</sup>
<i>Magnolia virginiana</i>	sweetbay magnolia	-	SE	Along bays; in swamps; in wet, forested lowlands; and in grasslands <sup>(6)</sup>
<i>Melanthium virginicum</i>	Virginia bunchflower	-	SE	Railroad ditches, grasslands, marshes, and wet wooded areas <sup>(6)</sup>
<i>Mimulus alatus</i>	winged monkey-flower	-	SR	Muddy shores of lakes, swamps, and wet forests <sup>(5)</sup>
<i>Monarda clinopodia</i>	basil balm	-	SE	Ravines in mesic forests, thickets, and lakeshores <sup>(5)</sup>
<i>Oldenlandia uniflora</i>	clustered bluets	-	SE	Sandy soils in swamps, bogs, and margins of streams and reservoirs <sup>(13)</sup>
<i>Oligoneuron rigidum</i> var. <i>rigidum</i>	stiff leaf goldenrod	-	ST	Dry open areas such as rocky slopes, thickets, edges of forests, and grasslands <sup>(2)</sup>
<i>Onosmodium virginianum</i>	Virginia false gromwell	-	SE	Open coastal uplands, inland rocky wooded areas in dry soils <sup>(2)</sup>
<i>Orontium aquaticum</i>	golden club	-	ST	Freshwater swamps and tidal marshes, and sphagnum swamps, fens, and coastal ponds <sup>(2)</sup>
<i>Oxalis violacea</i>	violet wood sorrel	-	ST	Rich, rocky soils on steep hillsides and open summits <sup>(2)</sup>
<i>Panicum rigidulum</i> var. <i>elongatum</i>	tall flat panic grass	-	SE	Mesic flatwoods and forested lowlands, prairies, and edges of lakes <sup>(5)</sup>
<i>Paspalum laeve</i>	field beadgrass	-	SE	Sandy soils in open woodlands and prairies <sup>(1)</sup>
<i>Pinus virginiana</i>	Virginia pine	-	SE	Areas of poor soils such as maritime oak forests, pine/oak barrens, and rocky summits <sup>(2)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Platanthera ciliaris</i>	orange fringed orchid	-	SE	Wide range of habitats from wet, rich soils to dry, rocky mountainous areas <sup>(1)</sup>
<i>Platanthera hookeri</i>	Hooker's orchid	-	SE	Pine or poplar forests with open understories in dry to moist soils <sup>(2)</sup>
<i>Podostemum ceratophyllum</i>	Riverweed	-	ST	In fast-flowing streams and rivers with rocky bottoms <sup>(2)</sup>
<i>Polygala lutea</i>	orange milkwort	-	SE	Wet, sandy soils and marshes in pine barrens <sup>(14)</sup>
<i>Polygonum douglasii douglasii</i>	Douglas' knotweed	-	ST	Disturbed, dry areas such as rocky outcrops with sandy soils <sup>(6)</sup>
<i>Polygonum erectum</i>	erect knotweed	-	SE	Developed areas such as roadsides, sidewalks, and lawns and floodplain forests <sup>(5)</sup>
<i>Polygonum glaucum</i>	seabeach knotweed	-	SR	Coastal beaches <sup>(6)</sup>
<i>Polygonum tenue</i>	slender knotweed	-	SR	Dry, acidic soils in open areas such as rocky summits, scrubby wooded sites, and abandoned agricultural fields <sup>(5)</sup>
<i>Potamogeton diversifolius</i>	water thread pondweed	-	SE	Marshes and pond margins <sup>(2)</sup>
<i>Potamogeton pulcher</i>	spotted pondweed	-	ST	Ponds, marshes, and slow-moving streams and rivers <sup>(2)</sup>
<i>Pterospora andromedea</i>	giant pine drops	-	SE	Thick humus of coniferous forests <sup>(14)</sup>
<i>Pycnanthemum clinopodioides</i>	basil mountain mint	-	SE	Rocky soils in dry forests and grasslands <sup>(2)</sup>
<i>Pycnanthemum muticum</i>	blunt mountain mint	-	ST	Wet sandy soils in coastal swales, pond margins, swamps, and roadside thickets <sup>(2)</sup>
<i>Pycnanthemum torrei</i>	Torrey's mountain mint	-	SE	Dry, open areas of rocky hilltops, roadside ditches, and red cedar barrens <sup>(2)</sup>

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Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Ranunculus micranthus</i>	small-flowered crowfoot	-	ST	Partially shaded summits in forests <sup>(2)</sup>
<i>Rhynchospora scirpoides</i>	long-beaked beakrush	-	SR	Wet, sandy soils of pond margins in coastal pine barrens <sup>(2)</sup>
<i>Sabatia angularis</i>	rose pink	-	SE	Rocky soils in open woods, sandy soils, and pond margins <sup>(5)</sup>
<i>Sagittaria montevidensis</i> var. <i>spongiosa</i>	spongy arrowhead	-	ST	Mudflats in freshwater to brackish tidal marshes <sup>(2)</sup>
<i>Salvia lyrata</i>	lyre leaf sage	-	SE	Rich, rocky soils in open forests; pastures with sandy soils <sup>(14)</sup>
<i>Scirpus georgianus</i>	Georgia bulrush	-	SE	Moist grasslands and borders of wet forests and marshes <sup>(2)</sup>
<i>Scleria pauciflora</i> var. <i>caroliniana</i>	few-flowered nutrush	-	SE	Mesic to wet woods, grasslands, and bogs <sup>(6)</sup>
<i>Scutellaria integrifolia</i>	hyssop skullcap	-	SE	Fields and clearings in upland forests, roadside ditches, swamps, and pond margins <sup>(2)</sup>
<i>Sericocarpus linifolius</i>	flax leaf whitetop	-	ST	Open woods, roadside ditches, and fields <sup>(6)</sup>
<i>Sisyrinchium mucronatum</i>	Michaux's blue-eyed grass	-	SE	Fields, roadside ditches, edges of forests, and coastal grasslands <sup>(2)</sup>
<i>Smilax pulverulenta</i>	Jacob's ladder	-	SE	Rich, limestone soils in woods and thickets <sup>(6)</sup>
<i>Solidago latissimifolia</i>	coastal goldenrod	-	SE	Coastal freshwater to brackish swamps and thickets <sup>(6)</sup>
<i>Solidago sempervirens</i> var. <i>mexicana</i>	seaside goldenrod	-	SE	Sand dunes and brackish marsh margins <sup>(6)</sup>
<i>Sporobolus clandestinus</i>	rough rush grass	-	SE	Sandy soils in open forests, prairies, and limestone bluffs <sup>(5)</sup>
<i>Suaeda linearis</i>	narrow leaf sea blite	-	SE	Beaches and salt marshes <sup>(6)</sup>

2

1

Table 2-6 (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Symphyotrichum boreale</i>	northern bog aster	-	ST	Fens, clearings within coniferous swamps, meadows, shores of ponds and lakes <sup>(2)</sup>
<i>Symphyotrichum subulatum</i> var. <i>subulatum</i>	saltmarsh aster	-	ST	Saltwater marshes, margins of tidal creeks and salt ponds, and brackish swales among sand dunes <sup>(2)</sup>
<i>Trichomanes intricatum</i>	Appalachian bristle fern	-	SE	Protected cracks and crevices in rock <sup>(1)</sup>
<i>Trichostema setaceum</i>	tiny blue curls	-	SE	Dry forests, old fields, rocky outcrops, and coastal sandy soils <sup>(13)</sup>
<i>Tripsacum dactyloides</i>	northern gamma grass	-	ST	Mesic grasslands and margins of streams and salt marshes <sup>(8)</sup>
<i>Trollius laxus</i>	spreading globeflower	-	SR	Limestone soils in meadows and open swamps <sup>(6)</sup>
<i>Utricularia minor</i>	lesser bladderwort	-	ST	Wet meadows and still waters of shallow ponds <sup>(5)</sup>
<i>Utricularia radiata</i>	small floating bladderwort	-	ST	Ponds and slow-moving waters <sup>(2)</sup>
<i>Veronicastrum virginicum</i>	Culver's root	-	ST	Moist prairies and woods, meadows, and banks of streams <sup>(1)</sup>
<i>Viburnum dentatum</i> var. <i>venosum</i>	southern arrowwood	-	ST	Moist soils in open woods and edges of streams <sup>(8)</sup>
<i>Viburnum nudum</i> var. <i>nudum</i>	possum haw	-	SE	Hardwood swamps <sup>(13)</sup>
<i>Viola brittoniana</i>	coast violet	-	SE	Wet soils in borders of woodlands, meadows, and near coastal streams and rivers <sup>(1)</sup>
<i>Viola hirsutula</i>	southern wood violet	-	SE	Shallow, rocky soils in rich woods <sup>(15)</sup>
<i>Viola primulifolia</i>	primrose leaf violet	-	ST	Sandy soils in marsh edges, meadows <sup>(5)</sup>

2

1

**Table 2-6** (continued)

Scientific Name	Common Name	Federal Status <sup>(a)</sup>	New York State Status <sup>(b)</sup>	Habitat <sup>(c)</sup>
<i>Vitis vulpina</i>	winter grape	-	SE	Mesic to wet forests, lakeshores, agricultural fields <sup>(5)</sup>

2 <sup>(a)</sup>Federal listing status definitions: FC = Federal Candidate Species, FE = Federally Endangered, FT = Federally  
 3 Threatened (FWS 2008b)

4 <sup>(b)</sup>State listing status definitions: SE = State Endangered, SC = Species of Special Concern in New York, SR = State  
 5 Rare, ST = State Threatened (NYSDEC 2008h; NYNHP 2007)

6 <sup>(c)</sup> Habitat information sources:

7 1 NatureServe 2007

8 2 NYNHP 2008d

9 3 NYSDEC 2008i

10 4 Opler et al. 2006

11 5 Iverson et al. 1999

12 6 FNA Editorial Committee 1993+

13 7 Niering and Olmstead 1979

14 8 NRCS 2008

15 9 CPC 2008

16 10 NCSU 2008

17 11 Nearctica 2008

18 12 Britton and Brown 1913

19 13 KSNPC 2008

20 14 Lady Bird Johnson Wildflower Center Native Plant Information Network (NPIN) 2008

21 15 Pullen Herbarium 2008

22 **2.2.7 Radiological Impacts**

23 The following discussion focuses on the radiological environmental impacts and the dose  
 24 impacts to the public from normal plant operations at the IP2 and IP3 site. Radiological  
 25 releases, doses to members of the public, and the resultant environmental impacts, are  
 26 summarized in two IP2 and IP3 reports—the Annual Radioactive Effluent Release Report and  
 27 the Annual Radiological Environmental Operating Report. Limits for all radiological releases are  
 28 specified in the IP2 and IP3 ODCM and are used by Entergy to meet Federal radiation  
 29 protection limits and standards.

30 Radiological Environmental Impacts

31 Entergy conducts a radiological environmental monitoring program (REMP) in which radiological  
 32 impacts to the environment and the public around the IP2 and IP3 site are monitored,  
 33 documented, and compared to NRC standards. Entergy summarizes the results of its REMP in  
 34 an Annual Radiological Environmental Operating Report (Entergy 2007d; all items in this section  
 35 are from Entergy 2007d). The objectives of the IP2 and IP3 REMPs are the following:

- 36 • to enable the identification and quantification of changes in the radioactivity of the area
- 37 • to measure radionuclide concentrations in the environment attributable to operations of
- 38 the IP2 and IP3 site

39 Environmental monitoring and surveillance have been conducted at IP2 and IP3 since 1958,  
 40 4 years before the startup of IP1. The preoperational program was designed and implemented  
 41 to determine the background radioactivity and to measure the variations in activity levels from

1 natural and other sources in the vicinity, as well as fallout from nuclear weapons tests. The  
2 preoperational radiological data include both natural and manmade sources of environmental  
3 radioactivity. These background environmental data permit the detection and assessment of  
4 current levels of environmental activity attributable to plant operations.

5 The REMP at IP2 and IP3 directs Entergy to sample environmental media in the environs  
6 around the site to analyze and measure the radioactivity levels that may be present. The REMP  
7 designates sampling locations for the collection of environmental media for analysis. These  
8 sampling locations are divided into indicator and control locations. Indicator locations are  
9 established near the site, where the presence of radioactivity of plant origin is most likely to be  
10 detected. Control locations are established farther away (and upwind/upstream, where  
11 applicable) from the site, where the level would not generally be affected by plant discharges or  
12 effluents. The use of indicator and control locations enables the identification of potential  
13 sources of detected radioactivity as either background or from plant operations. The media  
14 samples are representative of the radiation exposure pathways to the public from all plant  
15 radioactive effluents. A total of 1342 analyses was performed in 2006. This amount is higher  
16 than required because of the inclusion of additional sample locations and media.

17 The REMP is used to measure the direct radiation and the airborne and waterborne pathway  
18 activity in the vicinity of the IP2 and IP3 site. Direct radiation pathways include radiation from  
19 buildings and plant structures, airborne material that may be released from the plant, or from  
20 cosmic radiation, fallout, and the naturally occurring radioactive materials in soil, air, and water.  
21 Analysis of thermoluminescent dosimeters (TLDs), which measure direct radiation, indicated  
22 that there were no increased radiation levels attributable to plant operations.

23 The airborne pathway includes measurements of air, precipitation, drinking water, and broadleaf  
24 vegetation samples. The airborne pathway measurements indicated that there was no  
25 increased radioactivity attributable to 2006 IP2 and IP3 station operation.

26 The waterborne pathway consists of Hudson River water, fish and invertebrates, aquatic  
27 vegetation, bottom sediment, and shoreline sediment. Measurements of the media comprising  
28 the waterborne pathway indicated that, while some very low levels of plant discharged  
29 radioactivity were detected, there was no adverse radiological impact to the surrounding  
30 environment attributed to IP2 and IP3 operations (Entergy 2007d).

### 31 2006 REMP Results

32 The following is a detailed discussion of the radionuclides detected by the 2006 REMP that may  
33 be attributable to current plant operations (all information summarized from Entergy 2007d).

34 During 2006, cesium-137, strontium-90, and tritium were the only potentially plant-related  
35 radionuclides detected in some environmental samples. Tritium may be present in the local  
36 environment because of either natural occurrence, other manmade sources, or plant operations.  
37 Small amounts of tritium were detected in one of four quarterly composite samples from the  
38 discharge mixing zone (386 picocuries per liter (pCi/L) (14.28 becquerel per liter (Bq/L))). This  
39 composite sample was detected at a value much lower than the required lower limit of detection  
40 (LLD) of 3000 pCi/L (111 Bq/L).

41 In 2006, the detected radionuclide(s) attributable to past atmospheric weapons testing consisted  
42 of cesium-137 and strontium-90 in some media. The levels detected for cesium-137 were  
43 consistent with the historical levels of radionuclides resulting from weapons tests as measured

## Plant and the Environment

1 in previous years. Before 2006, strontium-90 analysis had not been conducted since 1984, so  
2 comparison to recent historical levels is not possible. However, the low levels detected in the  
3 environment are consistent with decayed quantities of activity from historic atmospheric  
4 weapons testing. Strontium-90 was detected in four fish and invertebrate samples, three in the  
5 control samples and one in the indicator samples. Since the levels detected were comparable  
6 in the indicator and control location samples, atmospheric weapons testing is the likely cause.  
7 Of 18 special water samples, 5 indicated strontium-90 at levels close to the level of detection, at  
8 an average of 0.78 pCi/L (0.028 Bq/L). All of these detections are considered to be residual  
9 levels from atmospheric weapons tests.

10 Iodine-131 is also produced in fission reactors but can result from nonplant-related manmade  
11 sources (e.g., medical administrations). Iodine-131 was not detected in 2006. Cobalt-58 and  
12 cobalt-60 are activation/corrosion products also related to plant operations. They are produced  
13 by neutron activation in the reactor core. As cobalt-58 has a much shorter half-life, its absence  
14 “dates” the presence of cobalt-60 as residual. When significant concentrations of cobalt-60 are  
15 detected but no cobalt-58, there is an increased likelihood that the cobalt-60 results from  
16 residual cobalt-60 from past operations. There was no cobalt-58 or cobalt-60 detected in the  
17 2006 REMP, though cobalt-58 and cobalt-60 have been observed in previous years.

18 Data resulting from analysis of the special water samples for gamma emitters, tritium analysis,  
19 and strontium-90 show that 18 samples were analyzed for strontium-90, and 5 of them showed  
20 detectable amounts of strontium-90. All of the results were very low (with a range of 0.49–  
21 1.26 pCi/L (0.018–0.046 Bq/L)) and within the range considered to be residual levels from  
22 atmospheric weapons tests. Other than the above, only naturally occurring radionuclides were  
23 detected in the special water samples.

24 The results of the gamma spectroscopy analyses of the monthly drinking water samples and  
25 results of tritium analysis of quarterly composites showed that, other than naturally occurring  
26 radionuclides, no radionuclides from plant operation were detected in drinking water samples.  
27 The data indicate that operation of IP2 and IP3 had no detectable radiological effect on drinking  
28 water.

29 The results of the analysis of bottom sediment samples for cesium-137 showed that it was  
30 detected at 7 of 10 indicator station samples, and at 1 of 3 control station samples. Cesium-134  
31 was not detected in any bottom sediment samples. The lack of cesium-134 suggests that the  
32 primary source of the cesium-137 in bottom sediment is from historical plant releases at least  
33 several years old and from residual weapons test fallout.

34 While not required by the ODCM, strontium-90 analysis was conducted at three indicator  
35 locations and one control location in August 2006. Strontium-90 was not identified in any of the  
36 samples. The detection of cesium-137 in bottom sediment has been generally decreasing over  
37 the last 10 years, and cesium-134 has not been detected in bottom sediment since 2002. The  
38 data for 2006 are consistent with but slightly lower than historical levels.

39 In summary, IP2- and IP3-related radionuclides were detected in 2006; however, residual  
40 radioactivity from atmospheric weapons tests and naturally occurring radioactivity were the  
41 predominant sources of radioactivity in the samples collected. The 2006 levels of radionuclides  
42 in the environment surrounding IP2 and IP3 are well below the NRC’s reporting levels as a  
43 result of IP2 and IP3 operations. The radioactivity levels in the environment were within the  
44 historical ranges (i.e., previous levels resulting from natural and manmade sources for the



1 detected radionuclides). Further, IP2 and IP3 operations did not result in an adverse impact to  
2 the public greater than environmental background levels. (Entergy 2007d)

### 3 2009 REMP Results

4 Because of the time period between the Staff's original review of the REMP data and the  
5 issuance of the final SEIS, the Staff extended the scope of its review to include the most current  
6 available data from the 2009 REMP report (all data from Entergy 2010b).

7 The following is a summary of the results of 2009 radiological environmental monitoring  
8 program contained in the applicant's annual REMP report.

#### 9 *Direct Radiation*

10 The 2009 and previous years' data show that there is no measurable direct radiation in the  
11 environment due to the operation of the Indian Point site.

#### 12 *Airborne Particulates and Radioiodine*

13 No airborne radioactivity attributable to the operation of Indian Point was detected in 2009.

#### 14 *Hudson River Water*

15 No radionuclides other than those that are naturally occurring were detected in the Hudson  
16 River Water samples.

#### 17 *Drinking Water*

18 The data indicates that operation of the Indian Point units had no detectable radiological impact  
19 on drinking water.

#### 20 *Hudson River Shoreline Soil*

21 Cs-137 has been and continues to be present in this media, both at indicator and control  
22 locations, at a consistent level over the past ten years.

#### 23 *Broad Leaf Vegetation*

24 The detection of low levels of Cs-137 has occurred sporadically at both indicator and control  
25 locations at relatively low concentrations for the past ten years and not at all in the last five  
26 years; however, Cs-137 was not detected in 2009.

#### 27 *Fish and Invertebrates*

28 The fish and invertebrate sample analysis results showed there were no plant related gamma  
29 emitting radionuclides detected in 2009. However, the results for Sr-90 in fish and invertebrate  
30 samples were reported as not reliable and under review. When the results are available and  
31 certified, Entergy will submit them as an addendum to the REMP report. The NRC staff  
32 reviewed the 2008 results for Sr-90 in fish and invertebrates, in place of the 2009 results. As in  
33 2009, no plant related gamma emitting radionuclides were detected in the samples. Sr-90 was  
34 found in two or six indicator samples (8.8 pCi/kg average) in the vicinity of the plant. Sr-90 was  
35 also found in two of six control samples (16.3 pCi/kg average) located approximately 20 miles  
36 upriver from the plant. The lower limit of detection (i.e., sensitivity of the analysis) was  
37 approximately 5 pCi/kg. The NRC's reporting level (i.e., the concentration value in an  
38 environmental sample, if exceeded, which must be reported to the NRC) for Sr-90 in fish  
39 samples is 40 pCi/kg.

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### 1 *Aquatic Vegetation*

2 Positive results for Cs-137 (17.3 +/- 4.1 pCi/kg) were reported for the sampling location at Lents  
3 Cove. However, the amount was at a level below the lower limit of detection of the measuring  
4 instrument. At this level even activity-free samples would, about 5% of the time, show a positive  
5 result due to normal background statistical fluctuations. In the historical record, a 17 pCi/kg  
6 result was reported for a 2005 aquatic vegetation sample. There are about five samples per  
7 year, varying from 3 to 10, going back to 2005. No I-131 was detected.

### 8 *Hudson River Bottom Sediment*

9 Cs-137 was detected at six of six indicator station samples and at one of two control station  
10 samples. This frequency of detection is not unusual. Cs-134 was not detected in any bottom  
11 sediment samples. The lack of Cs-134 suggests that the primary source of the Cs-137 in bottom  
12 sediment is from historical plant releases over the years and from residual weapons test fallout.  
13 Notably, the discharge canal bottom sediments were 232 pCi/kg and 1810 pCi/kg on samples  
14 taken three months apart. There is nothing in effluent release data and in monitoring well data  
15 that corresponds to this difference, yet the larger result is significantly different from other  
16 indicator and control locations from 2009 and the historical record. The average in 2009 is 493  
17 pCi/kg. This is consistent with historical annual average concentration for indicator locations.  
18 Samples taken in 2010 will be examined for their corroborative value. The detection of Cs-137  
19 in bottom sediment generally decreased from an average of 1200 pCi/kg in the early 1990s to  
20 500 pCi/kg in the mid-1990s to a recent value of 250 pCi/kg over the last three years. Cs-134  
21 has not been detected in bottom sediment since 2002.

### 22 *Precipitation*

23 Other than naturally occurring radionuclides, no radionuclides were detected in precipitation  
24 samples. A review of historical data over the last 10 years indicates tritium had been detected in  
25 both indicator and control precipitation samples in 1999; however, there have been no instances  
26 of positive values since that time.

### 27 *Soil*

28 Other than naturally occurring radionuclides, no plant-related activity was detected in any of the  
29 soil samples.

### 30 *Groundwater*

31 Tritium was detected at very low concentrations in seven of the 40 groundwater samples  
32 analyzed. The amount detected ranged from 193 to 329 pCi/L and averaged 244 pCi/L - which  
33 are well below the required LLD of 3000 pCi/L. Other than tritium, there were no potentially  
34 plant-related radionuclides detected in the groundwater samples.

### 35 *Land Use Census*

36 A census was performed in the vicinity of Indian Point in 2009. This census consisted of a milch  
37 animal and a residence census. The results of the 2009 census were generally same as the  
38 2007 census results. The New York Agricultural Statistic Service showed there were no animals  
39 producing milk for human consumption found 4-8 within 5 miles (8 km) of the plant. Field  
40 observations also yielded no milching animal locations within five miles. The 2009 land use  
41 census indicated there were no new residences that were closer in proximity to IPEC.

1 *Conclusion*

2 The applicant concludes that the 2009 REMP results demonstrate the relative contributions of  
3 different radionuclide sources, both natural and anthropogenic, to the environmental  
4 concentrations. The results indicate that the fallout from previous atmospheric weapons testing  
5 continues to contribute to detection of Cs-137 in some environmental samples. There are  
6 infrequent detections of plant related radionuclides in the environs; however, the radiological  
7 effects are very low and are significantly less than those from natural background and other  
8 anthropogenic sources (Entergy 2010b).

9 The NRC staff reviewed the IP2 and IP3 annual radiological environmental operating reports for  
10 2002 through 2006 and 2009 and looked for any significant impacts to the environment or any  
11 unusual trends in the data. A multi-year period provides a representative data set that covers a  
12 broad range of activities that occur at IP2 and IP3 such as, refueling outages, non-refueling  
13 outage years, routine operation, and years where there may be significant maintenance  
14 activities

15 Based on the NRC Staff's review of the applicant's historical and 2009 REMP data, no unusual  
16 trends were observed, and the data showed that there was no significant radiological impact to  
17 the environment from operations at the IP2 and IP3 site. Small amounts of radioactive material  
18 (i.e., tritium, cesium-137, iodine-131, and strontium-90) were detected that are below NRC's  
19 reporting values for radionuclides in environmental samples. Overall, the results were  
20 comparable to historical REMP results.

21 New York State Department of Health Monitoring

22 The New York State Department of Health (NYSDOH) also performs sampling and analysis of  
23 selected independent environmental media around IP2 and IP3. The NYSDOH environmental  
24 radiation monitoring program collects various types of samples to measure the concentrations of  
25 selected radionuclides in the environment. Samples of air, water, milk, sediment, vegetation,  
26 animals, and fish are typically obtained. In addition, TLDs are used to measure environmental  
27 gamma radiation levels in the immediate proximity of IP2 and IP3. The NRC staff reviewed the  
28 published data for the years 1993 and 1994, the most current publicly available reports. The  
29 data indicated that the radiation levels observed in the environment around IP2 and IP3 were  
30 low, or consistent with background radiation, and some samples were below the detection  
31 sensitivity for the analysis. No samples exceeded any of the New York State guidelines.

32 The following information was reported in the 1993 report (NYSDOH 1994):

- 33 • Radioactivity in air samples showed low levels of gross beta activity and levels of  
34 iodine-131 were usually below detection levels.
- 35 • No milk sample was collected, as the remaining nearby dairy farm had closed.
- 36 • Radioactivity in water samples showed low levels of gross beta activity.
- 37 • Tritium levels were at typical background levels.
- 38 • The levels for other radioisotopes were low with most samples below minimum  
39 detectable levels.

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- 1 • Direct environmental radiation shows that the TLD data are typical of the normal  
2 background level in this area.
- 3 The following information was reported in the 1994 report (NYSDOH 1995):
- 4 • Radioactivity in air samples showed low levels of gross beta activity, and levels of  
5 iodine-131 were below detection levels.
- 6 • No milk samples were collected in 1994, as the last dairy farm closed in 1992.
- 7 • Radioactivity in water samples showed low levels of gross beta activity.
- 8 • Tritium levels were at typical background levels.
- 9 • The levels for other radioisotopes were low with most samples below minimum  
10 detectable levels.
- 11 • Radioactivity in fish samples showed that naturally occurring potassium-40 is  
12 responsible for most of the activity. All other isotopes are below detectable levels.
- 13 • Direct environmental radiation values for the TLD data are typical of the normal  
14 background level in this area.

15 | Groundwater Contamination and Monitoring

16 | In August of 2005, Entergy discovered tritium contamination in groundwater outside the IP2  
17 | spent fuel pool (SFP). As a result, Entergy began an on-site and off-site groundwater  
18 | monitoring program (in September of 2005) in addition to the routine REMP. Entergy used this  
19 | monitoring program to characterize the on-site contamination, to quantify and determine its on-  
20 | site and off-site radiological impact to the workers, public and surrounding environment, and to  
21 | aid in identification and repair of any leaking systems, structures or components (Entergy  
22 | 2006d).

23 | In Section 5.1 of its ER, Entergy identified the release of radionuclides to groundwater as a  
24 | potentially new issue based on NRC staff analysis in a previous license renewal proceeding. In  
25 | its discussion of the issue, Entergy concluded that the radionuclide release does not affect the  
26 | onsite workforce, and that Entergy anticipated the leakage would not affect other environmental  
27 | resources, such as water use, land use, terrestrial or aquatic ecology, air quality, or  
28 | socioeconomics. In addition, Entergy asserted that no NRC dose limits have been exceeded,  
29 | and EPA drinking water limits are not applicable since no drinking water exposure pathway  
30 | exists (Entergy 2007a).

31 | Entergy has taken measures to control releases from the IP1 and IP2 SFPs using waste  
32 | management equipment and processes. Additional monitoring actions have also been  
33 | developed as part of the site's groundwater monitoring program, which supplements the existing  
34 | REMP to monitor potential impacts of site operations throughout the license renewal term and to  
35 | monitor potential impacts of site operations and waste and effluent management programs  
36 | (Entergy 2007a).

37 | In addition to Entergy's assertions in the IP2 and IP3 ER, Entergy provided the NRC additional  
38 | information, by report dated January 11, 2008, that included the conclusions of a 2-year  
39 | investigation of onsite leaks to groundwater that it had initiated following the 2005 discovery of

1 SFP leakage. Entergy stated that it had characterized and modeled the affected groundwater  
2 regime, and that it had identified sources of leakage and determined the radiological impacts  
3 resulting from this leakage. In the same letter, Entergy reported that it had begun a long-term  
4 groundwater monitoring program and initiated a remediation program to address the site  
5 groundwater conditions. Entergy also stated that it had performed radiological dose impact  
6 assessments and that it will continue to perform them, and report results to the NRC in each  
7 annual Radiological Effluent Release Report. Radiological Effluent Release Reports are  
8 publically available through the NRC. Entergy's investigation indicates that the only noteworthy  
9 dose pathway resulting from contaminated groundwater migration to the Hudson River is  
10 through the consumption of fish and invertebrates from the river. According to Entergy, the  
11 resultant calculated dose to a member of the public is below 1/100 of the federal limits (Entergy  
12 2008c).

13 As part of the NRC's ongoing regulatory oversight program, the NRC staff performed an  
14 extensive inspection of Entergy's actions to respond to the abnormal leakage as well Entergy's  
15 groundwater monitoring program. This inspection focused on assessing Entergy's groundwater  
16 investigation to evaluate the extent of contamination, as well as the effectiveness of actions  
17 taken or planned to effect mitigation and remediation of the condition. The NRC staff adopts the  
18 findings and content of the inspection report, released by letter dated May 13, 2008, in this SEIS  
19 (NRC 2008). The inspection findings include the following key points (NRC 2008):

20 (12) Currently, there is no drinking water exposure pathway to humans that is affected by the  
21 contaminated groundwater conditions at the IP2 and IP3 site. Potable water sources in  
22 the area of concern are not presently derived from groundwater sources or the Hudson  
23 River, a fact confirmed by the New York State Department of Health. The principal  
24 exposure pathway to humans is from the assumed consumption of aquatic foods (i.e.,  
25 fish or invertebrates) taken from the Hudson River in the vicinity of Indian Point that has  
26 the potential to be affected by radiological effluent releases. However, no radioactivity  
27 distinguishable from background was detected during the most recent sampling and  
28 analysis of fish and crabs taken from the affected portion of the Hudson River and  
29 designated control locations.

30 (13) The annual calculated exposure to the maximum exposed hypothetical individual, based  
31 on application of Regulatory Guide 1.109, "Calculation of Annual Doses to Man from  
32 Routine Release of Reactor Effluents for the Purpose of Evaluation Compliance with 10  
33 CFR Part 50, Appendix I," relative to the liquid effluent aquatic food exposure pathway is  
34 currently, and expected to remain, less than 0.1 % of the NRC's "As Low As is  
35 Reasonably Achievable (ALARA)" guidelines of Appendix I of Part 50 (3 mrem/yr (0.03  
36 mSv/yr) total body and 10 mrem/yr (0.1 mSv/yr) maximum organ), which is considered to  
37 be negligible with respect to public health and safety, and the environment.

38 Finally, by letter dated May 15, 2008, Entergy reaffirmed its January 11<sup>th</sup> letter and provided the  
39 NRC a list of commitments for further actions to address groundwater contamination (Entergy  
40 2008d). Entergy indicated that it would remove spent fuel from the IP1 SFP, process remaining  
41 water and "bottoms" from the IP1 SFP, and incorporate aspects of the long-term groundwater  
42 monitoring program in the site's ODCM and associated procedures. To date, NRC staff has  
43 observed that Entergy has removed all spent fuel from the IP1 SFP and drained the pool, as  
44 well as incorporated aspects of the monitoring program into the ODCM and associated  
45 procedures. As of October, 2009, Entergy had drained and cleaned the IP1 SFP (NRC 2009).

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1 Also, NRC findings since the 2008 inspection reports have been consistent with the 2008  
2 inspection report.

3 New York State Groundwater Investigations

4 New York State performed its own groundwater investigation of the tritium leakage at Indian  
5 Point and reported its findings in a Community Fact Sheet (NYSDEC 2007d) as follows:

6 The New York State Department of Environmental Conservation (DEC) and the  
7 New York State Department of Health (DOH) have been participating in the  
8 ongoing groundwater investigation of radionuclide contamination in groundwater  
9 under the plant, and the release of that water to the Hudson River. The purpose  
10 of our involvement is to protect the interests of the citizens and the environment  
11 of the State of New York by helping to ensure that Entergy performs a timely,  
12 comprehensive characterization of site groundwater contamination, takes  
13 appropriate actions to identify and stop the sources of the leak, and undertakes  
14 any necessary remedial actions.

15 The key findings reported by New York State are listed below:

- 16 • There are no residential or municipal drinking water wells or surface reservoirs near the  
17 plant.
- 18 • There are no known impacts to any drinking water source.
- 19 • No contaminated groundwater is moving toward surrounding properties.
- 20 • Contaminated groundwater is moving into the Hudson River.
- 21 • Public exposure can occur from the groundwater entering the Hudson River through  
22 consumption of fish.
- 23 • NYSDOH has confirmed Entergy's calculated dose to humans from fish.
- 24 • Strontium-90 levels in fish near the site (18.8 pCi/kg (0.69 Bq/kg)) are no higher than in  
25 those fish collected from background locations across the State.
- 26 • Recent strontium-90 data in fish are limited. (The State plans to conduct additional  
27 sampling.)

28 Dose Impacts to the Public

29 The results of the IP2 and IP3 radiological releases into the environment are summarized in the  
30 IP2 and IP3 Annual Radioactive Effluent Release Reports. Limits for all radiological releases  
31 are specified in the IP2 and IP3 ODCMs and used to meet Federal radiation protection  
32 standards. In the draft SEIS, the NRC staff performed a review of historical radiological release  
33 data during the period 2002 through 2006 and the resultant dose calculations revealed that the  
34 calculated doses to maximally exposed individuals in the vicinity of IP2 and IP3 were a small  
35 fraction of the limits specified in the IP2 and IP3 ODCM to meet the dose design objectives in  
36 Appendix I to 10 CFR Part 50, as well as the dose limits in 10 CFR Part 20 and EPA's  
37 40 CFR Part 190, as indicated in the following summary list. The NRC staff has reviewed data  
38 from 2009 and confirmed that calculated doses to maximally exposed individuals in the vicinity

1 of IP2 and IP3 remained a small fraction of these same limits. The current results are described  
 2 in “Indian Point Units 1, 2, and 3—2009 Annual Radioactive Effluent Release Report” (Entergy  
 3 2010a). A breakdown of the calculated maximum dose to an individual located at the IP2 and  
 4 IP3 site boundary from liquid and gaseous effluents and direct radiation shine from IP1 and the  
 5 two operating reactor units during 2009 is summarized below:

- 6 • The calculated maximum whole-body dose to an offsite member of the general public  
 7 from liquid effluents was  $9.00 \times 10^{-4}$  mrem ( $9.00 \times 10^{-6}$  mSv) for IP1 and IP2 and  
 8  $2.49 \times 10^{-4}$  mrem ( $2.49 \times 10^{-6}$  mSv) for IP3, well below the 3 mrem (0.03 mSv) dose design  
 9 objective in Appendix I to 10 CFR Part 50.
- 10 • The calculated maximum organ dose to an off-site member of the general public from  
 11 liquid effluents was  $1.71 \times 10^{-3}$  mrem ( $1.71 \times 10^{-5}$  mSv) for IP1 and IP2 (child bone) and  
 12  $4.59 \times 10^{-4}$  mrem ( $4.59 \times 10^{-6}$  mSv) for IP3 (adult GI tract), well below the 10 mrem  
 13 (0.10 mSv) dose design objective in Appendix I to 10 CFR Part 50.
- 14 • The calculated maximum gamma air dose at the site boundary from noble gas  
 15 discharges was  $1.14 \times 10^{-4}$  millirad (mrad) ( $1.14 \times 10^{-6}$  milligray (mGy)) for IP1 and IP2 and  
 16  $6.82 \times 10^{-5}$  mrad ( $6.82 \times 10^{-7}$  mGy) for IP3, well below the 10 mrad (0.10 mGy) dose design  
 17 objective in Appendix I to 10 CFR Part 50.
- 18 • The calculated maximum beta air dose at the site boundary from noble gas discharges  
 19 was  $1.77 \times 10^{-4}$  mrad ( $1.77 \times 10^{-6}$  mGy) for IP1 and IP2 and  $1.77 \times 10^{-4}$  mrad ( $1.77 \times 10^{-6}$  mGy)  
 20 for IP3, well below the 20 mrad (0.20 mGy) dose design objective in Appendix I to  
 21 10 CFR Part 50.
- 22 • The calculated maximum organ dose to an offsite member of the general public from  
 23 gaseous iodine, tritium, and particulate effluents was  $2.10 \times 10^{-3}$  mrem ( $2.10 \times 10^{-5}$  mSv) to  
 24 the child liver for IP1 and IP2 and  $3.18 \times 10^{-3}$  mrem ( $3.18 \times 10^{-5}$  mSv) to the child liver for  
 25 IP3, well below the 15 mrem (0.15 mSv) dose design objective in Appendix I to  
 26 10 CFR Part 50.
- 27 • The calculated maximum total whole-body dose to an offsite member of the general  
 28 public from the site’s combined groundwater and storm drain pathways is  
 29  $2.56 \times 10^{-4}$  mrem ( $2.56 \times 10^{-6}$  mSv).
- 30 • The calculated maximum organ (adult bone) dose to an offsite member of the general  
 31 public from the site’s combined groundwater and storm drain pathways is  
 32  $1.03 \times 10^{-3}$  mrem ( $1.03 \times 10^{-5}$  mSv).
- 33 • The calculated maximum total body dose to an offsite member of the public from all  
 34 radioactive emissions (radioactive gaseous and liquid effluents, direct radiation shine,  
 35 and new liquid effluent release pathway) from the IP2 and IP3 site was 5.11 mrem  
 36 ( $5.11 \times 10^{-2}$  mSv), well below EPA’s 25 mrem (0.25 mSv) limit in 40 CFR Part 190.

37 The NRC staff reviewed the 2006 and 2009 Radioactive Effluent Release Report and found that  
 38 the 2006 and 2009 radiological data are consistent, with reasonable variation as the result of  
 39 operating conditions and outages, with the 5-year historical radiological effluent releases and

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1 resultant doses. These results, including those from the new issue concerning a new liquid  
2 effluent release pathway, confirm that IP2 and IP3 is operating in compliance with Federal  
3 radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and  
4 40 CFR Part 190. As noted in Section 2.1.4 of this SEIS, the applicant does not anticipate any  
5 significant changes to the radioactive effluent releases or exposure pathways from IP2 and IP3  
6 operations during the license renewal term, and, therefore, the NRC staff expects that impacts  
7 to the environment are not likely to change.

8 Entergy has indicated that it may replace IP2 and IP3 reactor vessel heads and control rod drive  
9 mechanisms during the period of extended operation. Such an action is not expected to change  
10 the applicant's ability to maintain radiological doses to members of the public well within  
11 regulatory limits. This is based on the absence of any projected significant increases in the  
12 amount of radioactive liquid, gaseous, or solid waste as a result of the replacements, as  
13 discussed in Section 2.1.4 of this SEIS. Thus, the staff concludes that similar small doses to  
14 members of the public and small impacts to the environment are expected during the period of  
15 extended operations.

### 16 2.2.8 Socioeconomic Factors

17 This section describes current socioeconomic factors that have the potential to be directly or  
18 indirectly affected by changes in IP2 and IP3 operations. IP2 and IP3 and the communities that  
19 support them can be described as a dynamic socioeconomic system. The communities provide  
20 the people, goods, and services required by IP2 and IP3 operations. IP2 and IP3 operations, in  
21 turn, create the demand and pay for the people, goods, and services in the form of wages,  
22 salaries, and benefits for jobs and dollar expenditures for goods and services. The measure of  
23 the communities' ability to support the demands of IP2 and IP3 depends on their ability to  
24 respond to changing environmental, social, economic, and demographic conditions.

25 The socioeconomic region of influence (ROI) is defined by the areas where IP2 and IP3  
26 employees and their families reside, spend their income, and use their benefits, thereby  
27 affecting the economic conditions of the region. The IP2 and IP3 ROI consists of a four-county  
28 area (Dutchess, Orange, Putnam, and Westchester Counties) where approximately 84 percent  
29 of IP2 and IP3 employees reside. The following sections describe the housing, public services,  
30 offsite land use, visual aesthetics and noise, population demography, and the economy in the  
31 ROI surrounding IP2 and IP3.

32 Entergy employs a permanent workforce of approximately 1255 employees (Entergy 2007a).  
33 Approximately 90 percent live in Dutchess, Orange, Putnam, Rockland, Ulster, and Westchester  
34 Counties, New York, and Bergen County, New Jersey (Table 2-7). The remaining 10 percent of  
35 the workforce is divided among 36 counties in Connecticut, Pennsylvania, New Jersey, New  
36 York, and elsewhere with numbers ranging from 1 to 15 employees per county. Given the  
37 residential locations of IP2 and IP3 employees, the most significant impacts of plant operations  
38 are likely to occur in Dutchess, Orange, Putnam, and Westchester Counties. The focus of the  
39 socioeconomic impact analysis in this SEIS is therefore on the impacts of IP2 and IP3 on these  
40 four counties.

41 Refueling outages at IP2 and IP3 occur at 24-month intervals for each unit, which results in an  
42 outage each year for one or the other units. During refueling outages, site employment



1 increases by 950 workers for approximately 30 days (Entergy 2007a). During outages, most of  
 2 these workers are likely to reside in the four-county ROI.

3 **Table 2-7. IP2 and IP3 Employee Residence by County in 2006**

County	Number of IP Energy Center Personnel	Percentage of Total
Bergen, NJ	17	1.4
Dutchess, NY	528	42.1
Orange, NY	243	19.4
Putnam, NY	78	6.2
Rockland, NY	28	2.2
Ulster, NY	31	2.5
Westchester, NY	206	16.4
Other	124	9.9
<b>Total</b>	<b>1255</b>	<b>100.1</b>

Source: Entergy 2007a

4 **2.2.8.1 Housing**

5 Table 2-8 lists the total number of occupied housing units, vacancy rates, and median value in  
 6 the ROI in 2006. According to the 2000 Census, there were over 613,000 housing units in the  
 7 ROI, of which approximately 584,000 were occupied. The median value of owner-occupied  
 8 units ranged from \$141,500 in Orange County to \$285,800 in Westchester County. The  
 9 vacancy rate was the lowest in Westchester County (3.5 percent) and highest in Putnam County  
 10 (6.6 percent).

11 In 2006, the estimated total number of housing units in Westchester County grew by more than  
 12 6,000 units to 355,581, and the total number of occupied units declined by 4000 units to  
 13 333,114. As a result, the number of available vacant housing units increased by more than  
 14 10,200 units to 22,467, or 6.3 percent of the available units. In addition, the estimated number  
 15 of available housing units also increased in Dutchess, Orange, and Putnam Counties (USCB  
 16 2008a).