4.0 OTHER ENVIRONMENTAL CONSIDERATIONS

4.1 Methodology

As discussed in the Executive Summary, cooling towers can frequently result in a plume of water vapor and liquid water droplets (spray drift). TRC performed its analysis of Project cooling tower plume impacts using the Seasonal/Annual Cooling Tower Impacts ("SACTI") model. Developed by researchers for the Electric Power Research Institute ("EPRI") in the mid 1980's,[33] the SACTI model was formulated especially for modeling cooling tower operations associated with electric generating facilities or power plants. The model is widely recognized by the power industry and regulatory agencies (including NYSDEC) as being the most comprehensive field-validated cooling tower plume model available for modeling power plant cooling tower plumes. The model has been tested and validated using actual field data. Thus, SACTI is considered by the power industry and regulatory agencies to be the model of choice for calculating potential environmental impacts from a wet evaporative cooling tower. A discussion of the structure of the SACTI model and the modeling methodology employed by this analysis is included in Appendix A of this report.

The SACTI cooling tower model calculates the seasonal and annual configuration of cooling tower vapor plumes. A visible cooling tower plume is evaporated water that will condense to form a visible cloud when it cools by coming into contact with air at a cooler ambient temperature. The condensed vapor plume from the cooling tower is essentially condensed distilled water that does not contain any minerals present in the circulating water. Any minerals that are emitted from the tower originate from the spray drift (small droplets of the circulating water) that are entrained in the exhaust air stream. Many of the drift droplets are fairly large compared to the condensed vapor droplets as they are emitted from the tower, and have an appreciable settling velocity causing many of them to fall out of the plume. The droplet size of the condensed water vapor is sufficiently small as to have no appreciable settling velocity.

Conditions simulated in the SACTI model include:

- Plume-induced fogging and icing (during freezing conditions) downwind of the cooling tower. A ground fog or icing condition occurs when the condensed vapor plume is lower than the tower outlet and impacts upon the ground.
- Frequencies of plume length, height and radius.
- Hours of plume shadowing (the amount and duration of plume shadows at a given location). Plume shadowing is also used as an indicator for the frequency and length of visible plumes.

[33] Policastro, A.J., L. Coke, and M. Wastag (1984). User's Manual:-Cooling Tower Plume Prediction Code, Electric Power Research Institute, EPRI CS-3403-CCM, Palo Alto, CA.

- Deposition of liquid water (drift) and minerals dissolved in the cooling tower plume drift (water droplets entrained in the plume during plume exhaust). Mineral deposition is primarily from the concentration of calcium and magnesium carbonates and sodium chloride in the circulating water.
- Salt deposition is experienced from cooling towers where salt or brackish water is used for make-up, as is the case for the proposed Project cooling towers.

The SACTI model can be used to determine the worst case plume configuration for a plume abated cooling tower, assuming no plume mitigation is being employed and the cooling tower is operated in the wet-only mode. The SACTI model does not allow calculation of combined impacts from cooling towers that are widely separated. Thus, only one tower was assessed and the impacts assumed to be representative for both towers. The combined effects of both Project cooling towers were determined by manually adding the impacts from each tower, in areas where the impacts from the towers could be seen, from their distribution around each tower, to overlap, thus representing the combined tower impacts.

The SACTI model calculates the effects of the Project cooling tower condensed water plume for ground fogging, rime ice formation, elevated plumes and mineral deposition using actual (representative) meteorological data. However, SACTI does not discern plume density, but discerns whether the plume water vapor content is greater than or less than the ambient saturation deficit (i.e., the amount of water vapor that must be added to the atmosphere to raise its relative humidity to 100%). Consequently, SACTI tabulates the presence of a potential condensed plume, but does not differentiate between a plume that is barely saturated and evaporating and one that is opaque with a high liquid water content ("LWC") of condensed water droplets. Essentially, SACTI considers any saturation deficit of greater than zero as forming a visible plume.[34] In the real world, a plume typically is not visible until the liquid water content is greater than a threshold value of approximately 0.2 grams/cubic meter such that the width (or length) of the plume exceeds the optical depth[35] of the condensed water vapor cloud.

Similarly, SACTI tabulates a ground rime icing condition if there is a tabulated occurrence of a ground fog when the ambient temperature is below 32°F. SACTI tabulates the conditions which may be conducive for rime ice formation, rather than actual formation of rime ice. Neither of these limitations, although properly noted, are considered to offset SACTI's usage or dominance

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[34] Once the cooling tower exhaust mixes with the atmosphere and cools, the plume may become super-saturated with respect to water vapor, such that the balance of water vapor in excess of the saturation deficit must condense as a condensed water vapor cloud, resulting in a visible plume.

[35] Optical depth or optical thickness is a measure of transparency, and is defined as the negative logarithm of the fraction of radiation (or light) that is scattered or absorbed on a path. The optical depth for a water droplet cloud (visible plume) is related to the LWC of the cloud.

for cooling tower modeling. SACTI remains the method of choice of most, if not all, regulatory agencies, including NYSDEC.

4.2 SACTI Modeling Analysis

The model analysis used ten years of actual hourly meteorological data (1999-2008)[36] recorded onsite at the IPEC meteorological monitoring station with seasonal mixing height data that was obtained from the mixing height[37] study and protocol prepared and used by EPA.[38] The use of onsite data provides a very accurate and representative meteorological data base for performing the cooling tower assessment. The onsite data was converted into the multiple-level NRC format that can be used by SACTI. Table 4-1 lists the specific cooling tower dimensional parameters input into SACTI. Wet mode operation of the cooling towers was simulated using the SACTI model as a single cell circular mechanical draft tower.

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[36] Enercon prepared a cooling tower plume impact study in 2003 using SACTI with IPEC data recorded for the period 1998-2002. (Enercon, 2003) The present analysis expanded upon the previous analysis and incorporated ten years of data, with a portion of the years overlapping the previous study. A larger period of record was chosen because SACTI uses a statistically based approach for calculating the plume impacts, such that a longer period of data will provide a preferable indicator of the average annual impacts. The meteorology for both periods is quite similar, resulting in similar results between the two studies.

[37] Mixing height is the height (above ground) to which the lower atmosphere will undergo mechanical or turbulent mixing, producing a nearly homogeneous air mass.

[38] Holzworth, George C., Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, NC. (January 1972).

Table 4-1: Cooling Tower Parameters

Parameters	Evaluated Cooling Tower
Number of Cells	1 cell per tower (two separate towers)
Tower Height (top of fan) (meters)	51.21
Cell Diameter (meters)	73.58
Tower Effective Diameter (meters)	73.58
Total Tower Heat Duty(1) (MWt)	2,052.02
Total Tower Heat Duty(1) (MMBtu/hr)	7,005.60
Cooling Water Range (°F)	20
Tower Air Flow (ACFM)	56,400,000
Tower Air Flow (Kg/sec)	33,538
Circulating Water flow (gpm)	700,000
Circulating Water flow (Kg/sec)	44,135
Liquid to Gas Ratio	1.316
Circulating water total dissolved solids (TDS) (ppm as NaCl)	7,200
Cycles of concentration (variable)	4
Drift Elimination efficiency (%)	0.001%
Water drift (pounds per hour)	3,502.8
Particulate emissions (pounds per hour)	25.22
Site Latitude (degrees North)	41.2833
Site Longitude (degrees West)	73.9667

(1)= Circulating water rate times temperature range converted to MWt and MMBtu/hr

4.2.1 Detailed Modeling Methodology

The SACTI model calculated the probable frequency of occurrence of ground-level plume fogging, rime icing, and elevated plume lengths during daylight conditions (i.e., used to estimate hours of elevated visible plumes). In the case of ground fogging and rime icing, the SACTI model provides results tabulated as total hours for the total block of data, which in this case is ten years (then converted to the average number of hours per year). To determine the maximum annual average of visible elevated plumes (without plume abatement), the elevated plume lengths were tabulated for only the daylight hours, where "daylight" included a half-hour before sunrise until a half-hour after sunset. In the case of mineral (dissolved solids, i.e., salt) deposition, the results are presented as the maximum average kilograms/square kilometer/month, which may be converted to milligrams/square centimeter/month (by dividing by 10,000).

4.2.2 Methodology for Estimating Ground-Level Impacts

The plume dispersion modeling program within the suite of SACTI programs considers that ground fogging and rime icing potentially occur during ten pre-defined meteorological scenarios. The meteorological processing program within the suite of SACTI programs tabulates the frequency of occurrence of these ten scenarios within the meteorological data set. In this way, SACTI can conservatively calculate an upper bound on the number of potential ground fogging and rime icing cases with a high degree of confidence. The lower bound would be no cases of either fogging or icing, since there is a possibility that in any given year the meteorological conditions conducive for plume fogging or icing do not occur.

For the purpose of this study, ground "fogging" has been defined to occur during the ten fogging scenarios when the plume is modeled to be in physical contact with the ground and/or the plume is below the height of the cooling tower. The area covered by the plume is then defined to be the area of ground fogging. Likewise, ground-level rime icing is assumed to occur during five (of the ten) plume fogging scenarios for which the air temperature is less than freezing. Note that, in addition to plume fogging and rime ice formation, additional plume impacts, such as visible plume length and frequency, and mineral deposition were considered in this analysis. A more detailed explanation of these conditions is provided in Appendix A of this report.

4.3 Summary of Modeled Impacts

The SACTI modeling results are tabulated and presented in the attached figures which illustrate the frequency of occurrence as average hours per year. Table 4-2 provides a summary of the maximum average number of hours of ground fog and rime ice formation, with distance and direction from each tower being identified.

Table 4-2: Summary of Potential Cooling Tower Plume Impacts

Description (units based on 10-years of hourly meteorology[1])	Wet-only Operation - Evaporative Tower			
	Configuration	**Maximum Value**	**Direction of Plume towards**	**Distance from Tower (meters)**
Plume Ground Fogging	2 RMDCT[2]	14 (hrs/yr)	SE	550 (IPEC Unit 2)
Rime Icing	2 RMDCT	0	-	-
Elevated Visible Plume (during daylight hours)	2 RMDCT	610 (hrs)	SE	200 (IPEC Unit 3)
Salt Deposition	2 RMDCT	0.013 ($mg/cm^2/mo$)	SSE	1,800 (IPEC Unit 3)

(1) Entergy Indian Point Onsite Meteorological Tower (1999-2008)

(2) RMDCT - Round Mechanical Draft Cooling Tower. These results reflect impacts from the combined operation of both the north (IPEC Unit 2) and the south (IPEC Unit 3) cooling towers being studied.

4.3.1 Ground Fogging Associated with Plume

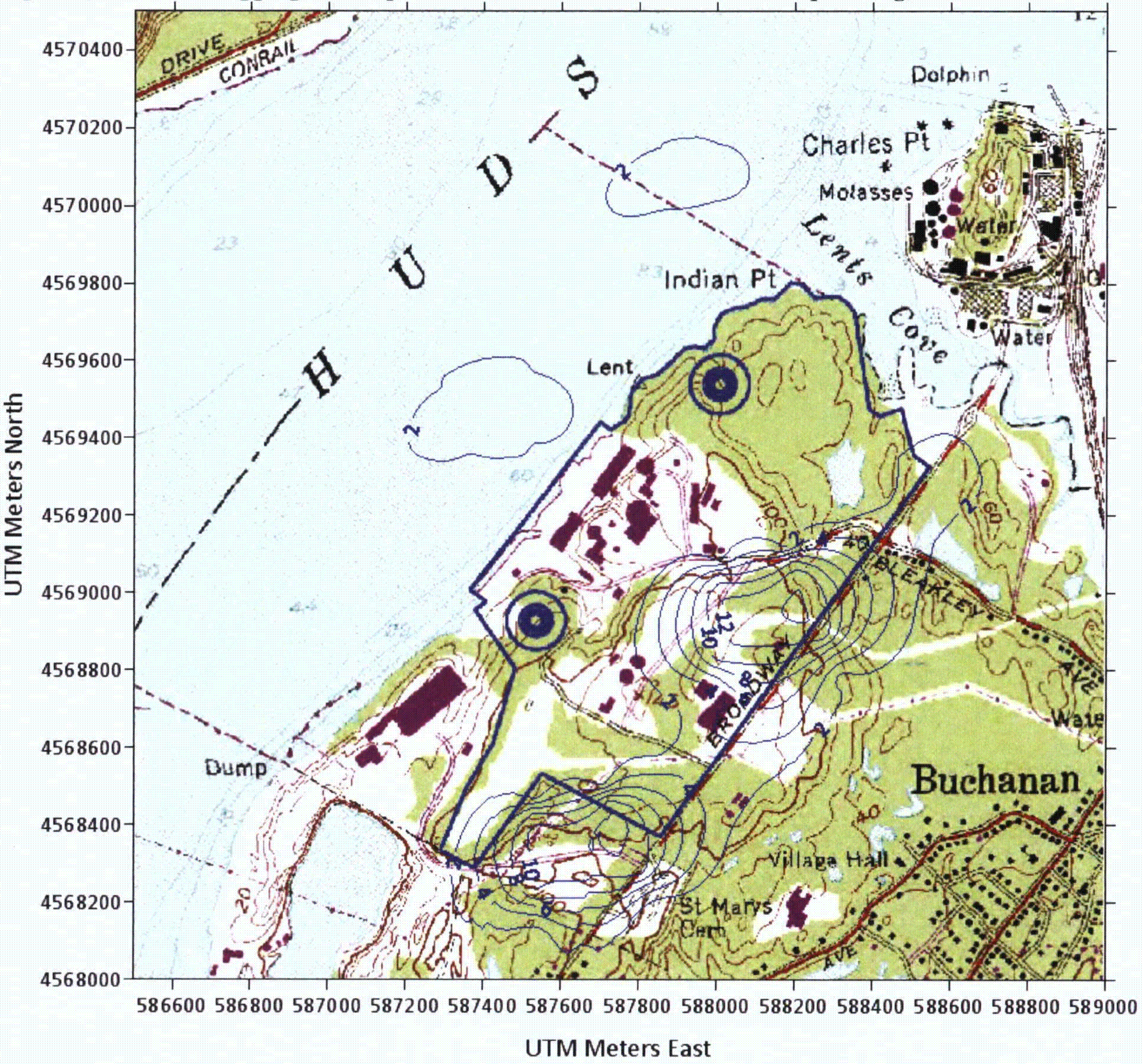
A ground fog attributed to a cooling tower occurs when atmospheric conditions[39] cause the condensed water vapor plume to come into contact with or impact upon the ground surface. Table 4-3 provides the average number of hours per year of ground fog occurrence by distance and direction from the cooling towers being studied (assuming no plume abatement). As indicated on this table, a maximum average of about 13 hours of plume fogging may be expected to occur approximately 500 - 600 meters (1640 - 1970 feet) south-southeast of each cooling tower. The table presents the fogging counts for only the north (CT2) cooling tower, and synergistic effects between the two cooling towers can result in an extra hour of ground fog at the location of maximum impact, resulting in approximately a maximum of 14 hours per year at the location of maximum impact. The location of this maximum impact primarily is on the IPEC facility property. This area is illustrated by the contours of fogging hours presented in Figure 4-1 that examined the ground fog hours from both cooling towers being studied. In between the two towers, however, the contours would merge to form two distinct maximum locations. The values indicate the total number of hours each year a ground fog plume may occur at each specific location around the facility. While any ground fog events from the north cooling tower (CT2) are typically confined to the facility property, the ground fog events that occur due to the south cooling tower (CT3) are shown to occur immediately off of the facility site towards the south and along Broadway in the Village of Buchanan.

[39] Such conditions are typically cool ambient temperatures, high relative humidity and strong winds.

Table 4-3: Average Annual Plume Fogging Hours (CT2 wet mode) One Tower

Distance	Direction Plume is Headed															
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	1	0	0	0	0	0	1	1	2	1	0	0	0	0	0	1
450	1	0	0	0	0	0	1	1	2	1	0	0	0	0	0	1
500	9	1	0	0	0	0	2	3	3	1	0	0	1	2	3	10
550	11	1	0	0	0	0	2	3	3	1	0	0	2	3	3	13
600	11	1	0	0	0	0	1	2	2	1	0	0	2	3	3	13
650	10	1	0	0	0	0	1	2	2	1	0	0	2	3	3	12
700	10	1	0	0	0	0	1	2	2	1	0	0	2	3	3	12
750	5	0	0	0	0	0	0	1	1	0	0	0	1	1	2	6
825	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
850	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
900	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
950	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4-1: Plume Fogging Hours per Year (Wet Mode - Both Towers Operating)



4.3.2 Elevated Visible Plumes

When each individual Project cooling tower is operated in wet mode, and when both are operated in this fashion, condensed water vapor plumes visible to the surrounding community will form under certain meteorological conditions. Normally, these visible plumes will be confined to the area immediately over the cooling tower and over the IPEC property. However, under cool temperatures (typically during the late fall, winter, and early spring seasons) with high ambient humidity, such elevated visible plumes may extend for several hundred to thousands of meters. Figure 4-2 illustrates the average number of counts for elevated visible plumes per year for the wet mode case, using the ten year meteorological data set. Note that these counts reflect the combined elevated plumes for both cooling towers being studied.

These counts are based on daytime conditions only (which include the half hour before sunrise until a half hour after sunset). Plumes that occur at night under cooler meteorological conditions, therefore, are not counted. As illustrated, the SACTI model results indicate that a visible plume would occur immediately south and northwest of each tower during an average maximum of 610 daylight hours per year, or approximately 13 percent of the total daylight hours during the year. The aesthetic impact of the potential elevated visible plumes from the cooling towers being studied was assessed by Saratoga Associates.[40]

4.3.3 Salt (NaCl) Deposition

Figure 4-3 provides the average maximum mineral deposition rate (milligrams/square centimeter/month) by distance and direction from the combined deposition from both cooling towers being studied. The circulating water was conservatively assumed to contain as much as 7,200 ppm of total dissolved solids, primarily as sodium chloride (NaCl).[41] As drift droplets are emitted and deposit downwind from the towers the minerals in the circulating water may be deposited. Cooling tower drift from the Project cooling towers is anticipated to be kept to a minimum through the use of high efficiency drift eliminators with liquid water drift being maintained at or below 0.001% of the circulating water rate. However, due to the substantial height of the tower and exhaust plume, the mineral (i.e., salt) nonetheless would be carried a considerable distance from the cooling towers being studied. The salt deposition pattern is in two lobes, towards the northwest and southeast of the towers. The salt deposition from both cooling towers will be additive, as indicated by the deposition pattern illustrated in Figure 4-3.

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[40] Saratoga Associates. "Indian Point Energy Center Closed Cycle Cooling Conversion Feasibility Study – Visual Assessment", Prepared for Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC. (June 1, 2009).

[41] The assumed total dissolved solids content of the circulating water is based on an annual average Hudson River makeup water salinity of 1,800 ppm and 4 cycles of concentration.

Figure 4-2: Average Annual Hours of Elevated Visible Plumes (in Wet Mode - Both Towers Operating)

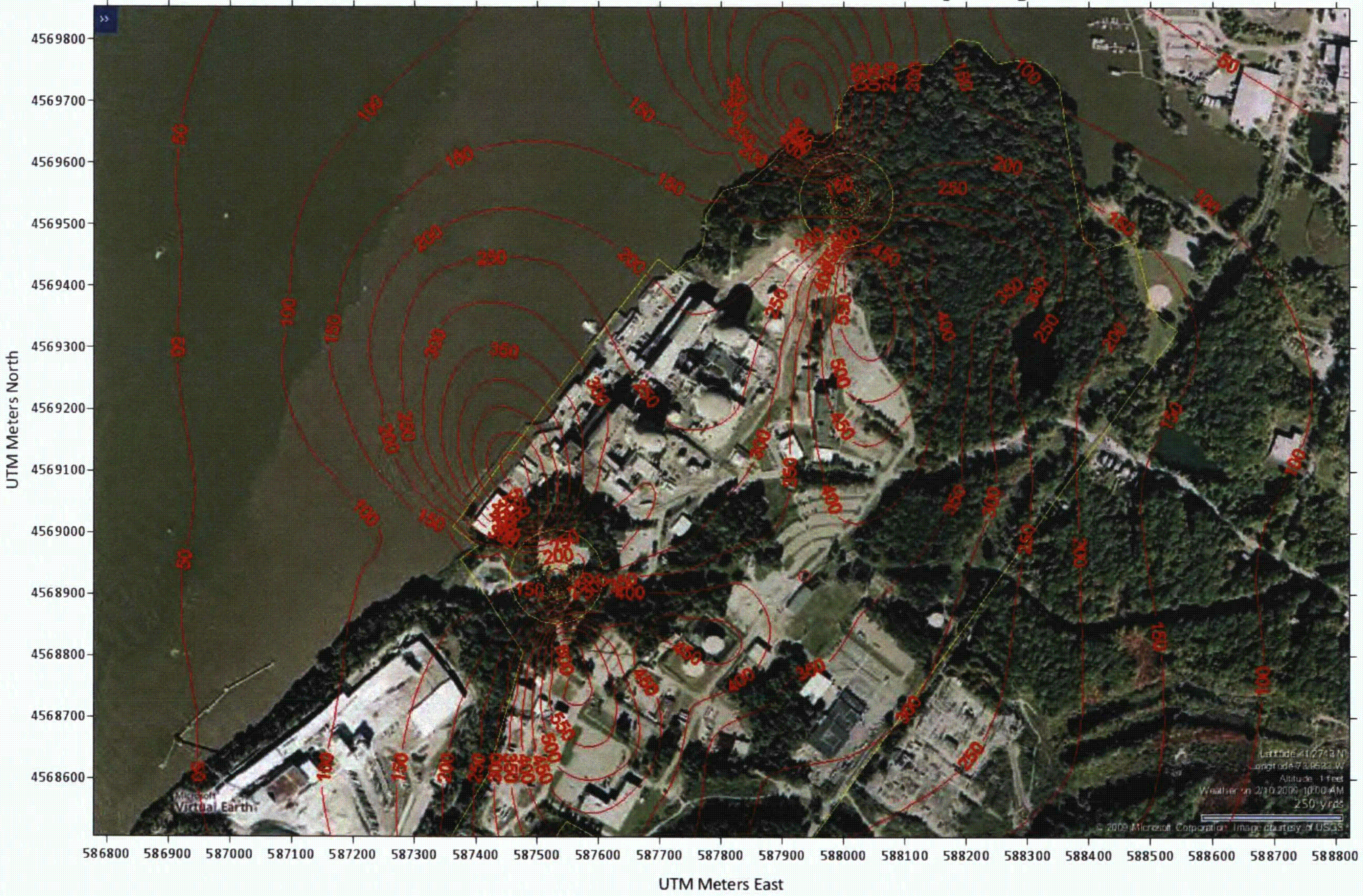
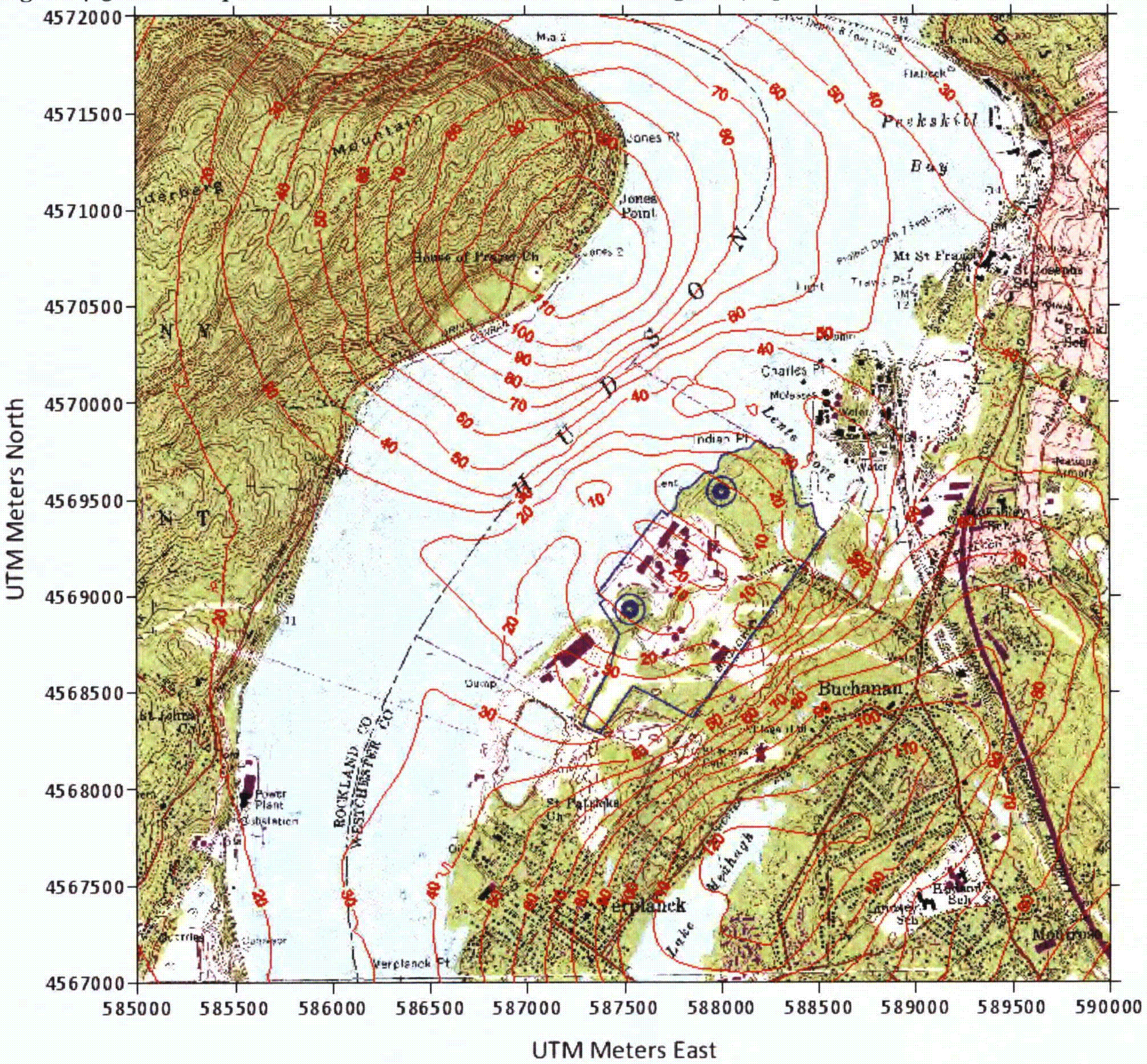


Figure 4-3: NaCl Deposition – Wet Mode Both Towers (milligrams/square centimeter/month x 10^{-4})



NYSDEC does not directly regulate mineral deposition from the cooling towers. The maximum combined deposition rate for the cooling towers being studied is 0.0127 $mg/cm^2/month$ located approximately 1,800 meters (6,000 feet) south-southeast of the IPEC Unit 3. This value is sufficiently low so as to not cause an adverse impact to vegetation.

4.4 Other Environmental Considerations Conclusion

The water vapor plumes resulting from the Project cooling towers were rigorously assessed using the SACTI cooling tower plume model. Ten years of hourly on-site meteorological data were used to determine potential fogging, opacity (i.e., visible elevated plumes) and salt deposition impacts. A combined minimal number of about 14 hours per year of ground fog plumes would occur if the Project cooling towers were operated without plume abatement, most, if not all of which would be eliminated by operating in plume abatement mode. Similarly, without plume abatement, the cooling tower(s) being studied would result in occasional condensed elevated water vapor plumes which would be visible. The vast majority of time these visible plumes would be immediately above the tower(s) and within several hundred feet towards the northeast. Under high humidity conditions, the elevated visible plumes may extend off of the facility property. However, the plumes would be well above the ground, and would normally evaporate and dissipate within several hundred feet of the facility. On rare occasions, visible plumes extend an appreciable distance from the facility. Due to the high efficiency drift eliminators, mineral (i.e., salt) deposition will not pose an adverse impact either off of IPEC property.

5.0 SUMMARY OF CONCLUSIONS

5.1 Description of Project

TRC evaluated air quality impacts and other environmental considerations of the Project, which is identified by Entergy's consultant Enercon to consist of two hybrid circular mechanical draft cooling towers, one for each steam turbine condenser at IPEC. The purpose of the Project cooling towers is to dissipate heat generated by the stations. In order to do so, the Project cooling towers draw in a significant amount of water from the Hudson River. The water drawn in contains the same dissolved solids concentration as the river. The predominant mineral in the circulating water is common salt. In order to reduce the amount of water used, the circulating water in the cooling towers is recycled. This results in increased dissolved mineral concentration because the dissolved solids remain as water evaporates. In addition to the concentrated salt and minerals, the circulating water contains additives such as biocides and anti-scaling chemicals. During operation, a portion of the recycled circulating water is discharged from the towers in the form of very small water droplets or spray drift. The spray drift, like the circulating water, contains an appreciable concentration of dissolved minerals and additives. These dissolved solids in the spray drift form a fine particulate matter with an aerodynamic diameter less than 2.5 micrometers (PM-2.5) which is emitted from the towers as the drift liquid evaporates. As such, these Project towers, individually and collectively, will result in particulate matter emissions.

5.2 Fine Particulate Emissions Impacts

TRC assessed the air quality impact from the Project cooling towers (i.e., PM-10 and PM-2.5 emissions) using the current state-of-the-art air quality dispersion model – AERMOD – for the following operational conditions:

- Plume abated mode;
- Wet mode;
- Towers operating in combination;
- Towers operating individually; and
- Drift rates of 0.001% of circulating water, and 0.0005% of circulating water.

The worst case particulate matter impacts occurred during wet mode operating conditions. The maximum ground level concentrations of PM-10 and PM-2.5, when added to a representative background concentration for Westchester County were shown to exceed the NAAQS by a substantial margin. When TRC considered higher efficiency (0.0005%) drift eliminators as a mitigation measure assuming a reduction of the spray drift by half, the 24-hour concentrations of PM-10 and PM-2.5 will still exceed the NAAQS by a substantial margin under various operating parameters. The conclusion of the analysis is that under the conditions that the

Project cooling towers will be required to operate, the particulate emissions would preclude the Project from obtaining a 6 NYCRR Part 201 Air Permit from NYSDEC.

5.3 Other Environmental Impacts

TRC assessed other environmental considerations including ground fogging caused by the condensed water vapor plume from the Project cooling towers impinging on the ground, and the deposition of salt from the cooling tower spray drift. TRC assessed the water vapor plume impacts using the SACTI model. Since SACTI is unable to assess plume abated towers, the Project cooling towers were assessed while operating in wet mode only. As such, the analysis was considered very conservative since the plume abated mode would mitigate and possibly eliminate any environment impacts associated with the condensed water vapor plumes. The analysis concluded that the cooling towers would result in ground fog conditions for an average of 14 hours per year, assuming that the towers were not operated with plume abatement.

Similarly, TRC assessed the impact of salt deposition around the IPEC facility. TRC concluded that salt deposition would be minimal and well below any thresholds that would indicate an adverse impact.

5.4 Conclusion

TRC and Enercon concluded that the Project's closed cycle cooling towers would emit particulates in excess of 100 tons per year, the regulatory threshold for requiring the Project to undergo a major new source review for particulate emissions, triggering a state requirement for obtaining an air quality construction and operating permit under 6 NYCRR Parts 201 and 231. TRC assessed the impact of the fine particulate on the local and surrounding communities and determined that it posed a significant adverse threat to the ambient air quality. TRC further concluded that mitigation measures that could reduce the adverse impact, such a higher efficiency drift eliminators or reductions in the dissolved solids content of the circulating water, do not sufficiently eliminate the adverse impact or are infeasible.

In conclusion, TRC's AERMOD analysis demonstrates that the particulate emissions from the Project cooling towers will cause an adverse air quality impact to the surrounding community, such that obtaining a required construction and operating air emissions permit pursuant to 6 NYCRR Part 201 would not be possible.

6.0 REFERENCES

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TRC

APPENDIX A

SACTI MODEL DESCRIPTION

Appendix A
SACTI Model Description

The EPRI SACTI CWT model calculates the seasonal and annual impacts of cooling water tower ("CWT") vapor plumes. Various environmental impacts simulated in the SACTI model include:

- Plume-induced ground fogging and rime icing (during freezing conditions) downwind of the CWT;
- Visible plume length and height;
- Elevated plumes and plume shadowing (the frequency and length of elevated plumes at a given location);
- Deposition of minerals (salt) contained in CWT plume drift (water droplets entrained in the plume during plume exhaust).

The SACTI model is a multiple-source model that predicts CWT plume impacts from any number of identical natural draft, linear mechanical draft, or circular mechanical draft CWTs. The SACTI model was designed to provide predictions that can be used in the licensing of power plants with CWTs. The model developers validated the model with field and laboratory data in all situations where good quality data existed.

The seasonal/annual modeling methodology employed by the SACTI model is a parameterization scheme that reduces the available hourly meteorological data to between 30 and 100 categories (typically 35-45 plume categories are used) of unique meteorological conditions (from a CWT plume dispersion perspective). Potential ground fogging and rime icing cases are reduced to a predefined 10 categories, which are assumed by the model to be the result of aerodynamic downwash in the lee (downwind side) of the CWT. Plumes that are rapidly brought to the ground due to aerodynamic effects will always be lower in height than the tower. The elevated plumes will typically be at or higher than the height of the tower. Rime icing events are tabulated by SACTI when a ground fog event occurs while the ambient temperature is below freezing (32 °F).

Each category is modeled separately and the modeling results of the category are assumed to apply for all occurrences of the category for the period for which modeling is performed. The number of specific categories for a given situation is dependent upon the CWT geometry, tower emission parameters, and the meteorological conditions experienced at the site. The categorization scheme used in the SACTI model allows a user to analyze multiple years of meteorological data without the need to model every hour of every year to determine plume impacts. The representative scenarios are assumed to apply for multiple hours, thereby greatly reducing computer execution time.

However, as discussed earlier, because SACTI is a statistically based model, a large meteorological database is recommended to provide a large selection of meteorological conditions.

SACTI Suite of Programs

The SACTI model is composed of four separate programs: a meteorological preprocessing program (PREP); a plume dispersion program (MULT); a program to produce tabular summaries of the modeling results (TABLES); and a graphical postprocessor program (PAGE).

To begin a SACTI modeling analysis, the PREP program reads a sequential hourly meteorological data file and generates a set of meteorological scenarios that produce significant plume dispersion effects. The MULT program then computes the expected plume dispersion for each meteorological scenario developed by PREP. The output of the PREP program is a sequential hourly listing of the meteorological conditions and plume dispersion category for each hour of meteorological data processed. The output from the MULT program is a listing of the plume dispersion and fogging impacts for each meteorological scenario (category) simulated.

The TABLES program combines the output of the PREP and MULT programs and produces a set of tabular frequency of occurrence listings of the various environmental effects produced by the CWT plume. The environmental effects computed by the TABLES program are the average of the individual impacts of each scenario model weighted by the number occurrences of that scenario in the input PREP data file.

The post-processing program, PAGE, produces computer page plots of the output from the TABLES program. Only the first three programs were needed for this analysis. Graphical post-processing was performed using a separate graphics package, rather than the PAGE program.

The SACTI-PREP model generates five scenarios that are assumed to produce CWT plume rime icing and ground fogging, and five additional scenarios that produce CWT plume ground fogging only. Because plume ground fogging and rime icing occur during plume downwash conditions, and downwash is assumed to be different for circular and linear CWTs of the same size, the rime icing and ground fogging scenarios for these two tower types are different. These 10 scenarios are independent of individual tower or plume geometry characteristics, except that plumes from natural draft CWTs are assumed not to produce ground level fogging and rime icing.

An additional number of scenarios are also developed that are functions of the meteorological conditions occurring in the input meteorological data. These scenarios depend upon observed wind speed, dry bulb and dew point temperatures, atmospheric stability, and other meteorological factors, in addition to specific CWT parameters. These scenarios can vary with the specific CWT modeled and are used to estimate the potential for rime icing and ground fogging impacts. A total of 10 downwash (ground fogging and rime icing scenarios) and 35 plume scenarios were used by SACTI for the Project's CWT analysis.

Mineral deposition is simulated by SACTI by calculating the amount of liquid water that is emitted by the tower through drift (liquid water droplets that are entrained in the exhaust flow). The drift contains dissolved minerals, and in the case of the IPEC cooling towers in this study, predominately sodium chloride from the tidal Hudson River being used for makeup, and any anti-scaling agents used to treat the circulating water. The drift droplets are modeled as a tilted plume, causing deposition of the droplets in the immediate vicinity of the tower. If sufficiently heavy, the mineral deposition will manifest itself as a white film on surfaces and can be particularly noticeable on vehicles (i.e., windshields and windows) that may be parked adjacent to the tower for any extended period of time (days or weeks).

TRC

APPENDIX B

RACT/BACT/LAER Clearing House Search

Appendix B
Recent BACT/LAER Determinations for Cooling Towers
Particulate Emissions

FACILITY	LOCATION	PERMIT DATE	OPERATING STATUS	CONTROL DESCRIPTION	PM LIMIT LB/HR	LIMIT CALC BASIS	DRIFT RATE %	PERMIT LIMIT BASIS
SWEPCO ARSENAL HILL POWER PLANT	LOUISIANA	3/20/2008	?	MIST ELIMINATORS	1 4	None	?	BACT-PSD
GREAT RIVER ENERGY SPIRITWOOD STATION	IOWA	9/14/2007	?	DRIFT ELIMINATOR	–	None	0.0005%	BACT-PSD
HOMELAND ENERGY SOLUTIONS	IOWA	8/8/2007	?	DRIFT ELIMINATOR / DEMISTER	--	None	0 0005%	BACT-PSD
ANCLOTE POWER PLANT	FLORIDA	12/22/2006	?	DRIFT ELIMINATORS	24 66	Tons/Yr	0 0005%	UNKNOWN
WESTERN GREENBRIER COGENERATION, LLC	GREENBRIER, WV	4/26/2006	NO	DRIFT ELIMINATORS @ 0.0005% DRIFT RATE	0.79	None	0.0005%	BACT-PSD
GOLDEN GRAIN ENERGY	CERRO GORDO, IA	4/19/2006	NO	MIST ELIMINATOR	1.33	None	?	BACT-PSD
RODEMACHER BROWNFIELD UNIT 3	RAPIDES, LA	2/23/2006	NO	DRIFT ELIMINATORS	1.13	None	0 0050%	BACT-PSD
FORSYTH ENERGY PLANT	FORSYTH, NC	9/29/2005	NO	MIST ELIMINATOR	0.002	None	0 0005%	BACT-PSD
WANAPA ENERGY CENTER	UMATILLA, OR	8/8/2005	NO	INSTALLATION OF HIGH EFFICIENCY 0 0005% DRIFT ELIMINATORS LIMIT TOTAL DISSOLVED SOLIDS IN THE WATER TO LESS THAN 3,532 PPMW	–	N/A	0.0005%	BACT-PSD
PLAQUEMINE PVC PLANT	IBERVILLE, LA	7/27/2005	NO	GOOD DESIGN, MAINTENANCE, AND INTEGRATED DRIFT ELIMINATORS	0 19	Lb/MMGal	?	BACT-PSD
XCEL ENERGY (PSCO) - COMANCHE STATION	PUEBLO, CO	7/5/2005	NO	DRIFT ELIMINATORS TO ACHIEVE 0.0005 % DRIFT OR LESS	–	N/A	0.0005%	BACT-PSD
CRESCENT CITY POWER	ORLEANS, LA	6/6/2005	NO	NONE INDICATED	2 61	None	0.0050%	BACT-PSD
NEWMONT NV ENERGY - TS POWER PLANT	EUREKA, NV	5/5/2005	NO	DRIFT ELIMINATORS	--	N/A	0 0005%	BACT-PSD
ARIZONA CLEAN FUELS YUMA	YUMA, AZ	4/14/2005	NO	HIGH EFFICIENCY DRIFT ELIMINATORS	1 60	None	?	BACT-PSD
TRIGEN-NASSAU ENERGY CORPORATION	NASSAU, NY	3/31/2005	NO	NONE INDICATED	–	N/A	0.0005%	BACT-PSD
OPPD - NEBRASKA CITY STATION	OTOE, NE	3/9/2005	NO	NONE INDICATED	0.001	None	?	BACT-PSD
DARRINGTON ENERGY COGENERATION POWER PLANT	SNOHOMISH, WA	2/11/2005	NO	INSTALLATION OF DRIFT ELIMINATORS WITH DRIFT LOSS OF LESS THAN 0 001% OF THE RECIRCULATING WATER FLOW RATE.	--	N/A	0 001%	BACT-PSD
BP CHERRY POINT COGENERATION PROJECT	WHATCOM, WA	1/11/2005	NO	INSTALLATION OF DRIFT ELIMINATORS WITH DRIFT LOSS OF LESS THAN 0.001% OF THE RECIRCULATING WATER FLOW RATE.	--	N/A	0 001%	BACT-PSD
DUKE ENERGY HANGING ROCK ENERGY FACILITY	LAWRENCE, OH	12/28/2004	?	DRIFT ELIMINATORS	2 60	None	?	BACT-PSD
NUCOR STEEL	HERTFORD, NC	11/23/2004	?	MIST ELIMINATORS WITH A 0 008 % DRIFT LOSS	--	N/A	0 008%	BACT-PSD
MIRANT - DICKERSON STATION	MONTGOMERY, MD	11/5/2004	YES	MIST ELIMINATORS	--	N/A	0 001%	BACT-PSD
WPS WESTON 4 - NORTH SITE	WAUSAU, WI	10/19/2004	U.C	HIGH EFFICIENCY DRIFT ELIMINATORS (0 002%)	3 76	None	0.002%	BACT-PSD
MICHOUD ELECTRIC GENERATING PLANT	ORLEANS, LA	10/12/2004	?	DRIFT ELIMINATORS & GOOD OPERATING PRACTICE	0 05	None	0.001%	BACT-PSD
J R SIMPLOT COMPANY - DON SIDING PLANT	POWER, ID	4/5/2004	YES	DRIFT ELIMINATORS	3.53	None	?	RACT
LONGVIEW POWER, LLC	MAIDSVILLE, WV	3/2/2004	NO	REDUNDANT BAFFLE AND MESH DEMISTER SYSTEM	0 90	None	0 0002%	BACT-PSD
BATON ROUGE REFINERY	EAST BATON ROUGE, LA	2/18/2004	YES	DRIFT ELIMINATOR SYSTEM	–	N/A	0.003%	BACT-PSD
SANTEE COOPER CROSS GENERATING STATION	PINESVILLE, SC	2/18/2004	NO	NONE INDICATED	1.86	None	?	OTHER
ACE ETHANOL - STANLEY	CHIPPEWA, WI	1/21/2004	?	MIST ELIMINATORS	0.65	None	0.005%	BACT-PSD
LA PAZ GENERATING FACILITY	LA PAZ, AZ	9/4/2003	?	DRIFT ELIMINATORS	5.30	N/A	0.0005%	BACT-PSD
PLUM POINT ENERGY	ARKANSAS	8/20/2003	?	MIST ELIMINATORS	0.80	None	?	OTHER
DUKE ENERGY WASHINGTON COUNTY LLC	WASHINGTON, OH	8/14/2003	?	NONE INDICATED	2.08	None	?	BACT-PSD
UWGP - FUEL GRADE ETHANOL PLANT	FRIESLAND, WI	8/14/2003	?	0 005% MAX. DRIFT RATE, 2,000 PPM SOLIDS, MAX FLOW OF 22,000 GPM	1 10	None	0 0005%	OTHER
LIMA CHEMICALS COMPLEX	LIMA, OH	7/10/2003	YES	DRIFT ELIMINATORS + LDAR PROGRAM	1 40	None	?	BACT-PSD
CHOCOLATE BAYOU PLANT	ALVIN, TX	3/24/2003	NO	NONE INDICATED	0 54	None	?	OTHER
DUKE ENERGY STEPHENS, LLC	OKLAHOMA	3/21/2003	?	DRIFT ELIMINATORS	1 20	None	?	BACT-PSD
ENNIS TRACTEBEL POWER	ENNIS, TX	1/31/2003	NO	NONE INDICATED	1 93	None	?	OTHER
BRAZOS VALLEY ELECTRIC GENERATING	RICHMOND, TX	12/31/2002	?	NONE INDICATED	1.58	None	?	BACT-PSD
ATOFINA CHEMICALS INCORPORATED	BEAUMONT, TX	12/19/2002	NO	NONE INDICATED	0.06	None	?	OTHER
DOW TEXAS OPERATIONS FREEPORT	FREEPORT, TX	11/26/2002	?	NONE INDICATED	5.05	None	?	BACT-PSD
TENASKA INDIANA PARTNERS, L.P.	OTWELL, IN	11/12/2002	?	NONE INDICATED	1.10	None	0.0005%	BACT-PSD
LAWRENCE ENERGY	OHIO	9/24/2002	YES	HIGH EFFICIENCY DRIFT ELIMINATORS	1.69	None	?	SIP
CLOVIS ENERGY FACILITY	*HOUSTON, NM*	*6/27/2002*	?	*DRIFT ELIMINATORS*	0 70	*None*	?	BACT-PSD
GENOVA OK I POWER PROJECT	OKLAHOMA	6/13/2002	?	DRIFT ELIMINATORS	0 31	None	0 001%	BACT-PSD
REDBUD POWER PLT	OKLAHOMA	5/6/2002	?	DRIFT ELIMINATORS	3 17	None	?	BACT-PSD
BATON ROUGE REFINERY	BATON ROUGE, LA	4/26/2002	NO	DRIFT ELIMINATOR (MECHANICAL DRAFT DESIGN)	0 77	None	?	BACT-PSD
LIBERTY GENERATING STATION	LINDEN CITY, NJ	3/28/2002	?	NONE INDICATED	0 90	Tons/Yr	?	OTHER
LIMA ENERGY COMPANY	CINCINNATI, OH	3/26/2002	YES	IMPLEMENTATION OF HIGH EFFICIENCY DRIFT ELIMINATORS	1 88	None	?	BACT-PSD
WEATHERFORD ELECTRIC GENERATION	TEXAS	3/11/2002	NO	NONE INDICATED	1 45	None	?	OTHER
PERRYVILLE POWER STATION	ALEXANDRIA, LA	3/8/2002	?	DRIFT ELIMINATORS	3.30	None	?	BACT-PSD
GEISMAR PLANT	GEISMAR, LA	2/26/2002	?	DRIFT ELIMINATORS	1.72	None	?	BACT-PSD
THOMAS B FITZHUGH GENERATING STATION	OZARK, AR	2/15/2002	?	DRIFT ELIMINATORS	0 40	None	?	BACT-PSD
MUSTANG ENERGY PROJECT	OKLAHOMA	2/12/2002	?	DRIFT ELIMINATORS	3 78	None	0.0040%	BACT-PSD
ENNIS TRACTEBEL POWER	ENNIS, TX	1/31/2002	NO	NONE INDICATED	0 50	None	?	OTHER
ACADIA POWER STATION, ACADIA POWER	LOUISIANA	1/31/2002	?	INTEGRATED DRIFT ELIMINATORS	0.76	None	?	BACT-PSD
SAM RAYBURN GENERATION STATION	NURSERY, TX	1/17/2002	?	DRIFT ELIMINATORS	0.84	None	0 0005%	BACT-PSD
JACKSON COUNTY POWER, LLC	OHIO	12/27/2001	YES	NONE INDICATED	3.43	None	?	BACT-PSD
PLAQUEMINE, IBERVILLE PARISH	COLUMBUS, LA	12/26/2001	?	GOP	1 70	None	0 0005%	BACT-PSD
DUKE ENERGY HANGING ROCK ENERGY FACILITY	CHARLOTTE, NC	12/13/2001	YES	DRIFT ELIMINATORS	0.33	None	?	BACT-PSD
HOLLAND ENERGY, LLC	HOLLAND, IL	12/3/2001	?	DRIFT ELIMINATORS	1.90	Tons/Yr	0.0005%	BACT-PSD
LSP NELSON ENERGY, LLC	NELSON, IL	11/19/2001	NO	DRIFT ELIMINATORS	6.90	Tons/Yr	0 001%	BACT-PSD
HOT SPRINGS POWER PROJECT	ARKANSAS	11/9/2001	?	HIGH EFFICENCY DRIFT ELIMINATOR	0 90	None	?	BACT-PSD
COGENERATION PLANT (AES-PRCP)	*PUERTO RICO*	10/29/2001	YES	*DRIFT ELIMINATOR*	0 33	*None*	?	BACT-PSD
AES RED OAK LLC	SAYREVILLE, NJ	[illegible]	YES	NONE INDICATED	[illegible]	Tons/Yr	?	BACT-PSD

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Recent BACT/LAER Determinations for Cooling Towers
Particulate Emissions

FACILITY	LOCATION	PERMIT DATE	OPERATING STATUS	CONTROL DESCRIPTION	PM LIMIT LB/HR	LIMIT CALC BASIS	DRIFT RATE %	PERMIT LIMIT BASIS
WEBERS FALLS ENERGY FACILITY	NORMAN, OK	10/22/2001	?	DRIFT ELIMINATORS	1.20	None	?	BACT-PSD
TENASKA ARKANSAS PARTNERS, LP	OMAHA, AR	10/9/2001	?	DRIFT ELIMINATORS	2 17	Lb/MMGal	?	BACT-PSD
ALCOA ALUMINUM SHEET, PLATE & FOIL	ELMENDORF, TX	9/28/2001	NO	NONE INDICATED	1.10	None	?	BACT-PSD
EL PASO MANATEE ENERGY CENTER	PINEY POINT, FL	9/11/2001	NO	USE OF FRESH WATER AND DRIFT ELIMINATORS	0 40	None	0.0005%	BACT-PSD
EL PASO BELLE GLADE ENERGY CENTER	BELLE GLADE, FL	9/7/2001	NO	USE OF FRESH WATER AND DRIFT ELIMINATORS	0 40	None	0 0005%	BACT-PSD
NAFTA REGION OLEFINS COMPLEX	PORT ARTHUR, TX	9/5/2001	NO	NONE INDICATED	2.31	None	?	BACT-PSD
DEER PARK ENERGY CENTER	HOUSTON, TX	8/22/2001	?	NONE INDICATED	5.26	None	?	BACT-PSD
EL PASO BROWARD ENERGY CENTER	DEERFIELD BEACH, FL	8/17/2001	NO	USE OF FRESH WATER AND DRIFT ELIMINATORS	0.40	None	0.0005%	BACT-PSD
FREMONT ENERGY CENTER, LLC	OHIO	8/9/2001	YES	HIGH EFFICIENCY DRIFT ELIMINATORS	1.50	None	?	BACT-PSD
MONTGOMERY COUNTY POWER PROJECT	TEXAS	6/27/2001	NO	NONE INDICATED	1.13	None	?	BACT-OTHER
BELL ENERGY FACILITY	TEMPLE, TX	6/26/2001	NO	HIGH-EFFICIENCY DRIFT ELIMINATORS	0.04	None	?	BACT-PSD
MANTUA CREEK GENERATING FACILITY	MANTUA CREEK, NJ	6/26/2001	?	DRIFT ELIMINATOR	1.47	None	0.0005%	NSPS
LIMESTONE ELECTRIC GENERATING STATION	HOUSTON, TX	5/23/2001	NO	MIST & DRIFT ELIMINATORS	0.29	None	?	BACT-PSD
CARVILLE ENERGY CENTER	NORTHBROOK, LA	5/16/2001	?	DRIFT ELIMINATOR AND GOP	1.19	None	?	BACT-PSD
CPV CANA POWER GENERATING FACILITY	ST LUCIE, FL	5/3/2001	NO	DRIFT ELIMINATOR	–	N/A	0 0005%	BACT-PSD
KIAMICHI ENERGY FACILITY	OKLAHOMA	5/1/2001	?	DRIFT ELIMINATORS	14 10	None	?	BACT-PSD
DUKE ENERGY HOT SPRINGS	MALVERN, AR	12/29/2000	NO	DRIFT ELIMINATOR	0 70	None	?	BACT-PSD
DEMING ENERGY FACILITY	NEW MEXICO	12/29/2000	NO	HIGH EFFICIENCY DRIFT ELIMINATORS, GOOD ENGINEERING PRACTICES	1 60	None	0 0005%	BACT-OTHER
CAROLINA POWER AND LIGHT - RICHMOND CO	RALEIGH, NC	12/21/2000	?	DRIFT ELIMINATORS	1.38	Lb/Day	?	BACT-PSD
CEDAR BLUFF POWER PROJECT	TEXAS	12/21/2000	NO	NONE INDICATED	1.69	None	?	OTHER
PALESTINE ENERGY FACILITY	PALESTINE, TX	12/13/2000	NO	NONE INDICATED	4.32	None	?	BACT-PSD
HARRIS ENERGY FACILITY	HOUSTON, TX	8/31/2000	NO	NONE INDICATED	1.30	None	?	BACT-PSD
PERRYVILLE	ALEXANDRIA, LA	8/25/2000	?	DRIFT ELIMINATORS	3 30	None	?	BACT-PSD
AES WOLF HOLLOW LP	AUSTIN, TX	7/20/2000	NO	NONE INDICATED	0.002	None	0 01%	OTHER
WISE COUNTY POWER	HOUSTON, TX	7/14/2000	NO	NONE INDICATED	1.05	None	?	BACT-OTHER
SHELL CHEMICAL COMPANY - GEISMAR PLANT	GEISMAR, LA	5/10/2000	?	DRIFT ELIMINATORS	0.51	None	?	BACT-PSD
AGRIFIOS- OLIN FACILITY	PASADENA, TX	4/27/2000	NO	DESIGNED TO REDUCE DRIFT (OVERSPRAY) TO MINIMIZE PM EMISSIONS	4.50	None	?	BACT-OTHER
BASTROP CLEAN ENERGY CENTER	BASTROP, TX	3/21/2000	NO	NONE INDICATED	2.45	None	?	BACT-PSD
GATEWAY POWER PROJECT	TEXAS	3/20/2000	?	NONE INDICATED	1.07	None	?	BACT-PSD
JACK COUNTY POWER PLANT	HOUSTON, TX	3/14/2000	NO	NONE INDICATED	0.04	None	?	BACT-PSD
EXXON-MOBIL BEAUMONT REFINERY	BEAUMONT, TX	3/14/2000	?	NONE INDICATED	1.10	None	?	NSPS
FORNEY PLANT	HOUSTON, TX	3/6/2000	NO	NONE INDICATED	4.23	None	?	BACT-PSD
SAN JUAN REPOWERING PROJECT	MONACILLOS, PR	3/2/2000	?	DRIFT ELIMINATORS	0 004	None	0 0005%	OTHER
BAYTOWN COGENERATION PLANT	TEXAS	2/11/2000	?	NONE INDICATED	1.90	None	?	BACT-PSD
CORPUS CHRISTI ENERGY CENTER	TEXAS	2/4/2000	NO	NONE INDICATED	11.15	None	?	OTHER
KAUFMAN COGEN LP	CHARLOTTE, NC	1/31/2000	NO	NONE INDICATED	0.04	None	?	BACT-PSD
ARCHER GENERATING STATION	FARMERS BRANCH, TX	1/3/2000	?	NONE INDICATED	17.50	None	?	BACT-PSD
CARVILLE ENERGY CENTER	NORTHBROOK, LA	12/9/1999	?	GOP TO LIMIT EXCESS WATER & AIR FLOW & AVOID BYPASS OF THE DRIFT ELIMINATOR	0.92	None	?	BACT-PSD
RIO NOGALES POWER PROJECT	TEXAS	12/3/1999	?	NONE INDICATED	3.20	None	?	BACT-PSD
PPG INDUSTRIES	LAKE CHARLES, LA	12/2/1999	?	DRIFT ELIMINATOR	1.00	None	?	BACT-PSD
CORDOVA ENERGY CENTER	CORDOVA, IL	9/28/1999	?	DRIFT ELIMINATORS	4 11	Tons/Yr	0 002%	BACT-PSD
LAKE CHARLES REFINERY	WESTLAKE, LA	8/12/1999	?	DRIFT ELIMINATOR	1 30	None	0 004%	BACT-PSD
GREGORY POWER FACILITY	TEXAS	6/16/1999	NO	NONE INDICATED	0 01	None	?	BACT-PSD
LSP KENDALL ENERGY, LLC	MINOOKA, IL	6/2/1999	YES	DRIFT ELIMINATORS	6 90	Tons/Yr	0 001%	BACT-PSD
LAKE CHARLES REFINERY	WESTLAKE, LA	12/22/1998	NO	NONE INDICATED	1 00	None	?	BACT-OTHER
HIDALGO ENERGY FACILITY	SAN ANTONIO, TX	12/22/1998	NO	NONE INDICATED	3 52	None	?	BACT-PSD
PARIS GENERATING STATION	DALLAS, TX	10/28/1998	?	NONE INDICATED	2 40	None	?	BACT-PSD
FINA OIL AND CHEMICAL COMPANY	PORT ARTHUR, TX	9/8/1998	NO	NONE INDICATED	1.90	None	?	BACT-PSD
NSA-A DIVISION OF SOUTHWIRE COMPANY"	HAWESVILLE, KY	5/29/1998	?	REASONABLE POLLUTION PRECAUTIONS	0 29	None	?	OTHER
CHARTER STEEL DIVISION	SAUKVILLE, WI	2/26/1997	?	DRIFT ELIMINATOR & TDS IN THE COOLING WATER < 1.2% BY WT	1.30	None	?	BACT-PSD
CROWN/VISTA ENERGY PROJECT (CVEP)	WEST DEPFORD, NJ	10/1/1993	NO	DRIFT ELIMINATOR	5 90	None	?	BACT-PSD
BERGEN PLANT	NEWARK, NJ	5/27/1993	?	HIGH EFFICIENCY DRIFT ELIMINATOR	0 50	None	?	NSPS
KEYSTONE COGENERATION SYSTEMS, INC.	LOGAN TOWNSHIP, NJ	9/6/1991	YES	NONE INDICATED	3 10	None	?	BACT-OTHER
FLORIDA POWER CORPORATION CRYSTAL RIVER	CRYSTAL RIVER, FL	8/30/1990	YES	DRIFT ELIMINATOR	–	N/A	?	BACT-PSD

GOP = GOOD OPERATING PRACTICES, LDAR = LEAK DETECTION AND REPAIR, TDS = TOTAL DISSOLVED SOLIDS

Appendix C
Flora and Terrestrial Fauna Habitat and Communities in the Vicinity of IPEC

Coastal Zone Management Act Consistency Certification
in Support of
USNRC's Renewal of Indian Point Unit 2 and 3 Operating Licenses

Prepared for:

Entergy Nuclear Indian Point 2, LLC;
Entergy Nuclear Indian Point 3, LLC;
and Entergy Nuclear Operations, Inc.

Prepared by:

AKRF, Inc.

December 2012

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LIST OF ACRONYMS, DEFINED TERMS, AND ABBREVIATIONS FOR UNITS OF MEASUREMENT

Acronym, defined term, or abbreviation	Definition
BGEPA	Bald and Golden Eagle Protection Act
CFWHRF	Coastal Fish and Wildlife Habitat Rating Form
ECL	Environmental Conservation Law
ESA	Endangered Species Act
FSEIS	Final Supplemental Environmental Impact Statement
IPEC	Indian Point Energy Center (IP2 and IP3)
License Renewal	renewal of IPEC's operating licenses
NYCMP	New York Coastal Management Program
NYNHP	New York Natural Heritage Program
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
ppt	parts per thousand
RM	river mile
SCFWH	Significant Coastal Fish and Wildlife Habitat
USFWS	United States Fish and Wildlife Service
USNRC	United States Nuclear Regulatory Commission

I. INTRODUCTION

This Appendix describes the flora and terrestrial fauna habitat in the vicinity of Indian Point Energy Center ("IPEC"), and evaluates whether the United States Nuclear Regulatory Commission's ("USNRC") operating license renewal ("License Renewal") for IPEC is consistent with Policies 7, 8, and 9 of the New York State Department of State ("NYSDOS") New York Coastal Management Program ("NYCMP").

AKRF's key findings are as follows:

- no State- or federally listed plant species, ecological communities, or wildlife are documented for the IPEC Site;
- although State-listed rare, threatened, and endangered plant species occur within the vicinity of IPEC, they will not be adversely affected by the License Renewal;
- although State-listed ecological communities occur within the vicinity of IPEC, they will not be adversely affected by License Renewal;
- although State-listed threatened, endangered, and special concern wildlife occur within the vicinity of IPEC, they will not be adversely affected by the License Renewal;
- although federally listed wildlife species occur within the vicinity of IPEC, they will not be adversely affected by IPEC License Renewal; and
- although recreationally important terrestrial wildlife species occur in the vicinity of IPEC, they will not be adversely affected by IPEC License Renewal.

This Appendix addresses five areas in the vicinity of IPEC: the Hudson River in the IPEC region (River Mile ("RM") 41–44); the three Hudson River NYSDOS Significant Coastal Fish and Wildlife Habitats ("SCFWHs") that NYSDOS requested Entergy to consider in this Consistency Certification, namely, Hudson RM 44–56, Iona Island Marsh located at RM 45, and Haverstraw Bay (RM 34–40); the Coastal Zone portions of Orange, Putnam, Rockland, Westchester (see Figure C-1), and Dutchess Counties; and the newly proposed Hudson Highland Expansion Area RM 56-60 SCFWH.[1]

II. DATA SOURCES

To identify terrestrial plants, ecological communities, and wildlife (*i.e.*, those identified as rare, special concern, threatened or endangered species, or considered a candidate species

[1] After Entergy's License Renewal Application was filed with USNRC in 2007, NYSDOS proposed expanding the boundaries of RM 44 to 56 SCFWH to include RM 57 to 60 and RM 40 to 43 - the portion of the Hudson River adjacent to IPEC - within the new "Hudson Highlands" SCFWH. In a recent letter from the Acting Chief of the National Oceanographic and Atmospheric Administration's (NOAA) Coastal Programs Division, NOAA advised NYSDOS that changes to the NYCMP adopted after submission of an application to a federal agency cannot be applied retroactively to that consistency certification review (NOAA 2012).

under the Endangered Species Act ("ESA") that have the potential to occur within the vicinity of IPEC, the following data sources were consulted: NYSDOS guidance, the New York Natural Heritage Program ("NYNHP") database, United States Fish and Wildlife Service ("USFWS") County Lists of federally listed species, and the USNRC's December 2010 Final Supplemental Environmental Impact Statement ("FSEIS"). A brief description of these data sources and methodology is provided below.

A. NYSDOS Habitat Rating Forms

The NYSDOS Coastal Fish and Wildlife Habitat Rating Forms ("CFWHRFs") for the three SCFWHs were reviewed to determine the presence of any listed plant species occurring within these habitats (NYSDOS 1987a, b, c). No federally or State-listed plant species were specifically identified as occurring within the three SCFWHs in the CFWHRFs. However, the bald eagle (*Haliaeetus leucocephalus*) was listed in CFWHRF for the proposed new Hudson Highlands SCFWH (NYSDOS 2011). In addition, all terrestrial species noted in the CFWHRFs, including those that are not state or federally listed, are included in this analysis.

NYSDOS's CFWHRFs identify the presence of several ecological communities in the CFWHRFs as occurring in the three SCFWHs and the proposed Hudson Highlands SCFWH that are being assessed for IPEC License Renewal. These communities range from deep water habitats to rocky uplands. These ecological communities have also been defined by NYNHP and therefore have been described under the NYNHP headings below.

B. NYNHP Databases and NYSDEC Lists

In order to collect information on protected species within the State, letters dated September 25, 2009, and January 6, 2010, were sent to NYNHP requesting information on rare, special concern, threatened, endangered species, and significant ecological communities within the Hudson River between RM 34 and RM 56, within the three SCFWHs, and the Coastal Zone portions of Orange, Putnam, Rockland, and Westchester Counties (AKRF 2009, 2010). NYNHP sent responses to these requests on October 5, 2009, and February 1, 2010, with reports of rare or State-listed animals, plants, and ecological communities that NYNHP's databases indicate occur in the immediate vicinity of IPEC (NYNHP 2009a, 2010).

Following the 2009 and 2010 NYNHP correspondences, NYSDOS promulgated regulations proposing to expand the boundaries of the RM 44-56 SCFWH to include RM 56-60. In order to collect information on state-protected species within the boundaries of the proposed Hudson Highlands Expansion Area RM 56-60, a letter dated October 12, 2012, was sent to NYNHP requesting information on rare, special concern, threatened, endangered species of the Iona Island Marsh, Haverstraw Bay, and Hudson Highlands SCFWHs, and the Coastal Zone portions associated with these areas (AKRF 2012). NYNHP has not yet responded. In order to gain as much information as possible in support of this Consistency Certification, the New York State Department of Environmental Conservation's ("NYSDEC") New York Nature Explorer database was reviewed for data within a user defined area that included Hudson River Expansion Area RM 56-60 and the associated Coastal Zone (NYSDEC 2012). In addition, the NYNHP significant natural communities database was reviewed for ecological communities within the Hudson River between RM 34 to 60 and the associated Coastal Zone (NYSDEC 2009). Any species or ecological communities that were not previously documented by NYNHP in its 2009 and 2010 correspondences were added to this analysis.

The plant designations presented in the NYNHP and NYSDEC New York Nature Explorer data are taken from the NYSDEC's 6 NYCRR Section 193.3 "Protected Native Plants" regulations and the wildlife designations are from the Section 182.3 "Listing of Endangered and Threatened Species" and Section 182.4 "Listing of Species of Special Concern." On May 23, 2012, a new Section 193.3 was adopted to reflect changes in endangered, threatened, rare or exploitably vulnerable plant populations since the last revisions of the lists, which occurred in 2000. Therefore, all of the plant designations presented in the NYNHP data were cross-checked against the May 23, 2012 list and designations were updated accordingly.

With respect to the database query, NYNHP defines the distinction between a current and historical record to be the year 1980. Species observed and recorded since 1980 are considered to be current records; species observed and recorded prior to 1980 are considered historical records. Lists of species provided by NYNHP indicate that within the vicinity of the three SCFHWs, the IPEC Region, the Proposed Hudson Highland Expansion Area RM 56 to 60,[2] and/or the Coastal Zone (Table C-1; NYNHP 2009a, 2010) there are:

- 13 State-listed threatened plant species;
- 9 State-listed endangered plant species;
- 2 State-listed rare plant species;
- 12 State-listed historical-endangered plants records;
- 4 State-listed historical-threatened plants records;
- 1 State- listed historical-rare plant records;
- 13 rare ecological communities;
- 2 State-listed endangered bird species;
- 3 State-listed threatened bird species;
- 1 State-listed special concern bird species;
- 1 federally and State-listed endangered mammal species;
- 1 federally listed threatened and State-listed endangered turtle species;
- 1 State-listed threatened snake species;

[2] All river miles between 34 and 60 are included in all analyses. As an artifact of analyses conducted before NYSDOS proposed the Hudson Highlands SCFWH, Appendices A and C include RM 56–60 in the northern end of the Expansion Area, while Appendices B and D and the Exhibits to Appendix B include RM 57–60 in the northern end of the Expansion Area.

- 1 State-listed threatened lizard species;
- 1 State-listed special concern snake species;
- 1 State-listed special concern insect; and
- 6 unlisted/unprotected insects.

The information provided by NYNHP did not specify whether the State-protected species or rare natural communities are present on the IPEC Site itself, and specific locations of these species and communities were not specified in correspondence from NYNHP (NYNHP 2009a, 2010). However, to document State-listed flora, fauna, and ecological communities in the IPEC region, the majority of the plant species, natural community, and wildlife profiles were drawn from NYNHP Conservation Guides.

C. USFWS County List of Federally Endangered, Threatened, and Candidate Species

The USFWS County Lists for Orange, Putnam, Rockland, Westchester, and Dutchess Counties were consulted for the presence of federally listed endangered, threatened, or candidate plant species. One plant is listed as historically occurring in Rockland County (USFWS 2012a). No federally listed bird or insect species occur in the vicinity of IPEC, although one delisted bird species, bald eagle, is noted for all four counties. One federally listed endangered mammal (Indiana bat [*Myotis sodalist*]), one federally listed candidate mammal species (New England cottontail [*Sylvilagus transitionalis*]), and one federally listed threatened reptile species (bog turtle [*Glyptemys muhlenbergii*]) are noted for the five counties.

D. FSEIS

The FSEIS also evaluated the effects of License Renewal on plants, ecological communities, and terrestrial wildlife species that occur within the assessment area. Four state- and/or federally-listed wildlife species, the bald eagle, Indiana bat, the bog turtle, and the New England cottontail, as described above, were also evaluated in the FSEIS. These four species are presented in Section IV below.

III. LISTED PLANT SPECIES AND ECOLOGICAL COMMUNITIES

A. Plants

The species lists provided by NYNHP are for the immediate vicinity of the IPEC Site (RM 41–44), the three SCFWHs, and for the Coastal Zone. Although general locations (*i.e.*, at the county and SCFWH level) of specific plants were provided in correspondence from NYNHP, specific locations of individual species were not furnished. The information in this section is organized by source: NYSDOS, NYNHP, and USFWS. NYNHP State-listed plants are divided by the State ranking for each plant: endangered, threatened, rare, historical records of endangered plants, historical records of threatened plants, and historical records of rare plants. Summaries of NYSDOS-, NYNHP-, and USFWS-listed plants are presented in Table C-2.

The majority of species profiles below are drawn from NYNHP Conservation Guides, which provide both general habitat information known for each species (*i.e.*, water and soil regime, upland versus wetland, etc.) and specific ecological communities[3] identified within the State (*e.g.*, brackish-tidal marsh, oak-tulip tree forest, and acidic talus slope woodland) where each species has been documented. Thus, many of the following profiles include both general habitat information and specific ecological community information.

1. NYNHP-listed Endangered Plant Species Recorded Since 1980

a. Saltmarsh Bulrush

Saltmarsh bulrush (*Bolboschoenus novae-angliae* [*Scirpus novae-angliae*]) is a State-listed endangered species of the sedge (Cyperaceae) family. Habitat for this species includes saline to brackish marshes of tidal creeks and rivers, and brackish to fresh tidal shores (Fernald 1950). Due to these habitat preferences, this species is most likely a hybrid between the freshwater species, river bulrush (*Bolboschoenus fluviatilis*), and the saltwater species, sturdy bulrush (*Bolboschoenus robustus*) (FNA 2002a as cited in NYNHP 2011c). NYNHP-designated ecological communities associated with this species include brackish tidal marshes and tidal rivers (NYNHP 2011c).

Historical records indicate that six populations were known for New York, suggesting that this species had never been common. Currently, there are four saltmarsh bulrush populations within the State. These populations occur from western Long Island and New York City north through the lower Hudson River Valley to Orange County (NYNHP 2011c). Threats to this species include disturbances to habitat and associated water chemistry alterations, and invasion of habitat by common reed (*Phragmites australis*). One of the known historical populations was extirpated as a result of common reed invasion, and it is expected that, without management, common reed will potentially have an impact on all of the known populations in the future (NYNHP 2011c).

b. Straw Sedge

Straw sedge (*Carex straminea*) is a State-listed endangered plant of the sedge family. Habitat for this species in New York includes swamp margins and marshes. Within its range, other potential habitat includes freshwater swales, non-saline swamps, and wet meadows (Fernald 1950; Gleason and Cronquist 1991 as cited in NYNHP 2011e). NYNHP-designated ecological communities associated with this species include shallow emergent marshes. This species has the potential to occur in other NYNHP-designated ecological communities, including red maple-hardwood swamp and shrub swamps (NYNHP 2011e).

[3] Specific ecological communities of New York States are documented in "DRAFT Ecological Communities of New York State" (Edinger et al. 2002).

NYNHP recommends that recorded populations of this species be verified for their accuracy, as it is thought that reports and specimen labels of this species (more than 50 reports) may actually be misidentifications due to confusion over the taxonomic history of the species (NYNHP 2011e). Populations occur in southeastern New York (NYNHP 2011e). However, most of the populations are small, with the exception of one that has about 500 plants (NYNHP 2011e).

c. Lined Sedge

Lined sedge (*Carex striatula*) is a State-listed endangered plant of the sedge family. Habitat for this species includes deciduous granitic rocky woodlands in ravines with chestnut oak (*Quercus montana*), dry to moist ravine slopes, dry to mesic woods, rich open woods, and rich hardwoods (NYNHP 2011f; Gleason and Cronquist 1991 as cited in NYNHP 2011f; Rhoads and Block 2000 as cited in NYNHP 2011f; Fernald 1950). This species has the potential to occur in other NYNHP-designated ecological communities including the Appalachian oak-hickory forest, limestone woodland, maple-basswood rich mesic forest, and oak-tulip tree forest (NYNHP 2011f).

In New York State, lined sedge is at the northern edge of its range and is only known to occur in the lower Hudson Valley. Because this species is at the northern end of its range, it is likely that it has always been rare within the State. Historical records indicate that there were three known locations of this species. Currently, there is one known population of approximately 20 plants within the Hudson Valley. There are no known specific threats to populations of this species within the State (NYNHP 2011f).

d. Water Pigmyweed

Water pigmyweed (*Crassula aquatica [Tillaea aquatica]*) is a State-listed endangered plant of the stonecrop (Crassulaceae) family. In New York State, this annual species occurs in tidal mudflats, marshes, and rocky shorelines of the lower Hudson River and in one location on Long Island along the banks of an intertidal river (NYNHP 2011g). Within its range, this species occurs along pond margins, fresh to tidal shores, and coastal areas where mud shores and intertidal areas occur (Fernald 1950; Gleason and Cronquist 1991 as cited in NYNHP 2011g). NYNHP-designated ecological communities associated with this species include freshwater intertidal mudflats, freshwater intertidal shore, freshwater tidal marsh, and riverine submerged structure (NYNHP 2011g).

Historical records indicate that water pigmyweed has always been rare in New York. Currently, known populations of this species occur in the lower Hudson Valley. Current threats to this species include habitat invasion by common reed (NYNHP 2011g).

e. Yellow Flatsedge

Yellow flatsedge (*Cyperus flavescens*) is a State-listed endangered species of the sedge family. In New York State, habitats include salt marshes (high marsh) and coastal plain pond shores, as well as wet, sandy, and weedy roadsides (NYNHP 2011h). NYNHP-designated ecological communities associated with this species include coastal plain pond shores and unpaved road/path communities. This species also has the potential to occur in the NYNHP-designated high marsh community (NYNHP 2011h).

In New York State, habitat availability appears to be extensive, but the species is only known to occur from New York City north to Orange County (NYNHP 2011h). Historical records indicate that 15 populations once existed, but approximately half of these have been extirpated. Currently, there are five recorded populations, but more survey work is required to verify these populations. Current threats to this species include roadside management activities and habitat invasion by common reed (NYNHP 2011h).

f. Gypsy-wort

Gypsy-wort (*Lycopus rubellus*) is a State-listed endangered species of the mint (Lamiaceae) family. In New York State, this species occurs in marshes, fens, and flooded swamps. In one location on the Hudson River, it has been found growing in cracks of a stone wall. NYNHP-designated ecological communities associated with this species include marine riprap/artificial shore and medium fen (NYNHP 2011i).

Gypsy-wort has always occurred in low numbers within New York, and it is unlikely that more than five populations are present at one time. Historical records indicate that 10 occurrences have been documented, but not relocated. Currently, there are five small existing populations, but their likelihood of survival is not high. Some of the known populations are located within the lower Hudson Valley. Threats to the New York State populations have not been widely documented (NYNHP 2011i).

g. Virginia Pine

Virginia pine (*Pinus virginiana*) is a State-listed endangered plant of the pine family (Pinaceae). Habitat for this species includes sterile, dry soils. In New York, this species occurs in coastal oak forest openings, pitch pine and/or scrub oak barrens, and open rocky summits. One NYNHP-designated ecological community associated with this species is the pitch pine-oak-heath-rocky summit. This species has the potential to occur in other NYNHP-designated communities, including coastal oak-beech forest and coastal oak-heath forest (NYNHP 2011j).

In New York, Virginia pine occurs in the lower Hudson Valley north to Orange County. Currently, known populations are small and threatened by succession and/or invasion from surrounding vegetation (NYNHP 2011j).

h. Basil Mountain-mint

Basil mountain-mint (*Pycnanthemum clinopodioides*) is a State-listed endangered plant of the mint family. In New York State, populations of basil mountain-mint are typically found on south- or west-facing slopes in dry rocky soil. The species is often found in alkaline soil at sites located on traprock (diabase, a typically high-pH igneous rock) or calcareous bedrock where other mountain-mint species occur. NYNHP-designated ecological communities associated with this species include oak-hickory forests, woodlands, or savannas with exposed bedrock (NYNHP 2011k).

Basil mountain-mint is a globally rare species. In New York State, the range for this species is limited to the Palisades and Harlem Valley, which is the smallest range of any northeastern mountain-mint species (NYNHP 2011k). In addition, there are only three known basil mountain-mint populations within the State; two of which are small and one is threatened by competition from aggressive non-native plants (NYNHP 2011k). Threats to basil mountain-mint populations include succession within plant communities, encroachment of invasive plants, particularly black swallowwort (*Cynanchum* spp.), and in some cases, hybridization with other mountain-mint species (NYNHP 2011k).

i. Torrey's Mountain-mint

Torrey's mountain-mint (*Pycnanthemum torrei*) is a State-listed endangered plant of the mint family. In New York, this species occurs in dry, open areas of red cedar barrens, rocky summits, trails, and roadsides (NYNHP 2011l). Within its range, this species occurs in woods and thickets with fertile soils (Fernald 1950). NYNHP-designated ecological communities associated with this species include Appalachian oak-hickory forest and red cedar rocky summit. This species has the potential to occur in other NYNHP-designated communities characterized by limestone woodlands (NYNHP 2011l).

In New York, Torrey's mountain-mint is at the northeastern limit of its range, and, as such, this plant was never common within the State; populations are known to exist in Rockland and Dutchess Counties. There are three extant populations for the State and eight historical records for the New York City area. The three known populations are small or highly threatened by plant succession, development, or roadside management; the eight historical populations are thought to be extirpated. The best place to see this species is within High Tor Park in Rockland County (NYNHP 2011l).

2. NYNHP-listed Threatened Plant Species Recorded Since 1980

a. Woodland Agrimony

Woodland agrimony (*Agrimonia rostellata*) is a State-listed threatened species of the rose family. In New York State, habitat for this species includes rich mesic forests associated with slopes, calcareous bedrock of gorges, limestone shelves, streambanks, and other sites. Other habitat in New York includes dry oak woods, wooded pastures on rich soil and shrub thickets, (New York Natural Heritage Program 2006 as cited in NYNHP 2011lll). Within its range, this species also occurs in open woods, fields, thickets, and sandy clearings (Gleason and Cronquist 1991, Voss 1995, Rhoads and Block 2000, Fernald 1950 as cited in NYNHP 2011lll). NYNHP-designated ecological communities associated with this species include Appalachian oak-hickory forest, hemlock-northern hardwood forest, limestone woodland, and maple-basswood rich mesic forest (NYNHP 2011lll).

In New York, there are 17 known existing populations of woodland agrimony, each of which contains fewer than 100 plants, with the exception of one that has greater than 10,000 plants. These populations are considered stable and occur in the Hudson Valley, Long Island, and north and west of Albany. Sixteen historical populations are known, but many of these are extirpated as a result of development. Threats to this species are minimal. However, logging, development, succession, deer browsing, and invasive species are likely threats to some populations (NYNHP 2011lll).

b. Virginia Snakeroot

Virginia snakeroot (*Aristolochia serpentaria*) is a State-listed threatened plant of the birthwort (Aristolochiaceae) family. In New York, this species occurs in well-drained, rocky slopes of oak woods. Preferred drainage patterns for this species include southwest- to southeast- facing slopes in oak-hickory forests or chestnut oak forests where leaves collect in drainage channels. Within its range, Virginia snakeroot may occur in mesic forests, moist or dry upland woods, floodplains, and often in calcareous soils (FNA 1997 as cited in NYNHP 2011b; Gleason and Cronquist 1963; Mitchell and Beal 1979 as cited in NYNHP 2011b). NYNHP-designated ecological communities associated with this species include Appalachian oak-hickory and chestnut oak forests. Virginia snakeroot also has the potential to occur in other NYNYP-designated ecological communities, such as those characterized by limestone woodlands, oak-tulip tree forests, rich mesophytic forests, and successional old fields (NYNHP 2011b).

Virginia snakeroot is at the northern portion of its range in New York. Six known populations occur in the State on the west side of the Hudson River in the Hudson Highlands, and it is expected that with increased survey efforts additional populations of this plant will be discovered within the Hudson Highlands and the mid-Hudson Valley (NYNHP 2011b). With the exception of occasional deer browsing, threats to populations of this species are not known in New York State (NYNHP 2011b).

c. Smooth-bur Marigold

Smooth-bur marigold (*Bidens laevis*) is a State-listed threatened plant of the aster family (Asteraceae). In New York, the primary habitat for this species includes freshwater and brackish tidal mudflats and marshes. Associated species within these habitats include chairmaker's bulrush (*Schoenoplectus americanus*), annual wildrice (*Zizania aquatic*), Delmarva beggarticks (*Bidens bidentoides*), nodding beggartick (*Bidens cernua*), pickerelweed (*Pontederia cordata*), and green arrow arum (*Peltandra virginica*). Historical records indicate that this species once occurred in swamps, marshy meadows, and stream margins in western New York (NYNHP 2011m). Within its range, this species occurs along margins of freshwater or brackish pools and slow-moving streams and in low, wet places of coastal areas (Fernald 1950; Gleason and Cronquist 1963). NYNHP-designated communities associated with this species include brackish intertidal mudflats, brackish intertidal shores, brackish tidal marshes, freshwater intertidal mudflats, freshwater tidal marshes, and shallow emergent marshes (NYNHP 2011m).

In New York State, this species exists on Long Island and along the Hudson River, and, with the exception of the northern counties, is scattered throughout the State. Eleven populations have been recorded; 10 of these populations are present along the Hudson River. Common reed invasion within tidal marshes is the primary threat to the Hudson River populations (NYNHP 2011m).

d. Terrestrial Starwort

Terrestrial starwort (*Callitriche terrestris*) is a State-listed threatened plant of the water-starwort family (Callitrichaceae). In general, habitat for this species is diverse, as long as bare, muddy soil is present. In New York State, this species has been observed in a wide range of habitats, including mudflats, pond shores, and upland and wetland forests and in disturbed habitats of driveways and pastures (NYNHP 2011n). Within its range, habitat for this species also includes damp shaded soil, fallow fields, and footpaths (Gleason and Cronquist 1991 as cited in NYNHP 2011n; Fernald 1950). NYNHP-designated ecological communities associated with this species include chestnut oak forest, freshwater intertidal mudflats, hemlock-northern hardwood forest, pastureland, and red maple-hardwood swamp.

In New York, the majority of the known populations of this species occur within the Hudson Valley between Rockland and Columbia Counties. Currently, there are a total of 10 known populations, which all occupy disturbed sites. Because this species tends to persist in disturbed areas, such as unpaved or old secondary roads, human-induced threats to this species are related to the maintenance and upgrading of these roads to paved surfaces. Natural threats to this species include natural succession and drought (NYNHP 2011n).

e. Long's Bittercress

Long's bittercress (*Cardamine longii*) is a State-listed threatened species of the mustard family (Brassicaceae). Habitat within New York includes intertidal areas of tidal estuaries and backwater areas, including shaded portions of tidal swamps, mudflats, and muddy banks of tidal creeks. One known population is located in a non-tidal swamp forest on muddy, organic, alkaline soil (NYNHP 2011o). Within its range, other potential habitats include shady tidal banks and mucky areas under northern white cedar (*Thuja occidentalis*) and yellow birch (*Betula alleghaniensis*) woodlands and the edges of salt marshes (Crow 1982 as cited in NYNHP 2011o; Gleason and Cronquist 1991 as cited in NYNHP 2011o). NYNHP-designated ecological communities associated with this species include brackish intertidal mudflats, brackish intertidal shore, freshwater intertidal shore, freshwater tidal marsh, freshwater tidal swamp, red maple-hardwood swamp, and saltwater tidal creek.

In New York, Long's bittercress's range appears to be expanding northward up the Hudson River. Nine populations of this species occur along the Hudson River. The known populations of this species range in size from three to 300 plants. This species occurs in Iona Island Marsh and Bear Mountain State Park (NYNHP 2011o).

f. Clustered Sedge

Clustered sedge (*Carex cumulata*) is a State-listed threatened species of the sedge family. In New York, habitat for this species includes open rocky damp areas on acidic bedrock or shallow soil, recently burned areas, power line rights-of-way, open oak forests, woodlands, heathlands, and successional communities (NYNHP 2011p). Within its range, this species occurs in areas of dry, rocky, or sandy soil (Gleason and Cronquist 1963). NYNHP-designated ecological communities associated with this species include pitch pine-oak-heath rocky summit, pitch pine scrub oak barrens, rocky summit grassland, and shrub swamp. This species has the potential to occur in other communities designated by NYNHP, including mowed roadside/pathway, pitch pine-oak-heath woodland, and red cedar rocky summit (NYNHP 2011p).

Clustered sedge appears to be widely distributed within the State, and populations occur within the Hudson Valley. The majority of the plants in New York are found in the lower Hudson Valley in the Shawangunk Mountains, Hudson Highlands (*i.e.*, Breakneck Ridge), and Taconic Mountains (NYNHP 2011p). There are no known threats to populations of this species within New York State.

g. Marsh Straw Sedge

Marsh straw sedge (*Carex hormathodes*) is a State-listed threatened species of the sedge family. Within New York State, the common habitat for this species is in locations that are adjacent to salt or brackish coastal areas, but occasionally this species occurs in tidal marshes and within dune swales and dry or wet sands that are located slightly inland. Other habitats within the State include fens, wetland edges, and wet forests of coastal communities, fresh marshes, and rocky areas near the coast (NYNHP 2011q; Fernald 1950). NYNHP-designated ecological communities associated with this species include brackish interdunal swales, brackish meadow, brackish tidal marsh, high salt marsh, and sea level fen. This species has the potential to occur in other NYNHP-designated communities, including brackish intertidal shore, maritime beach, and maritime dunes (NYNHP 2011q).

In New York State, two populations of marsh straw sedge occur on the Hudson River, with the most northern populations occurring near Bear Mountain Bridge in Con Hook Marsh. Threats to populations of this species include habitat invasion by common reed, foot traffic, and habitat alterations due to roadway construction projects (NYNHP 2011q).

h. Midland Sedge

Midland sedge (*Carex mesochorea*) is a State-listed threatened plant of the sedge family. In New York, habitat for this species includes sandy soils of maritime grasslands, oak woods, mowed cemeteries, paths, and fields (NYNHP 2011d). Other habitats may include pitch pine-oak-heaths, rocky summits, and red cedar rocky summits.

This species is probably not native at the northern and eastern limits of its range, and since New York is near these range limits, further evaluation is warranted (NYNHP 2011d). Within New York, biologists consider the presence of Midland sedge a natural extension of a Midwestern population. Currently, there are eight known populations of this species within New York. These populations are known to exist in the Hudson Highlands (NYNHP 2011d).

With the exception of the invasion of habitat by exotic and invasive species, there are few known threats to this species. This sedge tends to colonize disturbed areas, particularly those that have been burned (*i.e.*, abandoned fire pits) or mowed (NYNHP 2011d). Since surveys for this species within New York have not been exhaustive, it is likely that the species is more common than the State rank may indicate, and based on long-term trends, it is expected that additional populations of this species will be discovered in the future (NYNHP 2011d).

i. Salt-marsh Spikerush

Salt-marsh spikerush (*Eleocharis uniglumis* var. *halophila*) is a State-listed threatened plant of the sedge family. In New York State, habitat for this species is diverse and includes the margins of fluctuating shorelines influenced by salt or brackish water. Within its range, this species tolerates a wide range of soil types, including peat, muck, and sand. NYNHP-designated ecological communities associated with this species include coastal plain pond and coastal plain pond shore. This species has the potential to occur in other NYNHP-designated communities, including brackish tidal marsh and high and low salt marshes (NYNHP 2011r).

In New York State, existing populations occur on the lower Hudson River north to Orange County. Current threats to this species include habitat invasion by common reed and habitat degradation as a result of stormwater runoff (NYNHP 2011r).

j. Featherfoil

Featherfoil (*Hottonia inflata*) is a State-listed threatened species of the primrose family (Primulaceae). In New York State, habitat for this species includes kettle ponds, vernal pools, coastal swales, and ponded areas of small streams. Other habitat includes pools, ditches, and quiet shallow waters or wet soil of coastal plain areas (Fernald 1950; Gleason and Cronquist 1963). The seed of this species is thought to be spread by ducks and beavers. NYNHP-designated ecological communities associated with this species include coastal plain pond, deep emergent marsh, pine-barrens vernal pond, shallow emergent marsh, shrub swamp, and vernal pool (NYNHP 2011s).

In New York, known populations of this species occur in the Hudson Valley north to Orange County. Featherfoil populations tend to fluctuate naturally, as the species has a two-year life cycle. Threats to populations of this species include habitat development and habitat invasion by Japanese silver grass (*Microstegium* spp.) (NYNHP 2011s).

k. Violet Wood-sorrel

Violet wood-sorrel (*Oxalis violacea*) is a State-listed threatened species of the wood-sorrel family (Oxalidaceae). In New York, the primary habitat for this species is steep rocky slopes and open summits on ledges, trail edges, and openings surrounded by oak-hickory communities that have rocky rich soils (NYNHP 2011t). Within its range, violet wood-sorrel occurs on gravelly banks and prairies and dry upland woods (Fernald 1950; Gleason and Cronquist 1991 as cited in NYNHP 2011t). NYNHP-designated communities associated with this species include Appalachian oak-hickory forest, calcareous talus slope woodland, chestnut oak forest, and red cedar rocky summit (NYNHP 2011t).

In New York State, the majority of the extant populations are within the lower Hudson Valley south of Columbia County. Threats to the species include habitat invasion by garlic mustard (*Alliaria petiolata*) and foot traffic (NYNHP 2011t).

l. Spongy Arrowhead

Spongy arrowhead (*Sagittaria montevidensis* var. *spongiosa*) is a State-listed threatened annual plant of the water-plantain family (Alismataceae). In New York State, the primary habitat for this species is freshwater to brackish intertidal mudflats, but the species occasionally occurs in adjacent brackish to fresh tidal marshes. Associated species include awl-leaf arrowhead (*Sagittaria subulata*) in mudflats and taller vegetation in the marshes (NYNHP 2011v). This species is also known to occur in shallow waters of the Hudson River (Haynes 1979 as cited in NYNHP 2011v). NYNHP-designated ecological communities associated with this species include brackish intertidal mudflats, brackish tidal marsh, freshwater intertidal mudflats, and freshwater tidal marsh (NYNHP 2011v).

In New York State, the habitat for this species is very limited. Known populations of this species occur in a location south of Albany, an area north of the Tappan Zee Bridge on the Hudson River, and in Iona Island Marsh. Currently, there are approximately 20 known extant populations of spongy arrowhead, and seven of these have no more than 100 plants. Threats to these populations include habitat alterations and disturbances as result of large wakes by boats (NYNHP 2011v).

m. Saltmarsh Aster

Saltmarsh aster (*Symphyotrichum subulatum* var. *subulatum [Aster subulatus* var. *euroauster]*) is a State-listed threatened plant of the aster family. In New York, the habitat for this species includes coastal salt to brackish marshes, saltwater influenced communities of tidal channel edges and creek banks, shrub-dominated habitats, salt ponds, and disturbed habitats, as well as wet brackish swales in between maritime dunes. This species also occurs in inland salt marshes, artificial salt ponds, and salt storage sites near the City of Syracuse (NYNHP 2011w). Within its range, this species occurs in the vicinity of salted highways and salt mines, fresh thickets, and woodland edges (Brouillet et al. 2006 as cited in NYNHP 2011w; Fernald 1950). NYNHP-designated ecological communities associated with this species include brackish interdunal swales, brackish meadow, brackish tidal marsh, coastal salt pond, estuarine riprap/artificial shore, high salt marsh, inland salt marsh, salt shrub, and sea level fen (NYNHP 2011w).

In New York, saltmarsh aster occurs along brackish tidal drainages of the Hudson River north to Putnam and Rockland Counties. At least five out of the extant populations are small, with 50 or fewer individuals. The habitat for this species is limited within the State, and much of it has been damaged or destroyed. Populations have declined over the past 100 years, and current populations are threatened by habitat invasion by common reed and purple loosestrife (*Lythrum salicaria*), alterations to habitat, and browsing by deer (NYNHP 2011w).

3. NYNHP-listed Rare Plant Species Recorded Since 1980

a. Small-flowered Crowfoot

Small-flowered crowfoot (*Ranunculus micranthus*) is a rare species of the buttercup family (Ranunculaceae). In New York, small-flowered crowfoot occurs on south- and southeast-facing slopes of ridges and summits. The species prefers partial shade and small openings; sites often have rich soils and high species diversity. This species has also been observed in acidic sandstone soils. The plant has been observed in a wide-range of forest communities, including beech-sugar maple, oak-hickory, and red cedar summits. NYNHP-designated ecological communities associated with this species include acidic talus slope woodland, Appalachian oak-hickory forest, pitch pine-oak-heath rocky summit, pitch pine-oak-heath woodland, pitch pine-scrub oak barrens, and rocky summit grasslands (NYNHP 2011u).

Within New York, small-flowered crowfoot occurs within the lower Hudson Valley to Columbia County. Currently, there are 22 extant populations that are in good to excellent condition, and it is expected that more populations are present in dry forests of the lower Hudson Valley. Small-flowered crowfoot has always been a rare plant in the State, but the number of extant populations has remained the same over the past 100 years. Iona Island North Knoll is the best location in the State to see this species (NYNHP 2011u).

b. Delmarva Beggars-ticks

Delmarva beggar-ticks (*Bidens bidentoides*) is a rare species of the aster family. Within New York State, habitat for this species includes NYNHP-designated freshwater tidal mudflats and marsh ecological communities. Delmarva beggar-ticks are usually found in the transitional area between the two communities and within sandy or muddy openings of the vegetated portions of the freshwater tidal marsh (New York Natural Heritage Program 2007 as cited in NYNHP 2011mmm). Within its range, this species also occurs along fresh and brackish tidal shores and estuaries (Gleason 1963).

In New York, Delmarva beggar-ticks occur in the freshwater tidally-influenced segment along the Hudson River as far north as Rensselaer County. There are 26 existing populations and many historical populations have been also found. These populations are thought to be stable and additional populations are expected to exist in New York (NYNHP 2011mmm). Threats to this species include: erosion from boat wakes in shoreline habitats, overuse by recreational boaters, development along the shoreline, future sea-level rise, and minor impacts from invasive species.

4. NYNHP Historical Records of State-Listed Endangered Plants Documented Before 1980

a. Puttyroot

Puttyroot (*Aplectrum hyemale*) is a State-listed endangered plant of the orchid family. In New York, this species occurs near limestone outcrops or in calcareous talus of rich deciduous or mixed deciduous-evergreen woods in soils of mesic upland to damp low ground areas. Within its range, this species also has the potential to occur in habitats ranging from upland to swamp forests and beech-maple woods, but is less likely to occur in rich wooded slopes and bottom lands (FNA 2002 as cited in NYNHP 2011aa; Voss 1972 as cited in NYNHP 2011aa; Rhoads and Block 2000 as cited in NYNHP 2011aa). NYNHP-designated ecological communities associated with this species include Appalachian oak-hickory forest and limestone woodland. This species also has the potential to occur in other NYNHP-designated communities, including beech-maple mesic forest, calcareous talus slope woodland, maple-basswood rich mesic forest, and rich mesophytic forest (NYNHP 2011aa).

Historical records indicate that this species once occurred throughout New York State, but currently there are no known occurrences in the Hudson River Valley. Threats to this population are thought to include acid rain, deer browsing, and changes in soil composition and chemistry (NYNHP 2011aa).

b. Wild Potato-vine

Wild potato-vine (*Ipomoea pandurata*) is a State-listed endangered species of the morning glory family (Convolvulaceae). This species occurs in dry fields, slopes, and thickets, and dry open or partially shaded soil (Connecticut Botanical Society 2005; Fernald 1950). Distribution data for New York State indicate that the species occurs in Dutchess County (USDA 2012a). Little information is available for this species within New York State.

c. Riverbank Quillwort

Riverbank quillwort (*Isoetes riparia*) is a State-listed endangered species of the quillwort family (Isoetaceae). In New York, habitat for this species includes pond margins, cobble shores of large rivers, tidal mudflats, and gravelly shallows of lakes (New York Natural Heritage Program 2004 as cited in NYNHP 2011nnn). In addition to the habitats listed above, within its range, the habitat for this species is diverse and includes streams, tidal shores and estuaries, and calcareous to slightly acidic substrates in fresh, usually oligotrophic water (Flora of North America 1993 as cited in NYNHP 2011nnn), and gravelly or muddy tidal and non-tidal freshwater shores, streams, and fresh or slightly brackish rivers (Gleason and Cronquist 1991, Fernald 1970, Flora of North America 1993 as cited in NYNHP 2011nnn). NYNHP-designated ecological communities associated with this species include brackish intertidal mudflats, cobble shore wet meadow, freshwater intertidal mudflats, inland calcareous lake shore, and unconfined river (NYNHP 2011nnn).

There are two known populations located in the vicinity of the Taconic Range and the Delaware River, and a number of historical populations within the state, including areas along the Hudson River. However, historical populations along the Hudson River have not been found in recent years. Another population is reported for the Shawangunk Mountains near Mohonk Lake, but this population has not been relocated since the late 1970s. Riverbank quillwort is also found on the Vermont side of Lake Champlain, which suggests that it could also be found in the northern portions of the lake on the New York side. Water quality degradation is thought to be the reason for the decline of this species. Known threats include pollutants, run-off, boat traffic, among others (NYNHP2011nnn).

d. Large Twayblade

Large twayblade (*Liparis liliifolia*) is a State-listed endangered species of the orchid family (Orchidaceae). In New York State, habitat for this species occurs in both wetland and upland areas. Large twayblade is known to grow in hummocks in sphagnous peat in red maple-dominated swamps and is also known to occur in dry woods in limestone soils, wooded talus slopes, and at railroad rights-of-way at the edge of swamps (NYNHP 2011x). Within its range, this species also occurs in loamy or sandy woods and clearings and rich woods (Fernald 1950; Gleason and Cronquist 1991 as cited in NYNHP 2011x). Large twayblade is known to occur in early to mid-successional forests in areas recovering from disturbance. NYNHP-designated communities associated with this species include limestone woodland, red maple-hardwood swamp, and shrub swamp. This species also has the potential to occur in NYNHP-designated red cedar rocky summit (NYNHP 2011x).

In New York State, this species is at the northern edge of its range and is found in scattered populations across the State with the exception of the northern counties. Large twayblade appears to have declined within the State, as there are 52 historical records for this species but only eight known populations. Four of the existing populations have been surveyed, and plants were present in three of them (NYNHP 2011x). Threats to the species include flooding due to beaver activities, extirpation of some pollinators (*i.e.*, flies exterminated during mosquito control activities), and maturation of mid-successional communities (Mattrick 2004 as cited in NYNHP 2011x).

e. Virginia False Gromwell

Virginia false gromwell (*Onosmodium virginianum*) is a State-listed endangered species of the borage family (Boraginaceae). Habitat for this species within the State is based on one single population, which occurs inland in a NYNHP-designated red cedar barrens community. Within this habitat, the soils are calcareous, exposed bedrock is present, and there is mixture of tree, grass, and herbaceous species (NYNHP 2011y). Within its range, this species occupies maritime upland and inland limestone and other rocky calcareous sites, pinelands, dry sandy woods, and open sands (NYNHP 2011y; Fernald 1950).

In New York State, populations of this species are known to occur in the lower Hudson Valley. Historical records indicate that in the late 1800s and early 1900s, 22 known locations were known from areas that have since been developed. The single known population has 20 plants and is located in Dutchess County (NYNHP 2011y).

f. Hooker's Orchid

Hooker's orchid (*Platanthera hookeri*) is a State-listed endangered species of the orchid family. In New York State, the primary habitat for this species occurs in successional forest communities or forests with open understories dominated by poplar and pine species (NYNHP 2011z). Within its range, this species is also known to occur in a wide range of habitats, including dry to mesic coniferous and deciduous forest, rich moist woods, and thickets and borders (FNA 2002b as cited in NYNHP 2011z; Gleason and Cronquist 1991 as cited in NYNHP 2011z; Voss 1972 as cited in NYNHP 2011z). However, some reports contradict the above-mentioned habitat preferences and indicate that this species is less likely to occur in rich, well-drained deciduous woods and deciduous forest or hemlock-hardwoods (Rhoads and Block 2000 as cited in NYNHP 2011z; Voss 1972 as cited in NYNHP 2011z). Within New York State, this species occurs in the following NYNHP-designated ecological communities: beech-maple mesic forest, chestnut oak forest, hemlock-northern hardwood forest, red maple-hardwood swamp, and successional northern hardwood. This species also has the potential to occur within other NYNHP-designated ecological communities, including Appalachian oak-hickory forest, Appalachian oak-pine forest, calcareous talus slope woodland, limestone woodland, and pine-northern hardwood forest (NYNHP 2011z).

Within New York State, historical records indicate that this orchid occurred throughout a large portion of the State. However, currently, no known populations occur in the Hudson Valley region (NYNHP 2011z).

g. Catfoot

Catfoot (*Pseudognaphalium helleri* ssp. *micradenium*) is a State-listed endangered annual plant of the aster family. The species has range on the East Coast that extends from New York and New Jersey south and west to Virginia, Kentucky, and Georgia. Habitat for this species includes dry sandy soil of upland hardwood to mixed forests (Maine Department of Conservation 2004). This species has been documented in Rockland County (USDA 2012b). Very little information is available for the habitat and occurrences of this species within New York State.

h. Slender Marsh-pink

Slender marsh-pink (*Sabatia campanulata*) is a State-listed endangered plant of the gentian family (Gentianaceae). It is known to occur within 19 states (Zaremba 2004). In New

York, this species can be found on the upper edges of salt marshes, interdunal swales, and brackish tidal areas. One known population occurs in a salt marsh that receives freshwater seepage from gravel uplands. Associated species include northern bayberry (*Myrica pensylvanica*), cranberry (*Vaccinium macrocarpon*), drumheads (*Polygala cruciata*), swamp sunflower (*Helianthus angustifolius*), ridged yellow flax (*Linum striatum*), and common three-square (*Schoenoplectus pungens*). Within its range, this species also occurs in wet sands and peats (Newcomb 1977; Fernald 1950). Little information is documented on the extent of populations of this species within New York. However, two known populations in New York have been documented to have hundreds of individuals (Zaremba 2004). This species has been documented in Westchester County (USDA 2012c).

i. Michaux's Blue-eyed-Grass

Michaux's blue-eyed-grass (*Sisyrinchium mucronatum*) is a State-listed endangered species of the iris family (Iridaceae). In New York State, the primary habitat for this species is herb-dominated non-forested habitats, including fields, pastures, roadsides, forest edges, maritime grasslands, and ditches. Occasionally, this species occurs in non-forested shrub and sapling-dominated habitats. Michaux's blue-eyed grass occurs in soils ranging from very dry to seasonally wet or wetter and ranging from acidic to calcareous. This species is also known to occur in disturbed soils (NYNHP 2011gg). Within its range, this species occurs on prairies, moist open woods, and rock or sandy open shores, dry fields, roadsides, and open woods, and meadows (Cholewa and Henderson 2002 as cited in NYNHP 2011gg; Rhoads and Block 2000 as cited in NYNHP 2011gg; Gleason and Cronquist 1991 as cited in NYNHP 2011gg; Fernald 1950). NYNHP-designated ecological communities associated with this species include maritime grassland, mowed roadside/pathway, successional old field, and successional shrubland (NYNHP 2011gg).

In New York State, populations of this species are known throughout most of the State (NYNHP 2011gg). Although New York is located at the northern end of this species' range, habitat within the State is expansive, but long-term trends are unknown. There are seven extant populations and between 16 and 18 historical populations. Since Michaux's blue-eyed-grass prefers successional habitats, it is expected that it may not occur in one location over a long-term period (NYNHP 2011gg).

j. American Waterwort

American waterwort (*Elatine americana*) is a State-listed endangered plant of the waterwort family (Elatinaceae). In New York State, American waterwort occurs in intertidal mudflats and marshes along the Hudson River. Historically, this species occurred in kettle holes of the coastal plain (New York Natural Heritage Program 2007 as cited in NYNHP 2011ooo). Within its range, this species is known to occur along muddy tidal shores and at the margins of ponds and streams (Gleason 1952; Fernald 1970 as cited in NYNHP 2011ooo). NYNHP-designated ecological communities associated with this species include freshwater intertidal mudflats.

Two small populations, together containing less than 100 plants, are known to occur in New York State. A total of 18 historical populations are known for areas along the Hudson River with a small number on Long Island (NYNHP 2011ooo). Long-term trends for this species are unknown as the two existing populations have not been surveyed in recent years. According to NYNHP, historically, this species may not have been common in New York State (NYNHP 2011ooo). Shoreline use has been identified as a potential threat to this species (NYNHP 2011ooo).

k. Estuary Beggars-ticks

Estuary beggars-ticks (*Bidens hyperborea var. hyperborean*) is a State-listed endangered plant of the aster family. In New York State, estuary beggars-ticks only known habitats is freshwater intertidal mud flats and marshes containing three square (*Scirpus americana*), soft-stemmed bulrush (Scirpus validus), annual wildrice (*Zizania aquatica*), Delmarva beggars-ticks and narrow-leaf bur-read (*Sparganium eurycarpus*) (New York Natural Heritage Program 2007 as cited in NYNHP 2011ppp). Within its range, this species is known to occur within estuaries (Fernald 1970; Gleason 1952 as cited in NYNHP 2011ppp).

Two new populations (found in 1985) and one historical population is known to occur in New York State. No other historical populations have been found. Historically, this plant has not been common in New York State (NYNHP 2011ppp). Common reed invasion and recreational boating are potential threats to this species (NYNHP 2011ppp)

l. Mexican Seaside Goldenrod

Mexican seaside goldenrod (*Solidago sempervirens* var. *mexicana*) is a State-listed endangered plant of the aster family. In New York, habitat includes the high salt marsh community (NYNHP 2011qqq).

Three existing populations, each with hundreds of plants and seven historical populations with unknown statuses are known to occur in New York State. An additional two historical populations have been extirpated. Historically, this plant has not been common in New York. Common reed invasion is the known threat to all of the known populations of this species in New York (NYNHP 2011qqq)

5. NYNHP Historical Records of State-Listed Threatened Plants Documented Before 1980

a. Troublesome Sedge

Troublesome sedge (*Carex molesta*) is a State-listed threatened species of the sedge family. Primary habitat for this species includes wet fields, alvar grasslands, and oak openings in dry to wet calcareous soils. Within New York State, this species is also known to occur on river banks, woodlands, talus slopes, and disturbed areas (NYNHP 2011bb). Other habitats within its range include dry to slightly moist open grounds and woodland edges (Fernald 1950). NYNHP-designated ecological communities associated with this species include alvar grassland, inland calcareous lake shore, oak openings, and successional old field. This species also has the potential to occur in NYNHP-designated communities of alvar woodland, calcareous talus slope woodland, limestone woodland, and successional shrubland (NYNHP 2011bb).

There are 13 extant populations scattered across the New York State outside of the Catskill and Adirondack Mountains. Historical records indicate that there were 20 to 40 populations known at one time, but surveys have not been conducted to verify the status of these populations. Furthermore, due to the weedy nature of this species, it is possible that unrecorded populations are present throughout the State (NYNHP 2011bb).

b. Rough Avens

Rough avens (*Geum virginianum*) is a State-listed endangered plant of the rose family. In New York, rough avens occurs in a wide range of habitats, including Appalachian oak-hickory forests, northern-hardwood forests, woodlands of limestone bedrock substrates and swamps, sandy dunes, riverbanks, marshes, and roadsides (NYNHP 2011cc). Within its range, this species is also known to occur on rocky banks, dry woods, and in moist upland woods (Fernald 1950; Newcomb 1977; Gleason and Cronquist 1963). NYNHP-designated communities associated with this species include alvar woodland, great lakes dunes, hemlock-northern hardwood forest, shallow emergent marsh, and silver maple-ash swamp. This species also has the potential to occur in NYNHP-designated beech-maple mesic forests (NYNHP 2011cc).

In New York, rough avens is scattered throughout the State. Currently, there are 15 known populations and 22 historical records of this species, but little is known about them. Only one of these populations has more than 50 individuals. More survey work is required to document the status of existing populations and to understand the long-term trends of this species (NYNHP 2011cc). Threats to known populations within the State include development and invasive species (NYNHP 2011cc).

c. Eastern Grasswort

Eastern grasswort (*Lilaeopsis chinensis*) is a State-listed threatened species of the carrot family (Apiaceae). In New York, this species occurs in brackish marshes and intertidal mudflats, peat edges of salt marshes, muddy locations with brackish or salt water influences, and rocky shores adjacent to the abovementioned communities (NYNHP 2011dd). Within its range, eastern grasswort is also known to occur in tidal shores bordering the coastal plain, and mud of tidal and brackish marshes (Gleason and Cronquist 1991 as cited in NYNHP 2011dd). NYNHP-designated ecological communities associated with this species include brackish intertidal mudflats, brackish intertidal shore, brackish tidal marsh, low salt marsh, and sea level fen (NYNHP 2011dd).

In New York, this species is known to occur in brackish areas of the lower Hudson River. It is likely that no more than 50 populations of this species ever existed within the State, and currently there are nine known populations. There are a number of threats to this species, including alterations to habitat and hydrology, runoff, sedimentation, common reed invasion, and Canada goose activity (NYNHP 2011dd).

d. Globe-fruited Ludwigia

Globe-fruited ludwigia (*Ludwigia sphaerocarpa*) is a State-listed threatened species of the evening-primrose family (Onagraceae). In New York, the primary habitat for this species is the edges of shallow coastal plain ponds of pine barrens. Due to pond water variations, plants can occur on pond shores or within standing water of the ponds. This species is also known to occur in shrub swamps and inlets/outlets of wetlands of pine barrens. Within the lower Hudson Valley, one population is known to occur in shallow water on mats of floating vegetation along the shore of a pond (NYNHP 2011ee). Within its range, this species is also known to occur in wet soil, drainage ditches, stream shores, river marshes, swales, edges of limestone sinks, peaty bogs in pastures, and interdunal marshes (Gleason and Cronquist 1991 as cited in NYNHP 2011ee; Peng 1989 as cited in NYNHP 2011ee). NYNHP-designated ecological communities associated with this species include coastal plain pond, coastal plain pond shore, and pine barrens shrub swamp (NYNHP 2011ee).

Within New York, this species is at the northern edge of its range. Historical populations are known to have occurred in the lower Hudson Valley to as far north as Ulster County, but have not been seen in more than 70 years. Currently, 17 known extant populations exist. It is likely that habitat destruction as a result of development is the leading cause of the extirpation of this species at the historical locations (NYNHP 2011ee).

6. NYNHP Historical Records of State-Listed Rare Plants Documented Before 1980

a. Heartleaf Plantain

Heartleaf plantain (*Plantago cordata*) is a State-listed threatened species of the plantain family (Plantaginaceae). In New York, this species occurs in two different locations and habitats. In western New York, this species is found in gravelly streams within red maple-hardwood swamps. Within the Hudson Valley, heartleaf plantain occurs in freshwater habitats including intertidal mudflats, sandy or gravel shorelines of tidal waterways, tidal marshes, and gravelly shorelines of the Hudson River (NYNHP 2011ff). Within its range, this species also occurs in semi-aquatic areas of marshes and along streams, particularly with calcareous substrates (Gleason and Cronquist 1991 as cited in NYNHP 2011ff). NYNHP-designated ecological communities associated with this species include freshwater intertidal mudflats, freshwater intertidal shore, freshwater tidal creek, freshwater tidal marsh, and marsh headwater stream (NYNHP 2011ff).

In New York, a large proportion of the population is located on the Hudson River. Currently, there are approximately 30 known populations and sub-populations of this species along the freshwater tidal portion of the Hudson River. Several of these populations are small and have less than 40 individuals, with the exception of at least three populations that have more than 1,000 plants. It likely that one colony of about 3,000 plants located upstream is the main seed source of the populations located downstream (Mitchell and Sheviak 1983). All of the current and historical populations of this species within the State are located along the Hudson River. Although historical records indicate that this species occurred as far south as New York City on the Hudson River, current populations are known to exist between the Rondout Creek mouth (~RM 90) and Troy (RM 150) (NYNHP 2011ff).

7. USFWS-listed Plant Species

The following presents the one federally listed species documented by USFWS for the Coastal Zone. A summary of this species is presented in Table C-3.

a. Small Whorled Pogonia

The small whorled pogonia (*Isotria medeoloides*) is a federally listed threatened and a State-listed endangered plant of the orchid family (USFWS 2012a, b; Young 2010). This species prefers acidic soils and a thick layer of decaying leaf matter, and often occurs on the slopes that border small streams. Associated ecological communities include the open understory areas of older hardwood forests, including those that have beech, birch, maple, oak, and hickory species (USFWS 2012b).

Although historical records are available for this species, it is currently thought to be extirpated from New York (USFWS 2012b). Loss of populations of this species is thought to be due to development and habitat degradation as a result of urban expansion, forestry practices, and recreational activities (USFWS 2012b).

B. NYNHP/New York State Rare Ecological Communities

The following are profiles for 13 ecological communities provided by NYNHP for the immediate vicinity of the IPEC Site (RM 41–44), the three SCFWHs, the Coastal Zone, and RM 56 to 60.

1. Acidic Talus Slope Woodland

The acidic talus slope woodland community typically occurs on unstable well-drained talus slopes in dry shallow soils composed of non-calcareous bedrock (Edinger et al. 2002). Because the substrate is unstable, canopy cover is typically less than 50 percent. Common trees include chestnut oak, pignut hickory (*Carya glabra*), red oak (*Quercus rubra*), and white oak (*Quercus alba*). Smooth sumac (*Rhus glabra*) and scrub oak (*Quercus ilicifolia*) are other characteristic species. Pennsylvania sedge is common throughout the herbaceous layer. New York State-listed protected plant species that may be found in this community may include some of the following: musk root (*Adoxa moschatellina*), Fernald's sedge (*Carex merritt-fernaldii*), Carey's smartweed (*Persicaria careyi*), and small-flowered crowfoot. One federally and State-listed threatened plant, Northern monk's-hood (*Aconitum noveboracense*), also has the potential to occur within this community (NYNHP 2011hh). Within New York State, there are several hundred occurrences of the acidic talus slope woodland community. This community is present in the areas of the Hudson Highlands. Threats to this community include changes in land use, forest fragmentation, invasive species, over-browsing by deer, lack of fire, and air pollution (NYNHP 2011hh).

2. Appalachian Oak-Hickory Forest

The Appalachian oak-hickory forest is a hardwood forest that commonly occurs at the tops of ridges and upper slopes, and south- and west-facing slopes. The soils of this community are typically well-drained and comprised of loams or sandy loams. This community is broadly defined. Dominant trees include at least one species of oak along with other characteristic tree species including red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), pignut hickory, shagbark hickory (*Carya ovata*), and white ash (*Fraxinus americana*) (Edinger et al. 2002). Characteristic large shrubs may include flowering dogwood (*Cornus florida*) and American witch-hazel (*Hamemelis virginana*); smaller shrubs may include early low-bush blueberry (*Vaccinium pallidum*) and maple-leaf viburnum (*Viburnum acerifolium*). Herbaceous species and grasses typical of the Appalachian oak-hickory forest include wild sarsaparilla (*Aralia nudicaulis*) and black snakeroot (*Cimicifuga racemosa*) (NYNHP 2011ii).

In New York, the Appalachian oak-hickory forest is considered a matrix forest whereby the community has a widespread distribution and includes several large, high-quality occurrences, which may also have pockets of other ecological communities nested within them. Appalachian oak-hickory forests occur within the Hudson Highlands, the Hudson Limestone Valley, Taconic Foothills, and Catskill Mountains. Appalachian oak-hickory forests that are located on public or private conservation land are the most stable, but are in decline in unprotected areas due to development pressure, forest fragmentation, invasive species, and changes in land use (NYNHP 2011ii).

3. Brackish Intertidal Mudflats

Brackish intertidal mudflats are intertidal mudflats that are exposed at low tide and submerged at high tide in waters that have a salinity range from 0.5 to 18 parts per thousand ("ppt"). Vegetation of this community is limited and dominated by aquatic species, such as spongy arrowhead (*Sagittaria montevidensis*), strap-leaf arrowhead, mudwort (*Limosella australis*), and tapegrass (*Vallisneria americana*). State-protected species that have the potential to occur may include eastern grasswort, riverbank quillwort (*Isoetes riparia*), Long's bittercress, American waterwort (*Elatine americana*), spongy arrowhead, and smooth bur-marigold (NYNHP 2011jj).

In New York, this community occurs along the Hudson River in Dutchess, Orange, Putnam, Rockland, and Westchester Counties. Along the Hudson River, this community is present in Hudson Highlands State Park, Bear Mountain State Park, and Tallman Mountain State

Park, among others. Brackish intertidal mudflats are listed as potential communities of Iona Island Marsh. Threats to this community include shoreline development, invasive species, recreational boat traffic, and reductions of water quality as a result of shipping lane dredging (NYNHP 2011jj).

4. Brackish Tidal Marsh

The brackish tidal marsh community occurs where water salinity levels range between 0.5 and 18 ppt and water depth is less than 6 feet at high tide. Vegetation of the brackish tidal marsh community is dense and dominated by a mixture of salt marsh and freshwater tidal marsh graminoid species. Dominant species include narrowleaf cattail, crimsoneyed rosemallow (*Hibiscus moscheutos*), seaside goldenrod (*Solidago sempervirens*), saltmarsh fleabane (*Pluchea odorata*), and various bulrushes. However, brackish tidal marshes can also be dominated by common reed. Brackish tidal marshes that are dominated by common reed are not defined as brackish tidal marshes, but are defined by NYNHP as "cultural" communities (*i.e.*, those that have been affected by human activities). State-protected plant species that may occur in the brackish tidal marsh include eastern grasswort, Long's bittercress, saltmarsh aster, smooth bur-marigold, saltmarsh bulrush, and terrestrial starwort (NYNHP 2011kk).

Along the Hudson River, the occurrence of this community corresponds to the brackish tidal waters between New Hamburg/Poughkeepsie (~RM 75) and Hastings-on-Hudson (RM 22). Tidal brackish marshes are known to occur in Hudson Highlands State Park and Bear Mountain State Park. The primary threats to this community are shoreline development and invasive species, but reductions in water quality as a result of chemical runoff and dredging of the shipping lane may also threaten brackish tidal marshes. Brackish tidal marshes are listed as potentially occurring in RM 44–56, Iona Island Marsh, and Haverstraw Bay (NYNHP 2011kk).

5. Chestnut Oak Forest

The chestnut oak forest community occurs on well-drained rocky sites of glaciated areas of the Appalachians and the coastal plain. Dominant species include chestnut oak and red oak with ericaceous shrubs such as mountain laurel (*Kalmia latifolia*), huckleberry (*Gaylussacia spp.*), and low-bush blueberries in the understory. State-protected species that have the potential to occur in this community include Bayard's adder's-mouth orchid (*Malaxis bayardii*), glaucous sedge (*Carex glaucodea*), black-edge sedge, Virginia snakeroot, Hooker's orchid, terrestrial starwort, and violet wood-sorrel (NYNHP 2011ll).

In New York, this community occurs in the lower portion of the Hudson Valley in the Hudson Highlands. Threats to this community include development, changes in land use, invasive species, air pollution, fire suppression, and over-browsing by deer (NYNHP 2011ll).

6. Cliff Community

The cliff community is comprised of shallow soils with sparse vegetative cover on vertical non-calcareous bedrock walls. Plant species can be a variety of tree, shrub, and herbaceous species that grow in shallow pockets of soil that collects on ledges, cracks, and crevices within the bedrock. State-protected species that have the potential to occur in cliff communities include Bradley's spleenwort (*Asplenium bradleyi*), black-edge sedge (*Carex nigromarginata*), mountain spleenwort (*Asplenium montanum*), fragrant cliff fern (*Dryopteris fragrans*), golden corydalis (*Corydalis aurea*), alpine cliff fern (*Woodsia alpina*), and alpine goldenrod (*Solidago leiocarpa*) (NYNHP 2011mm).

In New York State, this community is widely distributed north of the North Atlantic Coast Ecoregion and is known to occur in the Catskill Mountains and the Hudson Highlands. Cliff communities are threatened by upslope development, recreational uses, habitat alterations, and invasive species (NYNHP 2011mm).

7. Freshwater Tidal Marsh

A freshwater tidal marsh is a marsh community that occurs in waters that are less than 6 feet deep and have a salinity of less than 0.5 ppt. These communities typically occur in shallow bays, shoals, and the mouths of tributaries of large tidal river systems with dominant aquatic vegetation that is emergent at high tide. Within the freshwater tidal marsh community, there are two vegetative zones: one that is located at a lower elevation and is dominated by short, broad-leaved emergent plant species that border mudflat areas or open water; and a zone located at a slightly higher-elevation that is dominated by taller graminoids (Edinger et al. 2002). The vegetation is dominated by aquatics that are emergent at high tide. Species within these zones may include kidneyleaf mud-plantain (*Heteranthera reniformis*), spotted jewelweed (*Impatiens capensis*), yellow pond-lily (*Nuphar advena*), pickerelweed, narrow-leaved cattail, and wild rice (NYNHP 2011nn).

Within New York State, freshwater tidal marsh communities are limited to the central portion of the Hudson River between Rensselaer and Rockland Counties, with the majority of the habitat occurring within Columbia, Green, Dutchess, and Ulster Counties. Examples of the freshwater tidal marsh community occur in the Hudson River, Bear Mountain State Park, Hudson River Islands State Park, and Tivoli Bay Wildlife and Management Area. Threats to this community include development, stormwater runoff, dredging of the shipping lane, and invasion by non-native invasive species, such as purple loosestrife and common reed (NYNHP 2011nn).

8. Oak-Tulip Tree Forest

The oak-tulip tree forest is a mesophytic hardwood community of well-drained soils. Dominant species include a variety of oaks, tulip tree (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), black birch (*Betula lenta*), and red maple. Flowering dogwood, American witch-hazel, sassafras (*Sassafras albidum*), and lowbush blueberries (*Vaccinium angustifolium, Vaccinium pallidum*) may occur in the sub-canopy and shrub layers. Species in the herbaceous layer include New York fern (*Thelypteris novaboracenis*), white wood aster (*Eurybia divaricata*), and Solomon's plume (*Maianthemum racemosum*) (Edinger et al. 2002). State-protected plants with the potential to occur within this community include Virginia snakeroot, wild comfrey (*Cynoglossum virginianum* var. *virginianum*), terrestrial starwort, narrow-leaved sedge (*Carex amphibola*), and Reznicek's sedge (*Carex reznicekii*) (NYNHP 2011oo).

In New York, this community occurs within the Hudson Highlands and the Hudson Limestone Valley. Bear Mountain Park is among one of the best locations to see this community. Threats to this community include development, invasive species, deer browsing, fire suppression, air pollution, and forest fragmentation (NYNHP 2011oo).

9. Pitch-pine-oak-heath Rocky Summit

The pitch-pine-oak-heath rocky summit community occurs on warm, rocky ridgetops, and summits in non-calcareous bedrock and dry, acidic soils. Vegetation is typically sparse, but widely defined where pine (*Pinus* spp.) species may be replaced with scrub oak or heath shrubs. This community is often surrounded by the chestnut oak forest community described above. State-protected plant species that have the potential to occur in this community include broom crowberry (*Corema conradii*), clustered sedge, Bayard's adder's-mouth orchid, Appalachian sandwort (*Minuartia glabra*), midland sedge, Fernald's sedge, and small-flowered crowfoot, among others (NYNHP 2011pp).

In New York, this community occurs in the eastern portion of the State from the Adirondack Mountains south through the Hudson Highlands. Bear Mountain State Park, Catskill Park, and Taconic State Park are among some of the locations where this community occurs. Threats to this community include development and recreational uses (NYNHP 2011pp).

10. Red Cedar Rocky Summit

The red cedar rocky summit community occurs on warm, rocky ridge-tops, and summits comprised of calcareous bedrock and dry soils. Vegetation is typically sparse with lichen-covered outcrops surrounded by the Appalachian oak-hickory forest community. The dominant tree species is the eastern red cedar (*Juniperus virginiana*), which may be dead or dying due to heat stress (Edinger et al. 2002). State-protected species that have the potential to occur in this community include clustered sedge, Bayard's Adder's-mouth orchid, midland sedge, large twayblade, violet wood-sorrel, and Torrey's mountain-mint (NYNHP 2011qq).

This community is present throughout New York State. Threats to this community include development and recreational traffic (NYNHP 2011qq).

11. Rocky Summit Grassland

Rocky summit grassland communities occur in rocky areas of summits, ridges, and outcrops. This grassland community is dominated by grasses, such as Indian grass (*Sorgastrum nutans*), and herbaceous plant species with limited cover of woody species, such as blueberries and red oak. State-protected plant species that have the potential to occur in a rocky summit grassland community include clustered sedge, basil mountain-mint, reflexed sedge (*Carex retroflexa*), midland sedge, and small-flowered crowfoot, among others (NYNHP 2011rr).

In New York, this community is found in the Lower New England Ecoregion within the Hudson Highlands. Threats to this community include development, overuse, fire suppression, invasive species, and deer browsing (NYNHP 2011rr).

12. Floodplain Forest

The floodplain forest is a hardwood forest that occurs on low terraces of river floodplains and river deltas with mineral soils. This is a broadly defined community with a plant composition that is variable, can be diverse, and is influenced by flood frequency and elevation along the river delta (NYNHP 2011rrr). Commonly occurring trees include silver maple (*Acer saccharinum*), ashes (*Fraxinus* spp.), cottonwood (*Populus deltoides*), red maple, box elder (*Acer negundo*), elms (*Ulmus americana*, *U. rubra*), hickories, butternut and black walnut (*Juglans cinerea*, *J. nigra)*, sycamore (*Platanus occidentalis*), white oak, pin oak (*Quercus palustris*), and river birch (*Betula nigra*). Dominant shrubs include spicebush (*Lindera benzoin*), ironwood (*Carpinus carolinianus)*, bladdernut (*Staphylea trifoliata*), speckled alder (*Alnus incana* spp. *rugosa*), dogwoods (*Cornus sericea*, *C. foemina* spp. *racemosa*, *C. amomum*), viburnums (*Viburnum cassinoides*, *V. prunifolium*, *V. dentatum*, *V. lentago*), and sapling canopy trees (Edinger et al. 2002).

In New York, there are several hundred occurrences statewide; these are limited to large streams and rivers. Most occurrences are small and degraded, but there are a few large, high quality old growth patches within the state. Floodplain forests that are located on public or private conservation land are the most stable, but are in decline in unprotected areas due to development pressure (NYNHP 2011rrr). A small portion of a floodplain forest is located in the northeastern portion of the Coastal Zone in Dutchess County.

13. Tidal River

The tidal river is an aquatic community with permanently flooded substrates that is restricted to the tidally influenced areas of the state. This community has two zones: a deepwater zone and a shallow zone. The deepwater zone has substrates that are usually covered with water at depths of six feet or more at low tide. The shallow zone has submerged substrates less than 6 feet in depth at low tide. The tidal river does not support emergent vegetation (NYNHP 2011sss; Edinger et al. 2002).

With respect to water salinity, there is a vertical salinity gradient, with a surface layer of fresh water (salinity less than 0.5 parts per thousand [ppt]) on top of a deeper layer of brackish water (salinity between 0.5 and 18.0 ppt). Salinity can fluctuate with the vertical movement of water due to the tides (NYNHP 2011sss; Edinger et al. 2002).

In New York State, the largest occurrence of this community within the state is the Hudson River. Smaller tidal rivers occur on Long Island. Threats to tidal rivers include pollution, shoreline development, dredging, commercial shipping, recreation, and invasive species (NYNHP 2011sss).

C. Discussion of Potential Impacts to Rare Plants and Natural Communities

1. IPEC Site

On the basis of a literature review, no known State or federally protected plants or rare natural communities are known to be present on the IPEC Site, and the current land use associated with the project site would not be likely to support rare species and communities. As IPEC License Renewal will not entail any new construction, disturbance, or development, License Renewal will not adversely affect State- or federally listed plants or rare natural communities.

The IPEC Site is highly developed with large expanses of impervious surfaces. Plant species likely to occur at the IPEC Site would be limited to successional, weedy, or invasive species that would be likely to occur within cracks and crevices of paved surfaces and undeveloped areas. Similarly, ecological communities of the project site would be limited to NYNHP-defined "cultural" communities characterized by disturbance. These communities may include mowed areas, wooded lots, and paved roads and paths.

2. RM 44–56 SCFWH

A number of State-protected plants and NYNHP-designated ecological communities occur within the RM 44–56 SCFWH, which is upstream from IPEC at RM 42. Significant ecological communities that occur within the RM 44–56 SCFWH include tidal river, brackish tidal marshes, and the cliff community. Within the brackish tidal marsh, State-protected plant species recorded after 1980 within RM 44–56 SCFWH include water pigmyweed, gypsy-wort, terrestrial starwort, Long's bittercress, and saltmarsh aster. Historical records indicate that slender marsh-pink once occurred within the RM 44–56 SCFWH prior to 1980 (NYNHP 2010). Threats to these species and rare natural communities are related to development, habitat disturbances, or invasive species in the immediate area of the listed plant or ecological community. IPEC License Renewal will not adversely affect State-protected plant species or rare natural communities located in the RM 44–56 SCFWH or elsewhere in the Hudson River.

3. Iona Island Marsh SCFWH

A number of State-protected plants and rare natural communities occur within the Iona Island Marsh SCFWH. Rare ecological communities that occur within the Iona Island Marsh SCFWH include tidal river, brackish tidal marshes, brackish intertidal flats, and freshwater tidal marshes. Narrow-leaved cattail is the dominant vegetation (NYSDEC 1998a), although in some portions of the marsh, common reed has become more prominent (Winogrand and Kiviat 1997; NYSDEC 2007a). State-protected plant species that occur within the vicinity of the Iona Island Marsh SCFWH include saltmarsh bulrush, water pigmyweed, yellow flatsedge, smooth-bur marigold, terrestrial starwort, Long's bittercress, small-flowered crowsfoot, spongy arrowhead, and saltmarsh aster. No known historical State-protected plant species are documented for the Iona Island Marsh SCFWH (NYNHP 2010). Threats to these species and rare natural communities pertain to development, habitat disturbances, or encroachment by invasive species in the immediate area of the plant or ecological community. IPEC License Renewal will not adversely affect State-protected plant species or rare natural communities of the Iona Island Marsh SCFWH or elsewhere in the Hudson River.

4. Haverstraw Bay SCFWH

A number of State-protected plants and rare natural communities have the potential to occur within the Haverstraw Bay SCFWH. With respect to natural communities, the Hudson River in Haverstraw Bay is classified as a tidal river. No other rare natural communities have been documented by NYNHP for Haverstraw Bay. Historical records indicate that the eastern starwort occurred within Haverstraw Bay prior to 1980 (NYNHP 2010). IPEC License Renewal will not adversely affect plant species or ecological communities located in the Haverstraw Bay SCFWH or elsewhere in the Hudson River.

5. Proposed Expansion Area RM 56-60

With respect to ecological communities, this section of river is designated as tidal river. No other ecological communities have been documented by NYNHP for the proposed Expansion Area RM 56-60 (NYSDEC 2009). No state-listed plants are known to occur within the proposed Expansion Area RM 56-60. IPEC License Renewal will not adversely affect ecological communities located in the proposed Expansion Area RM 56-60 or elsewhere in the Hudson River.

6. Coastal Zone

a. RM 34-56

A number of State-protected plants and rare natural communities occur within the RM 34–56 Coastal Zone. On the west side of the Hudson River, within Orange and Rockland Counties, rare natural communities include chestnut oak forest, oak-tulip tree forest, pitch pine-oak-heath rocky summit, and rocky summit grassland. Within Orange County, only brackish intertidal mudflats, brackish tidal marsh, acidic talus slope woodland, Appalachian oak-hickory forest, and red cedar rocky summit are found. State-protected plant species that occur within the Coastal Zone in Orange County include spongy arrowhead, saltmarsh bulrush, and marsh straw sedge in marsh and intertidal areas and lined sedge, Virginia pine, and straw sedge in upland areas. Within Rockland County, State-protected plants include Long's bittercress, saltmarsh aster, spongy arrowhead, saltmarsh bulrush, and terrestrial starwort in marshes and intertidal areas and basil mountain-mint, Torrey's mountain-mint, featherfoil, and midland sedge in upland areas. Historical records include Michaux's blue-eyed-grass and rough avens for the Coastal Zone within Orange County and catfoot, heartleaf plantain, troublesome sedge, wild potato vine, and straw sedge within the Coastal Zone of Rockland County (NYNHP 2010).

On the east side of the Hudson River, within Putnam and Westchester Counties, rare natural communities include the cliff community, Appalachian oak-hickory forest, chestnut oak forest, oak-tulip tree forest, and pitch pine-oak-heath rocky summit; within Westchester County, they include brackish intertidal mudflats, brackish tidal marsh, Appalachian oak-hickory forest, chestnut oak forest, and rocky summit grassland. State-protected species that occur within the Coastal Zone in Putnam County include gypsy-wort, Long's bittercress, saltmarsh aster, water pigmyweed, and smooth bur marigold in marsh and intertidal areas, and clustered sedge and violet wood-sorrel in upland habitats. NYNHP records for the Coastal Zone within Westchester County indicate that spongy arrowhead is the only listed State-protected species. Historical records indicate that slender marsh-pink and large twayblade were once present within the Coastal Zone of Putnam County and that eastern grasswort once occurred within the Coastal Zone of Westchester County (NYNHP 2010).

Several of the above-mentioned State-protected plant species and rare natural communities occur within State parkland. As described above, threats to these species and ecological communities, in habitats that are not protected, include development, habitat disturbances, and invasive species in the immediate area of the plant or rare ecological community. IPEC License Renewal will not adversely affect State-protected plant species or rare natural communities located in the RM 34–56 Coastal Zone or elsewhere in the Hudson River.

b. RM 56-60

A number of rare ecological communities occur within the east and west sides of the river in the Coastal Zone of the proposed Hudson Highlands Expansion Area RM 56-60. On the east side of the river within Putnam and Dutchess Counties, five upland communities including the oak-tulip tree forest, chestnut oak forest, Appalachian oak hickory forest, red cedar rocky summit, pitch pine-oak-heath-rocky summit, are present. Ecological communities associated with wetlands that are tidally influenced are the brackish tidal marsh, brackish intertidal wetlands, and tidal river communities located in the vicinity of Fishkill Creek.[4]

On the west side of the river, ecological communities of the Coastal Zone are mostly concentrated in Moodna Creek[5] where brackish tidal, intertidal wetlands, and tidal river communities are present. The one exception is the Appalachian oak hickory forest located in the southern portion of the Coastal Zone near the RM 44-56 Coastal Zone border.

IV. TERRESTRIAL WILDLIFE SPECIES

The following are profiles of terrestrial wildlife species occurring within the vicinity of IPEC, including birds, mammals, reptiles and amphibians, and insects. Species are presented according to their status, with federally listed or State-listed endangered, threatened, and special concern presented first.

[4] Fishkill Creek was designated a SCFWH in 1987 by NYSDOS (NYSDOS 1987d).

[5] Moodna Creek was designated a SCFWH in 1987 by NYSDOS (NYSDOS 1987e).

A. Birds

1. Peregrine Falcon

The peregrine falcon (*Falco peregrinus*) is a State-listed endangered species that is present in the vicinity of IPEC throughout the year. Peregrine falcons nest in natural and human-made settings including rocky cliffs, bridges, tall buildings, and other structures in proximity to large waterbodies (NYNHP 2011ss; Loucks 1998a). Wintering birds also use perching and roosting habitat in similar urban and natural habitats (White et al. 2002). Peregrine falcons feed primarily on medium to large birds, from songbirds to small waterfowl (NYNHP 2011ss).

Peregrine falcons were extirpated as breeders from the lower Hudson Valley by 1961, and wintering populations in the area also declined dramatically (Herbert and Herbert 1969). This was due to a combination of habitat loss, human disturbance (*e.g.*, hunting, collection of young by falconers), and reproductive effects caused by exposure to organochlorine pesticides, such as dichlorodiphenyltrichloroethane and dieldrin (NYNHP 2011ss; Herbert and Herbert 1969; White et al. 2002). Efforts to propagate, foster, and release falcons began in late 1960s, and their populations have recovered slightly (White et al. 2002). Nesting activity in the vicinity of IPEC returned in the mid-1980s; approximately five nesting pairs were located in the vicinity of IPEC in 2009 (Loucks 2009).

Threats to this species include: habitat alteration, nest disturbance, exposure to contaminants, and, for species nesting in urban centers, collisions with tall structures (NYNHP 2011ss). Taking of peregrine falcons or critical habitat within New York State would be pursuant to Article 11 of the Environmental Conservation Law ("ECL"), potentially requiring an Incidental Take Permit from the New York State Department of Environmental Conservation ("NYSDEC"). Due to range-wide recovery, peregrine falcons were delisted from the ESA, but they remain protected under the federal Migratory Bird Treaty Act.

2. Short-eared Owl

The short-eared owl (*Asio flammeus*) is a State-listed endangered species that is present in the vicinity of IPEC during wintering and migratory periods. This species has not been known to breed in the Hudson River Valley in the vicinity of IPEC in recent years (Schneider 2008). Habitat includes areas such as grasslands (*i.e.*, hayfields, fallow farm lands, and pastures) and freshwater marshes (NYNHP 2011tt). Preferred habitat is typically found adjacent to wet areas. Daytime roosting typically occurs on the ground and in/under low vegetation. Voles are the preferred prey of short-eared owls, although they will also prey upon other small mammals and sometimes birds, and occasionally insects (Schneider 2008).

While no breeding activity has been recorded in the vicinity of IPEC, any open marshes or grasslands within the vicinity of IPEC would provide suitable overwintering habitat. Short-eared owls have been noted overwintering in Westchester County (NYNHP 2010).

Threats to wintering short-eared owls in the vicinity of IPEC include habitat loss due to development, wetland loss, changes in farming practices (*i.e.*, converting hayfields to row crops, more frequent mowing of hayfields, etc.), and increased forest regeneration and succession in former grasslands (NYNHP 2011tt). Taking of short-eared owls or critical habitat within New York State would be pursuant to Article 11 of the ECL, potentially requiring an Incidental Take Permit from the NYSDEC. Short-eared owls are also protected under the federal Migratory Bird Treaty Act.

3. Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is a State-listed threatened species that is present in the vicinity of IPEC throughout the year. Bald eagles are typically found near large waterbodies (*i.e.*, bays, rivers, and lakes) that support sufficient prey populations. While they tend to avoid areas with human activity, they will construct nests and rear young within industrial and suburban sites adjacent to suitable foraging and nesting habitat (NYNHP 2011uu). Perching habitat includes mature deciduous and coniferous trees; eagles typically construct nests near water in tall pine, spruce, fir, cottonwood, oak, poplar, or beech trees (NYNHP 2011uu). Non-breeding adults and wintering birds are known to have communal roost sites, occasionally distant from food sources (Nye 2008).

Associated ecological communities include a variety of mixed hardwood forests (NYNHP 2011uu). This species feeds primarily on fish, injured waterbirds, mammals, and carrion. However, they are flexible in their foraging technique, and will hunt various types of prey, scavenge, and pirate food from other birds (NYNHP 2011uu).

Within the vicinity of IPEC, breeding and wintering bald eagles have been noted (Nye 2008). In terms of breeding, a single bald eagle nest was noted along the Hudson River in 1997 (the first such record in 100 years), and nesting in the lower Hudson River has increased to 24 nesting pairs with 15 successful nests in 2009 (NYSDEC 2012d; Nye 2009). Up to 87 bald eagles have been noted during wintering surveys in the lower Hudson River between Fishkill and Croton Point in recent years (Nye 2009). Wintering bald eagles have been noted to concentrate within the Hudson RM 44–56 SCFWH, which rarely freezes and provides a dependable foraging site for fish due to upwelling (NYSDOS 1987a). Fish species commonly taken by the wintering eagles include goldfish, brown bullhead, alewife, white perch, and sunfish. Roosting areas include Iona Island Marsh SCFWH and undisturbed woodlands along both sides of the Hudson River, particularly within sheltered coves (NYSDOS 1987b).

The bald eagle was delisted from the ESA by the USFWS in August 2007. While bald eagles are no longer protected under the ESA, they are protected under the Bald and Golden Eagle Protection Act ("BGEPA"). The USFWS Bald Eagle Management Guidelines are used to determine whether projects avoid impacts under the BGEPA (USFWS 2007). Taking of bald eagles or critical habitat within New York State would be pursuant to Article 11 of the ECL, potentially requiring an Incidental Take Permit from the NYSDEC.

4. Northern Harrier

The northern harrier (*Circus cyaneus*) is listed as a State-listed threatened species, and is potentially present in the assessment area throughout the year. It is considered a rare breeder in New York State and breeds in agricultural, grassland, old field, marsh, and wet meadow habitats (Marsti and Kirch 1998; Post 2008). Northern harriers construct their nests on the ground, generally in areas of tall, dense, and undisturbed herbaceous vegetation, often in or near wet habitats (Macwhirter and Bildstein 1996).

Within the vicinity of IPEC, no breeding activity has been observed, although northern harriers would be expected to forage in open areas during wintering periods, and pass through the area during migration (Post 2008). Threats to breeding and non-breeding northern harriers in the vicinity of IPEC include habitat loss due to development, human disturbance, wetland loss, alteration of farming practices (*i.e.*, converting hayfields to row crops, more frequent mowing of hayfields, etc.), and increased forest regeneration and succession in former grasslands (NYNHP 2011vv). Taking of northern harriers or critical habitat within New York State would be pursuant to Article 11 of the ECL, potentially requiring an Incidental Take Permit from the NYSDEC. They are also protected under the federal Migratory Bird Treaty Act.

5. Least Bittern

The least bittern (*Ixobrychus exilis*) is a State-listed threatened marsh-dwelling bird that is present in the vicinity of IPEC during the breeding and migratory seasons. In New York, least bitterns breed in shallow to deep emergent marshes and freshwater tidal marshes of the lower Hudson River. Preferred nesting habitat includes cattails, bulrush with bur-reed, sedges, or common reed; preferred nesting vegetation is tall and interspersed with pools of open water or slow-moving channels (Kennedy 2008). Larger marsh habitats are important breeding areas for this species. Least bittern diet includes small prey items, including fishes, amphibians, insects, and occasionally small mammals (NYNHP 2011ww).

Within the vicinity of IPEC, least bitterns are known to breed at Iona Island Marsh (NYSDOS 1987b). However, over the past 20 years, least bittern breeding activity has declined significantly at Iona Island Marsh SCFWH (Wells et al. 2008). This species is likely to use tall emergent marsh habitat within the vicinity of IPEC during spring and fall migration.

Threats to least bitterns include marsh degradation and loss, habitat fragmentation, intrusion of invasive species into breeding habitat, and prey-base effects due to reductions in water quality (NYNHP 2011ww). Taking of least bitterns or critical habitat within New York State would be pursuant to Article 11 of the ECL, potentially requiring an Incidental Take Permit from the NYSDEC. Least bitterns are also protected under the federal Migratory Bird Treaty Act.

6. Osprey

Osprey (*Pandion haliaetus*) is a raptor listed as a State-listed special concern species and is known to occur within the assessment area during breeding and migratory seasons. They are piscivorous raptors that breed and forage in coastal ecosystems within New York State (Nye 2008). Osprey nests are often built in trees or artificial nest platforms and will also nest on a variety of tall, man-made structures, including light and telephone poles, channel markers, houses, and pilings (Loucks 1998b).

Due to their tendency to nest on human structures in proximity to estuaries, foraging and nesting resources for osprey exist in the vicinity of IPEC. Iona Island Marsh is noted by NYSDOS as potential concentration areas for migrating osprey (NYSDOS 1987b). At least five NYSDEC breeding bird atlas blocks within the coastal zone of Orange, Putnam, Rockland, and Westchester Counties in the vicinity of IPEC recorded osprey nesting activity in recent years (Nye 2008).

Threats to osprey include susceptibility to environmental contaminants, habitat loss, and human disturbance (Nye 2008). Although osprey are listed as a special concern species, they are not afforded special protection under Article 11 of the ECL as presently written for New York State endangered and threatened species. They are protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

7. Canada Goose

The Canada goose (*Branta canadensis*) is a common waterfowl species in New York that is present in the vicinity of IPEC throughout the year. This species breeds and forages in a variety of wetland and upland habitats, from human-created to natural (McGowan 2008a). They are principally herbivorous, although will also feed on small fish and insects (Mowbray et al. 2002).

Canada goose is a widespread species within the vicinity of IPEC. This species is known to breed at Iona Island Marsh, is increasing as a breeding species in the lower Hudson Valley, and is also prevalent in winter within the vicinity of IPEC (Wells et al. 2008; Griffith 1998). There are few threats to Canada goose populations within the vicinity of IPEC; human modification of habitat has created ideal roosting and foraging habitat for this species (Griffith 1998). Canada goose is listed as a game species in New York, with a daily limit of three to eight individuals per day during the 2009-2010 New York State hunting season regulations (NYSDEC 2012a). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL. Breeding populations are actively managed in New York (NYSDEC 2007b).

8. Wood Duck

The wood duck (*Aix sponsa*) is a waterfowl species in New York that is present in the vicinity of IPEC throughout the year, though less often in winter. They nest in cavities (either natural or human-created), and in forested wetlands, swamps, beaver-modified habitats, and slow-moving streams (Swift 2008a). Wood ducks have a broad diet, and typically forage on seeds, fruits, and aquatic and terrestrial invertebrates in open water or forested wetland habitats (Hepp and Bellrose 1995).

Wood ducks are a widespread species within the vicinity of IPEC, and few threats to their population stability are apparent; they are increasing as a breeding species within the lower Hudson Valley, including the vicinity of IPEC (Swift 2008a). They breed, migrate, and winter within the vicinity of IPEC, including all three SCFWHs (NYSDOS 1987a, b, c). Wood duck is a game species in New York, with a daily limit of three individuals per day during the 2009-2010 New York State hunting season regulations (NYSDEC 2012b). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

9. American Black Duck

The American black duck (*Anas rubripes*) is a waterfowl species in New York that is present in the vicinity of IPEC throughout the year. This species breeds and forages in a variety of wetland habitats, from tidal wetlands to the shores of lakes, ponds, and streams (Swift 2008b; Levine 1998a). They feed on aquatic invertebrates and vertebrates, and aquatic and upland vegetation and crops (Longcore et al. 2000).

American black ducks breed, migrate, and winter within the vicinity of IPEC, including all three SCFWHs (NYSDOS 1987a, b, c). Over the past 20 years, declines in American black duck breeding populations have been noted in the vicinity of IPEC, possibly due to a combination of habitat loss, hunting pressure, and substantial interbreeding with mallards (Swift 2008b). While American black duck is listed as a Species of Greatest Conservation Need in New York, it is also a game species with a daily limit of one individual per day during the 2009-2010 New York State hunting season regulations (NYSDEC 2012b). The American black duck is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

10. Mallard

The mallard (*Anas platyrhynchos*) is an abundant waterfowl species in New York that is present in the vicinity of IPEC throughout the year. This species breeds and forages in a variety of wetland and upland habitats, from human-created to natural (Swift 2008c, Levine 1998b). They are omnivorous, feeding on aquatic invertebrates and vertebrates, to aquatic and upland vegetation (Drilling and McKinney 2002).

Mallards are a widespread species within the vicinity of IPEC, where there are few threats to their population stability. Mallards breed, migrate, and winter within the vicinity of IPEC, including all three SCFWHs (NYSDOS 1987a, b, c). Mallard is a game species in New York, with a daily limit of four individuals (including a maximum of two females) per day during the 2012-2013 New York State hunting season regulations (NYSDEC 2012b). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

11. Green Heron

The green heron (*Butorides virescens*) is a common heron species in New York State that is present in the vicinity of IPEC during breeding and migratory seasons (McCrimmon 2008; Sweet 1998). It is a semi-colonial nester, and will breed either singularly or in proximity to other wading birds. Habitat includes swamp thickets, forested wetlands, and occasionally drier locations in proximity to water (McCrimmon 2008).

Green herons are a widespread breeding and migratory species within the vicinity of IPEC (McCrimmon 2008). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

12. Virginia Rail

The Virginia rail (*Rallus limicola*) is the most common rail species in New York, and is present in the vicinity of IPEC throughout the year, though less often in winter. They typically breed in freshwater marshes with shallow water and tall emergent vegetation, and forage on invertebrates and insects during the breeding season and invertebrates and aquatic vegetation during the winter (Medler 2008a; Able 1998a; Conway 1995).

Virginia rail breeding populations have declined significantly at Iona Island Marsh, most likely due to a change in vegetation structure, but have remained relatively stable over the past 20 years (Wells et al. 2008). Threats include habitat degradation, pesticide exposure, collision with tall structures during migration, and hunting pressure (Conway 1995). Virginia rail is listed as a game species in New York, with a daily limit of eight individuals per day during September to November, according to the 2012-2013 New York State hunting season regulations (NYSDEC 2012c). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

13. Sora

The sora (*Porzana carolina*) is a rail species that is an uncommon breeder in New York. It is locally present in the vicinity of IPEC during the breeding and migratory seasons. They typically breed in freshwater marshes with shallow water and emergent vegetation, such as cattails, sedges, and bulrushes (Medler 2008b; Able 1998b). They feed on aquatic plants and invertebrates (Melvin and Gibbs 1996).

Although an uncommon breeder, Sora is declining as a breeding species in the vicinity of IPEC. Threats include habitat degradation, pesticide exposure, ingestion of lead and plastics, collision with tall structures during migration, and hunting pressure (Melvin and Gibbs 1996). Sora is listed as a game species in New York, with a daily limit of eight individuals per day during September to November, according to the 2012-2013 New York State hunting season regulations (NYSDEC 2012c). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

14. Common Moorhen

The common moorhen (*Gallinula chloropus*) is a local, declining breeder in New York that is mainly present in the vicinity of IPEC during the migratory season. They typically nest in open water habitats with dense cover of cattail and emergent species for security and nesting substrate (Medler 2008c). They generally feed on aquatic vegetation and invertebrates, including snails (Bannor and Kiviat 2002).

Common moorhens no longer appear to breed within the vicinity of IPEC from three confirmed breeding blocks in 1985 to none in 2005, although they do occur as migrants. Threats include hunting pressure, pesticides and contaminants, habitat degradation, and collisions with structures during migration (Medler 2008c; Bannor and Kiviat 2002). This species is listed as a game species in New York, with a daily limit of eight individuals per day during September to November, according to the 2012-2013 New York State hunting season regulations (NYSDEC 2012c). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

15. Spotted Sandpiper

The spotted sandpiper (*Actitis macularius*) is a shorebird species in New York that is present in the vicinity of IPEC during the breeding and migratory seasons. They will nest along the edge of any water source, from urban ponds to remote wetlands (McGowan 2008b). They typically feed on invertebrates and small fish (Oring et al. 1997).

Spotted sandpiper breeding populations appear stable within the vicinity of IPEC, and have been recorded at Iona Island Marsh (McGowan 2008b; NYSDOS 1987b). Potential threats include exposure to pesticides and various human impacts (Oring et al. 1997). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

16. Belted Kingfisher

The belted kingfisher (*Ceryle alcyon*) is a common species in New York State, and is present within the vicinity of IPEC throughout the year. They are cavity-nesters and breed in burrows constructed in banks associated with streams and lakes (McGowan 2008c). They primarily forage on fish species by hovering and plunge-diving (Kelly et al. 2009).

Within the vicinity of IPEC, belted kingfisher breeding populations appear to be stable where suitable breeding habitat exists (McGowan 2008c). Threats include shoreline development and human activities that degrade breeding habitat, and exposure to pesticides and contaminants (Kelly et al. 2009). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

17. Marsh Wren

The marsh wren (*Cistothorus palustris*) is a common marsh-dwelling passerine in New York and is present in the vicinity of IPEC during the breeding and migratory seasons. They nest in a variety of freshwater marshes, particularly those with dense reeds and shrubs (McGowan 2008d). They are opportunistic feeders, largely foraging on terrestrial invertebrates (*e.g.*, insects and spiders) and aquatic insects in freshwater marshes (Kroodsma and Verner 1997).

Although marsh wrens are found in the vicinity of IPEC, over the past 20 years they appear to be declining in this area (McGowan 2008d). Marsh wren populations have declined significantly at Iona Island Marsh (likely due to changes in vegetation structure) over the past 20 years (Wells et al. 2008). Threats include habitat degradation (including changes in habitat structure) and collisions with tall structures during migration (Kroodsma and Verner 1997). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

18. Kentucky Warbler

The Kentucky warbler (*Oporornis formosus*) is a ground-foraging wood warbler that is present in the vicinity of IPEC during migratory and breeding periods (NYNHP 2011xx). This species is an uncommon, local breeder in southeastern New York (McDonald 1998; Salzman 1998). Kentucky warblers are typically considered to be forest-interior songbirds (Robbins et al. 1989). They will nest in many a variety of forest communities provided that a dense layer of ground cover is present (Wenny et al. 1993). Kentucky warblers may be somewhat tolerant of habitat fragmentation compared with other warbler species and will nest in fragmented landscapes if there is a sufficiently dense understory within mature deciduous woodlands (Gibbs and Faaborg 1990; McDonald 1998).

According to the recent New York State Breeding Bird Atlas, breeding activity for Kentucky warblers occurred within Westchester and Orange Counties, though it has markedly declined as a breeding species in Westchester County since 1985 (Rosenberg 2008). Threats to this species include development and damage to forest understory by white-tailed deer (Rosenberg 2008). Although Kentucky warblers are listed as a Species of Greatest Conservation Need in New York State, no special protected status is applied to this species. It is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

19. Swamp Sparrow

The swamp sparrow (*Melospiza georgiana*) is a common passerine in New York State that is present in the vicinity of IPEC throughout the year. They breed in emergent and shrub wetland habitats and typically forage on arthropods, insects, and fruits/seeds during the breeding season, and vegetation during the winter period (Osborne 2008; Salzman and Parkes 1998; Mowbray 1997).

Swamp sparrow populations have declined as breeders at Iona Island Marsh over the past 20 years; this trend is apparent throughout the lower Hudson River (Wells et al. 2008; Osborne 2008). Threats include degradation of habitat, succession in wetlands (*i.e.*, from shrub to forested wetlands), and collision with tall structures during migration (Mowbray 1997). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

20. Red-winged Blackbird

The red-winged blackbird (*Agelaius phoeniceus*) is a common passerine in New York State and is present within the vicinity of IPEC throughout the year during breeding and migratory seasons. They are a common inhabitant of marshes, swamps, riparian habitats, and other wetland systems (Clark 2008; Smith 1998). They feed on a variety of small terrestrial and aquatic vertebrates and invertebrates and vegetation (Yasukawa and Searcy 1995).

Red-winged blackbird breeding populations have increased dramatically throughout the vicinity of IPEC over the past 20 years, including Iona Island Marsh (Clark 2008; Wells et al. 2008). There appear to be few threats to their population stability, although pesticide and contaminant exposure may adversely affect reproductive success in urban areas, and nuisance control of migrating and wintering flocks in agricultural and residential areas could adversely affect populations (Clark 2008). No special status is applied to this species, although it is protected under the federal Migratory Bird Treaty Act and New York State wildlife regulations within the ECL.

B. Mammals

The following are profiles for the five mammals listed by NYNHP for the immediate vicinity of the IPEC Site, the three SCFWHs, the Coastal Zone, and, and the proposed Hudson Highlands Expansion Area RM 56-60.

1. Indiana Bat

The Indiana bat (*Myotis sodalis*) is a federally and State-listed endangered species. Overwintering habitat includes caves and mines, and summer roosts and maternity colonies are typically found in living, dying, and dead trees in rural and suburban landscapes. Ecological communities associated with this species include Appalachian oak-hickory forest, beech-maple mesic forest, calcareous cliff community, calcareous talus slope woodland, deep emergent marsh, floodplain forest, hemlock-northern hardwood forest, limestone woodland, and maple-basswood rich mesic forest (NYNHP 2011yy). Up to 50,000 Indiana bats are known to hibernate in a single location, although relatively few hibernacula are known (USFWS 2006a).

No Indiana bat hibernacula are known in the vicinity of IPEC, although four are known from nearby Ulster County, one of which is the largest known Indiana bat hibernacula within the United States (NYNHP 2011yy). Breeding season records for Indiana bat occur within the vicinity of IPEC in Westchester, Putnam, Orange, and Rockland Counties (USFWS 2006a).

Threats to the Indiana bat include disease (*i.e.*, white nose syndrome); human disturbance in caves during hibernation, particularly those caves that are occupied by large populations; cave commercialization; constructed structures (*i.e.*, gates) at entrances to caves that restrict bat movement or alter airflow and temperatures; pesticides and environmental contaminants; and loss of foraging and breeding habitat due to destruction, alteration, and fragmentation of forested habitat (USFWS 2006a).

2. Eastern Small-footed Myotis

The eastern small-footed myotis (*Myotis leibii*) is a State-listed special concern species of the vesper bat (Vespertilionidae) family (NYNHP 2011zz). Habitat for this species differs from that of other bats, in that roosting locations and maternity colonies consist of rock crevices and talus slopes rather than trees. Habitat includes deciduous forests during the summer months within the vicinity of IPEC, and caves and mines during winter months in northern New York. Foraging activity often occurs in the vicinity of ponds, streams, and roadways (NYNHP 2011zz). Ecological communities associated with this species include Appalachian oak-hickory forest, beech-maple mesic forest, calcareous cliff community, chestnut oak forest, hemlock-northern hardwood forest, limestone woodland, maple-basswood rich mesic forest, and red cedar rocky summit (NYNHP 2011zz).

In the summer, the eastern small-footed myotis has been recorded at foraging locations in Orange and Putnam Counties, although the summer range for this species may include a wider area of southern New York (NYNHP 2011zz). Specific threats to the eastern small-footed myotis include foraging habitat loss, disease, and disturbance during their hibernation period such as mine collapse or closure, commercialization or frequent visitation of caves (NYNHP 2011zz).

3. New England Cottontail

The New England cottontail (*Sylvilagus transitionalis*) is a State-listed special concern species and a candidate species for federal protection under the ESA. Within New York, habitat for the New England cottontail includes early-successional areas of open woods, shrub lands, disturbed sites, thickets, and marshes (Whitaker and Hamilton 1998). Ecological communities associated with this species include beech-maple mesic forest, hemlock-northern hardwood forest, and sedge meadow (NYNHP 2011aaa).

Since the 1960s, the range of this species has shrunk by more than 75 percent, and has been reduced to five small populations throughout its historic range, including records within the vicinity of IPEC (USFWS 2006b; NYNHP 2011aaa; Litvaitis et al. 2006). Within the vicinity of IPEC, this species is known to occur within Westchester and Putnam Counties in isolated habitat patches of agricultural fields and edges and brushy edges of transportation corridors (Tash and Litvaitis 2007). Likely threats that have contributed to the decline of the New England cottontail include habitat alteration, forest fragmentation, and competition with the eastern cottontail rabbit (*Sylvilagus floridanus*) (Litvaitis 1993a as cited in NYNHP 2011aaa; Litvaitis 1993b; Tash and Litvaitis 2007).

4. Mink

The mink (*Neovison vison*) is listed as a game species in the southern zone of New York State (which includes the IPEC Site) and is a member of the Mustelidae family (Myers et al. 2012). Mink occupy a variety of wetland habitats, including streams, rivers, lakes, and freshwater and saltwater marshes and coasts (NYSDEC 2012e). In general, mink are more abundant in sparsely populated rural areas, although they occasionally are found in suburban settings (NYSDEC 2012e).

Mink are distributed throughout New York (NYSDEC 2012e). Within the vicinity of IPEC, they are known to occur within Iona Island Marsh, and minks are likely to occur in other wetland habitats located within the Coastal Zone within the vicinity of IPEC (NYSDOS 1987b). Mink are open to hunting and trapping, with possession of the appropriate game license (NYSDEC 2012c). There are no known threats to this species that would result in this species being listed under Article 11 of the ECL or Section 9 of ESA.

5. Muskrat

The muskrat (*Ondatra zibethicus*) is a game species in New York State of the family Cricetidae (NYSDEC 2012f; Myers et al. 2012). Muskrats occupy freshwater and brackish aquatic habitats, including streams, lakes, marshes, and streams, but they prefer marshlands that are heavily vegetated with cattails (*Typha* spp.), bur-reeds (*Sparganium* spp.), and bulrushes (*Schoenoplectus* spp.) (NYSDEC 2012f). They are distributed throughout New York State, including aquatic habitats within the vicinity of IPEC (NYSDEC 2012f). This species is known to occur within Iona Island Marsh and is likely to occur within all SCFWHs and RM 40-43 and RM 56-60 within the vicinity of IPEC (NYSDOS 1987b).

Muskrat are open to hunting and trapping, with possession of the appropriate game license (NYSDEC 2012c). There are no current threats to this species that would result in this species being listed under Article 11 of the ECL or Section 9 of ESA.

C. Reptiles and Amphibians

The following are profiles for the seven reptiles and amphibians listed by NYNHP for the immediate vicinity of the IPEC Site (RM 41–44), the three SCFWHs, and for the Coastal Zone.

1. Bog Turtle

The bog turtle (*Glyptemys muhlenbergii*), a member of the family Emydidae, is both a federally listed threatened species and a State-listed endangered species. Bog turtles require diverse micro-habitats within wetlands for basking, hibernation, foraging, and nesting. These microhabitats include dry pockets, fully saturated areas, and areas that are occasionally flooded (NRCS 2006). In New York, habitat for this species includes wet meadows with open canopies, sedge meadows, and calcareous fens. Bog turtles are usually found below 800 feet within the New York State (NYNHP 2011bbb).

Within the vicinity of IPEC, known bog turtle habitats include groundwater-fed wetlands that are either isolated or connected to larger wetland complexes. Within their range, bog turtles are known to occur in seepage and spring-fed emergent freshwater wetlands and in clear and slow-moving brooks with soft organic substrates. Ecological communities associated with the bog turtle include fens, red maple-hardwood swamp, red-maple tamarack swamp, and sedge meadow (NYNHP 2011bbb). Plant species associated with bog turtle habitat include a variety of sedges (*Carex* spp.), shrubby cinquefoil (*Potentilla fruticosa*), grass-of-parnassus (*Parnassia glauca*), mosses (*Sphagnum* spp.), and horsetail (*Equisetum* sp.) in the understory, with scattered trees and shrubs. Woody species within these habitats may include red maple, eastern red cedar, tamarack (*Larix laricina*), willows (*Salix* spp.), dogwood (*Cornus* spp.), and alder (*Alnus* spp.). These shrubs may occur in the shrub, subcanopy, and canopy (NYNHP 2011bbb).

In New York State, extant populations are known to occur within Orange and Putnam Counties, with Westchester County populations noted in the 1990s, although the status of the latter populations is unknown (NYNHP 2011bbb; NYSDEC 1998b; NYSDEC 2012g). Threats to this species include habitat loss, degradation, and fragmentation of its habitat, road mortality, ecological community succession, and the invasion of native vegetation by invasive exotic species. In addition, illegal collecting of this species as part of the pet trade has had a direct threat to populations (NYNHP 2011bbb). Taking of individuals or habitat would be required to comply with both the ESA and Article 11 of the ECL.

2. Timber Rattlesnake

The timber rattlesnake (*Crotalus horridus*) is a State-listed threatened species of the viper family (Viperidae). Habitat for this species includes mountainous or hilly deciduous or mixed deciduous-coniferous forests, often with rocky outcroppings with southern exposures (Petersen and Frisch 1986 as cited in NYNHP 2011ccc; Brown 1993 as cited in NYNHP 2011ccc; Conant and Collins 1998). In winter, the timber rattlesnake congregates in dens or hibernacula to hibernate (Brown 1993 as cited in NYNHP 2011ccc; Conant and Collins 1998). In New York, dens are often below ledges in accumulations of talus, in fractures with or underneath ledges or rock outcrops (NYNHP 2011ccc). Some examples of ecological communities associated with this species include acidic talus slope woodland, Appalachian oak-hickory forest, Appalachian oak-pine forest, beech-maple mesic forest, calcareous cliff community, calcareous talus slope woodland, chestnut oak forest, and cliff community (NYNHP 2011ccc).

Although widespread in New York State, timber rattlesnakes are typically found in isolated or semi-isolated populations within the vicinity of IPEC (*i.e.*, in Doodletown, adjacent to Iona Island Marsh). They have been recorded in the coastal zone of all four counties within the vicinity of IPEC (NYSDEC 2012h). Threats to this species include loss and fragmentation of habitat, mining, road mortality, illegal collecting, extermination, and pathogenic organisms (NYNHP 2011ccc). Taking of timber rattlesnakes or critical habitat within New York State would be pursuant to Article 11 of the ECL, potentially requiring an Incidental Take Permit from the NYSDEC. The collection or possession of any native snakes of New York is prohibited without a special collection license (NYSDEC 2012c).

3. Eastern Fence Lizard

The eastern fence lizard (*Sceloporus undulates*) is a State-listed threatened species of the spiny lizard family (Phrynosomatidae). Habitat for this species includes steep slopes with extensive open rocky outcrops surrounded by mixed-deciduous oak-dominated forests. Ecological communities associated with this species include chestnut oak forests, pitch pine-oak-heath rocky summit, post oak-blackjack oak barrens, and rocky summit grassland.

In New York, the natural range of this species is restricted to the Hudson Highlands (NYNHP 2011ddd; NYSDEC 2012i). Isolated colonies are present within the vicinity of IPEC in Putnam and Westchester Counties (NYNHP 2011ddd; NYSDEC 1998b). Threats to this species include habitat loss and illegal collecting (NYNHP 2011ddd). Taking of fence lizards or critical habitat within New York State would be pursuant to Article 11 of the ECL, potentially requiring an Incidental Take Permit from the NYSDEC.

4. Eastern Wormsnake

The eastern wormsnake (*Carphophis a. amoenus*) is a State-listed special concern species of the Colubrid family (Colubridae). It is rarely observed and occurs in moist forested habitats where the soil allows burrowing; it is also found beneath surface objects, including logs, stumps, rocks, and human debris (*e.g.*, boards, trash) (Conant and Collins 1998).

The eastern wormsnake is known to occur in or near rocky summit communities or similar habitats such as power line rights-of-way in deciduous forests (NYNHP 2011eee). Ecological communities associated with this species include Appalachian oak-hickory forest, chestnut oak forest, oak-tulip tree forest, and pitch pine-oak-heath rocky summit.

Within the vicinity of IPEC, the eastern wormsnake occurs in the coastal zone of all four counties (NYSDEC 1998b; NYSDEC 2012j). Threats to this species include habitat loss and fragmentation and mortality due to pesticides (NYNHP 2011eee). Although the eastern wormsnake is listed as a special concern species, it is not afforded special protection under Article 11 of the ECL as presently written for New York State endangered and threatened species. The collection or possession of any native snakes of New York is prohibited without a special (NYSDEC 2012c).

5. Green Frog

The green frog (*Lithobates clamitans melanota*) is a member of the Ranidae family. Habitat for this species includes shallow freshwater, springs, creeks, ditches, and edges of lakes and ponds (Conant and Collins 1998). This species can be found in large numbers in marshes, ponds, lakes, and backwaters of streams where food sources are also abundant (Johnson 2012). Within the vicinity of IPEC, green frogs are widely distributed and occur at Iona Island Marsh and in the coastal zone of all four counties (NYSDEC 1998b, NYSDEC 2012k; NYSDOS 1987b; NYSDEC 1998b).

Green frogs are open to hunting, taking, and possession, pursuant to small game license requirements, during the open hunting season (July 15 through September 30) (NYSDEC 2012c). There are no current threats to this species that would result in this species being listed by the State under Article 11 of the ECL or Section 9 of ESA.

6. Snapping Turtle

The snapping turtle (*Chelydra s. serpentina*) is a member of the Chelydridae family. This is one of the most common turtle species of New York (Ford and Johnson 2012). Habitat for snapping turtle consists of small or large permanent bodies of freshwater, occasionally brackish water, and can be found in a variety of waters ranging from pristine lakes, large rivers, and marshes to farm ponds, salt marshes, and canals (Conant and Collins 1998). However, habitat preferences are of slow-moving waters of shallow areas that have muddy substrates (Ford and Johnson 2012).

The common snapping turtle is widespread within the vicinity of IPEC and occurs at Iona Island Marsh and in the coastal zone of all four counties (NYSDEC 1998b, NYSDEC 2012l; NYSDOS 1987b; NYSDEC 1998b). Firearm or bow hunting of snapping turtles is allowed with a small game permit in New York State during the open hunting season (July 15 through September 30; NYSDEC 2012c). NYSDEC regulations state a daily limit of five and a seasonal limit of 30 (NYSDEC 2012c). There are no current threats to this species that would result in its being listed by the NYSDEC under Article 11 of the ECL or Section 9 of the ESA.

7. Northern Water Snake

The northern water snake (*Nerodia sipedon sipedon*) is a member of the Elapidae family. In New York, this species is found in, or in the vicinity, of almost any waterbody or wetland system, including swamps, marshes, bogs, streams, and lakes. Slow-moving or quiet waters are preferred habitat although this species is known to occur in the vicinity of waterfalls and rapids of streams (Johnson and Gibbs 2003; Conant and Collins 1998).

Northern water snakes are widely distributed within the vicinity of IPEC and occur in Iona Island Marsh and the coastal zone of all four counties (NYSDEC 1998b; NYSDEC 2012m; NYSDOS 1987b; NYSDEC 1998b). There do not appear to be current threats to this species that would result in it being listed by the State under Article 11 of the ECL and Section 9 of the ESA.

However, the collection or possession of any native snakes of New York is prohibited without a special collection license (NYSDEC 2012c).

D. Insects

The following are profiles for the seven insects listed by NYNHP for the IPEC Region, the three SCFWHs, the Coastal Zone, and RM 40-43 and RM 56-60.

1. Appalachian Azure

The Appalachian azure (*Celastrina neglectamajor*) is a butterfly of the blue, copper, hairstreak, and elfin family (Lycaenidae) that is unlisted/unprotected in New York State, though characterized as rare (NYNHP 2011ttt). Habitat for this species is a rich deciduous forest, containing black cohosh (*Actaea racemosa*), which is the sole foodplant for the larvae of this species.

Adult Appalachian azures are present between adults present in New York State from the middle or late May to the middle of June with larvae present into July. For the remainder of the year, this species exists as pupae in the leaf litter or humus layer.

2. Tiger Spiketail

The tiger spiketail (*Cordulegaster erronea*) is a dragonfly of the spiketail family (Cordulegastridae) that is unlisted/unprotected in New York State, though characterized as rare (NYNHP 2011fff). Habitat for this species is very specific and limited to fishless, partially shaded coldwater streams, spring trickles, and seepage areas that have non-silt substrates (Barlow 1995; Dunkle 2000; Nikula et al. 2003 as cited in NYNHP 2011fff; White 2010). The adult stage of this species is terrestrial; adults rest on vegetation along the edges of streams and seeps and feed in nearby fields and forest clearings. The larval stage of this species is aquatic, whereby females oviposit eggs into muddy substrates of shallow water habitats (Dunkle 2000; Nikula et al. 2003 as cited in NYNHP 2011fff).

The tiger spiketail is a resident species of New York State throughout the year (NYNHP 2011fff). This species occurs in the vicinity of IPEC in Putnam, Westchester, and Rockland Counties (Donnelly 2004 as cited in NYNHP 2011eee, NYNHP 2011fff).

3. Arrowhead Spiketail

The arrowhead spiketail (*Cordulegaster obliqua*) is a dragonfly of the spiketail family (Cordulegastridae) that is unlisted/unprotected in New York State, though characterized as rare. Within its range, arrowhead spiketails occur primarily in spring-fed streams and seeps of forested areas and occasionally in open wet meadows. Streams and seeps commonly have soft substrates, but sometimes this species occurs in streams with rocky bottoms. While adult arrowhead spiketails oviposit and primarily dwell within these habitats, they may feed in forest clearings in the vicinity of the breeding habitat (NYNHP 2011ggg).

The arrowhead spiketail is a resident species of New York State throughout the year (NYNHP 2011ggg). This species is present in the Hudson Valley, including Rockland County within the vicinity of IPEC. The preferred habitat occurrence is not uncommon; therefore, it is expected that this species occurs in a scattered distribution in other locations within the counties and regions for which it is known (NYNHP 2011ggg).

4. Needham's Skimmer

The Needham's skimmer (*Libellula needhami*) is a dragonfly of the skimmer family (Libellulidae) that is unlisted/unprotected in New York State, though characterized as rare. This species is known to occur in coastal areas of brackish marshes, tidal rivers, ponds, and lakes (Dunkle 2000; Nikula et al. 2003 as cited in NYNHP 2011hhh). Adults are largely terrestrial and occur in surrounding habitats, but tend to feed in marshes of coastal areas while larvae are found within the water (NYNHP 2011hhh).

The Needham's skimmer is a resident species of New York State throughout the year (Abbott 2007 as cited in NYNHP 2011hhh; Dunkle 2000). Records indicate that this species is present within the lower Hudson Valley to Orange County, and within the vicinity of IPEC at Iona Island Marsh, and in Rockland County (Donnelly 1999 as cited in NYNHP 2011hhh; NYNHP 2011hhh; NYNHP 2010). It is expected that additional Needham's skimmer populations may be discovered with increased surveying efforts (NYNHP 2011hhh).

5. Spatterdock Darner

The spatterdock darner (*Rhionaeschna mutata*) is a dragonfly of the darner family (Aeshnidae) that is unlisted/unprotected in New York State, though characterized as rare. Within its range, this species occurs in ponds and lakes, but primarily within fishless ponds with emergent aquatic vegetation, particularly spatterdocks/pond lilies (*Nuphar spp.*), or pools, open marsh, and bogs also with spatterdock (*Nuphar variegatum*) (Dunkle 2000; Nikula et al. 2003 as cited in NYNHP 2011iii). In general, the majority of the populations occur in small, densely vegetated ponds where some of the vegetative cover includes spatterdock. It is expected that certain habitat characteristics including water depth, substrate, pH, and vegetation may need to be studied to understand habitat preferences of this species (NYNHP 2011iii).

Spatterdock darner adults tend to feed along forest edges, fields, wetland edges, and dirt paths (Nikula et al. 2003 as cited in NYNHP 2011iii; Dunkle 2000 as cited in NYNHP 2011iii). Females lay eggs on the undersides of aquatic emergent vegetation and have a preference for spatterdock.

The spatterdock darner is a resident species of New York State throughout the year (NYNHP 2011iii). This species is widely distributed across multiple locations within nine counties in regions of the southern tier, including the southern Catskill Mountains, and southern

Hudson Valley. Given the wide distribution of this species across the State, and that the preferred habitat occurrence is not uncommon, it is expected that this species occurs in a scattered distribution in a small number of other locations within the counties and regions for which it is known (NYNHP 2011iii).

6. Mocha Emerald

The mocha emerald (*Somatochlora linearis*) is a dragonfly of the emerald family (Corduliidae) that is unlisted/unprotected in New York State, though characterized as rare. Habitat for this species includes shady streams of forests that range between 3 and 9 feet wide and have sand, gravel, or rocky bottoms (Dunkle 2000; Nikula et al. 2003 as cited in NYNHP 2011jjj; Holst 2005 as cited in NYNHP 2011jjj; White et al. 2010). Adults of this species are terrestrial and found in fields and forests adjacent forested streams. Males can be found as far as 60 to 90 feet from the streams during breeding periods (Dunkle 2000). Females oviposit into mud or shallow water at stream edges (Natural Heritage Endangered Species Program 2003 as cited in NYNHP 2011jjj; Nikula et al. 2003 as cited in NYNHP 2011jjj).

The mocha emerald is a resident species of New York State throughout the year. (NYNHP 2011jjj). Known populations of the mocha emerald occur in eight counties and are widely distributed across the Hudson Valley (Donnelly 2004 as cited in NYNHP 2011jjj; NYNHP 2011jjj). Surveys conducted between the early 1990s and 2002 revealed mocha emerald populations in Westchester, Rockland, Orange, and Dutchess Counties within the lower Hudson River Valley, including the vicinity of IPEC (Donnelly 2004 as cited in NYNHP 2011jjj; NYNHP 2011jjj; NYNHP 2009a). The full New York State range has not been determined for this species (NYNHP 2011jjj).

7. Gray Petaltail

The gray petaltail (*Tachopteryx thoreyi*) is a dragonfly of the petaltail family (Petaluridae) and is listed as a New York State special concern species. Within its range, habitat includes hillside seeps and fens of deciduous forest (Dunkle 2000). Within New York, habitat for this species includes streams, hillside and groundwater-fed seepages of streamlets and fens of rocky gorges, and glens of deciduous or mixed forests. Larval habitat includes mud, muck, vegetation, and moss of seepage areas with limited standing water (Needham et al. 2000 as cited in NYNHP 2011kkk; Nikula et al. 2003 as cited in NYNHP 2011kkk). Adult habitat includes both seepage areas and streams (NYNHP 2011kkk).

The gray petaltail is a resident species of New York State (NYNHP 2011kkk). It is distributed widely within the southern portion of the State; within the vicinity of IPEC, it is found in Rockland County (NYNHP 2011kkk; NYNHP 2010). Currently, there are 11 confirmed locations, many of which are very close to one another on protected lands. It is suspected that populations that are in close proximity may represent a single metapopulation (NYNHP 2011kkk). Long-term trends indicate that development throughout the lower Hudson Valley has caused the extirpation of this species at sites within this portion of its range (NYNHP 2011kkk).

V. ANALYSIS AND CONCLUSIONS

A number of federally and State-listed plants and wildlife and significant ecological communities are known to occur within the vicinity of IPEC, including within the SCFWHs and the proposed Hudson Highlands Expansion Area RM 56-60. As described above, threats to these flora and fauna and significant ecological communities, as documented by NYSDOS, range from invasive species to the use of significant ecological communities for recreational activities. However, the operation of IPEC cannot reasonably be identified as a threat to flora, terrestrial fauna, significant ecological communities, or federally or State-listed plants or terrestrial wildlife.

In addition, there are a number of game species within the vicinity of IPEC. However, the operation of IPEC has not adversely affected game species populations or hindered their presence within the vicinity of IPEC. Therefore, IPEC License Renewal will not adversely impact game species populations or the presence of these species within the vicinity of IPEC.

No new construction, land disturbance, or development is proposed as part of IPEC License Renewal. IPEC will continue to operate as it has over the term of its current operating licenses subject to all federal, State, and/or local regulations established to protect flora and terrestrial fauna within the vicinity of IPEC. Therefore, IPEC License Renewal cannot reasonably be considered to adversely affect flora, terrestrial fauna, or ecological communities.

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Tables

Table C-1
Relevant Terrestrial Plants Within the Vicinity of IPEC

Common Name	Scientific Name	RM 44–56	RM 56-60	Iona Island Marsh	Haverstraw Bay	Orange County	Putnam County	Rockland County	Westchester County	State Listing, State/Global Rank	Federal Rank
American Waterwort	*Elatine americana*		X							S1/G4	
Narrow-leaved Cattail	*Typha angustifolia*			X						N/A	
Woodland Agrimony	*Agrimonia rostellata*		X							S2/G5	
Virginia Snakeroot	*Aristolochia serpentaria*									S2/G4	
Saltmarsh Bulrush	*Bolboschoenus novae-angliae*			X		X				S1/G5	
Midland Sedge	*Carex mesochorea*							X		S2/G4G5	
Straw Sedge	*Carex straminea*					X		X[1]		S1/G5	
Lined Sedge	*Carex striatula*					X				S1/G4G5	
Water Pigmyweed	*Crassula aquatica*	X		X			X			S1/G5	
Yellow Flatsedge	*Cyperus flavescens*			X						S1/G5	
Riverbank Quillwort	*Isoetes riparia*		X							S1/G5?	
Gypsy-wort	*Lycopus rubellus*	X					X			S1/G5	
Virginia Pine	*Pinus virginiana*					X				S1/G5	
Basil Mountain-mint	*Pycnanthemum clinopodioides*							X		S1/G2	
Torrey's Mountain-mint	*Pycnanthemum torrei*							X		S1/G2	
Delmarva Beggar-ticks	*Bidens bidentoides*		X							S3/G3G4	
Estuary Beggar-ticks	*Bidens hyperborean var. hyperborea*		X							S1/G4T2T4	
Smooth Bur-marigold	*Bidens laevis*		X				X			S2/G5	
Terrestrial Starwort	*Callitriche terrestris*	X		X				X		S2S3/G5	
Long's Bittercress	*Cardamine longii*	X		X			X	X		S2/G3	
Clustered Sedge	*Carex cumulata*		X				X			S2S3/G4?	
Marsh Straw Sedge	*Carex hormathodes*					X				S2S3/G4G5	
Salt-marsh Spikerush	*Eleocharis uniglumis var. halophila*							X		S2/G4T4	

Table C-1 (cont'd)
Relevant Terrestrial Plants Within the Vicinity of IPEC

Common Name	Scientific Name	RM 44–56	RM 56-60	Iona Island Marsh	Haverstraw Bay	Orange County	Putnam County	Rockland County	Westchester County	State Listing, State/Global Rank	Federal Rank
Violet Wood-sorrel	*Oxalis violacea*						X			S2S3/G5	
Small-flowered Crowfoot	*Ranunculus micranthus*			X						S3/G5	
Spongy Arrowhead	*Sagittaria montevidensis var. spongiosa*	X	X	X		X		X	X	S2/G5T4	
Mexican Seaside Goldenrod	*Solidago sempervirens var. mexicana*		X							S1/G5T5?	
Saltmarsh Aster	*Symphyotrichum subulatum var. subulatum*	X		X			X	X		S2/G5T5	
Wild Potato-vine	*Ipomoea pandurata*							X		S1/G5	
Large Twayblade	*Liparis liliifolia*						X			S1/G5	
Virginia False Gromwell	*Onosmodium virginianum*								X	S1/G4G5	
Hooker's Orchid	*Platanthera hookeri*								X	S1/G4G5	
Catfoot	*Pseudognaphalium helleri ssp. Micradenium*							X		SH/ G4G5T3?	
Slender Marsh-pink	*Sabatia campanulata*	X					X			S1/G5	
Puttyroot	*Aplectrum hymenale*								X	S1/G5	
Troublesome Sedge	*Carex molesta*							X		S2S3/G4	
Rough Avens	*Geum laciniatum*					X				S2/G5	
Eastern Grasswort	*Lilaeopsis chinensis*				X				X	S2/G5	
Globe-fruited Ludwigia	*Ludwigia sphaerocarpa*								X	S2/G5	
Heartlead Plantain	*Plantago cordata*		X					X		S3/G4	
Michaux's Blue-eyed-grass	*Sisyrinchium mucronatum*					X				S1/G5	
Small Whorled Pogonia	*Isotria medeoloides*							X		E, SH/G2	T

Table C-2
NYNHP/New York State Rare Natural Communities

Species/ Communities	RM 56-60	Dutchess County	Orange County	Putnam County	Westchester County	Rockland County	State/ Global Rank
Acidic talus slope woodland	X		X				S3/G4?
Appalachian oak-hickory forest	X		X	X	X		S4/G4G5
Brackish intertidal mudflats	X		X		X		S1S2/G3G4
Brackish tidal marsh	X		X		X		S3S4/G4
Chestnut oak forest	X		X	X	X	X	S4/G5
Cliff community				X			S4/G5
Oak-tulip tree forest	X		X	X		X	S2S3/G4
Pitch pine-oak-heath rocky summit	X		X	X		X	S3S4/G4
Red cedar rocky summit	X		X				S3/G3G4
Rocky summit grassland			X		X	X	S3/G3G4
Floodplain Forest		X					S2/G3G4
Tidal River	X	X	X	X	X	X	S3/G4

Table C-3
Relevant Terrestrial Wildlife Within the Vicinity of IPEC

Common Name	Scientific Name	Hudson RM 44–56	Hudson RM 56-60	Iona Island Marsh	Haverstraw Bay	Orange County	Putnam County	Rockland County	Westchester County	State Listing, State/Global Rank	Federal Rank
Green Heron	*Butorides virescens*			X[1]							
Least Bittern	*Ixobrychus exilis*			X[1]						T, S3B,S1N/G4	
Canada Goose	*Branta canadensis*			X[1]						Game	
Mallard	*Anas platyrhynchos*			X[1]						Game	
American Black Duck	*Anas rubripes*			X[1]						Game	
Wood Duck	*Aix sponsa*			X[1]						Game	
Sora	*Porzana carolina*			X[1]						Game	
Common Moorhen	*Gallinula chloropus*			X[1]						Game	
Spotted Sandpiper	*Actitis macularia*			X[1]							
Belted Kingfisher	*Megaceryle alcyon*			X[1]							
Marsh Wren	*Cistothorus palustris*			X[1]							
Red-winged Blackbird	*Agelaius phoeniceus*			X[1]							
Swamp Sparrow	*Melospiza georgiana*			X[1]							
Osprey	*Pandion haliaetus*			X[1]	X[1]					SC	
Waterbird Concentration Area				X[1]	X[1]						

Table C-3 (cont'd)
Relevant Terrestrial Wildlife Within the Vicinity of IPEC

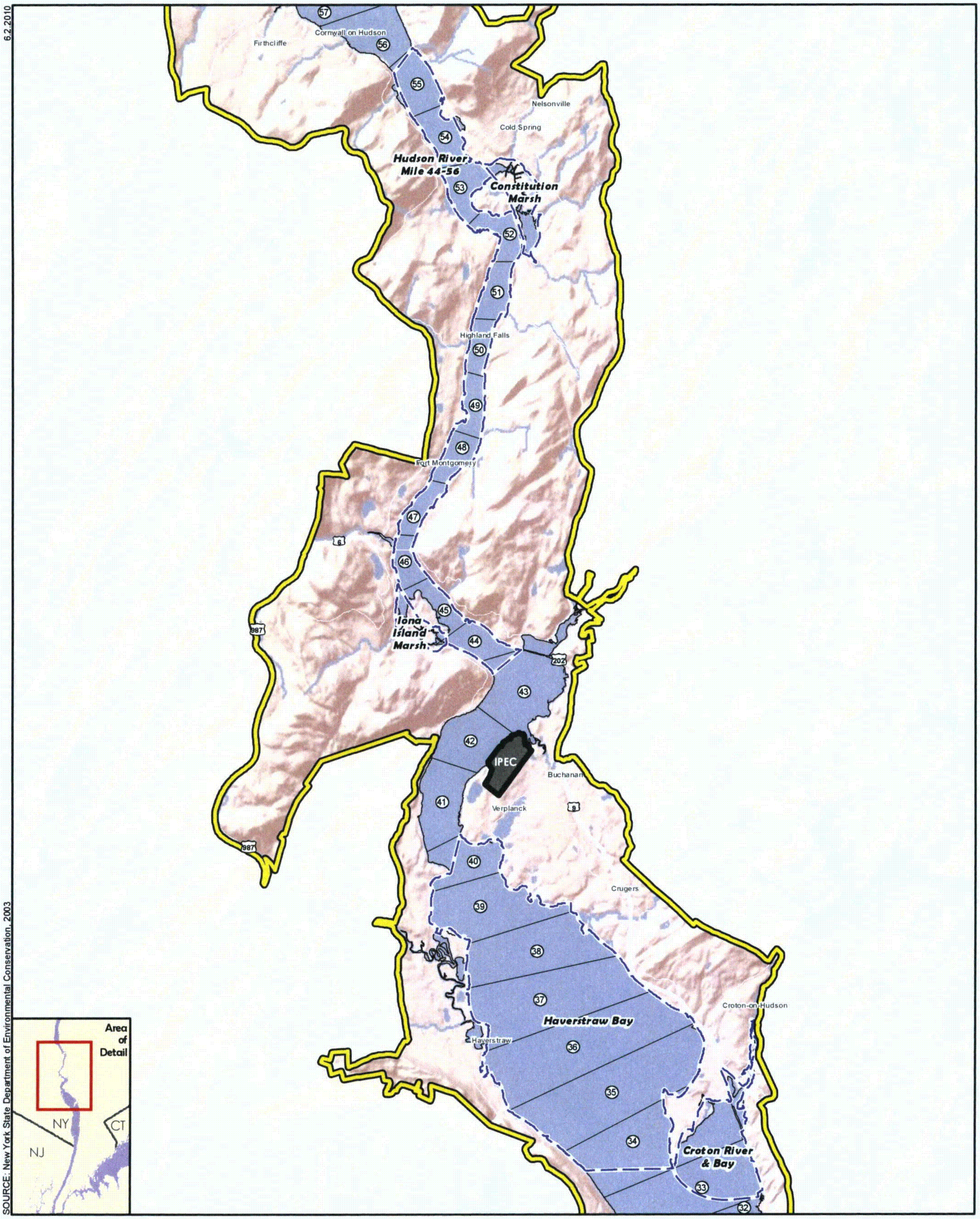
Common Name	Scientific Name	Hudson RM 44–56	Hudson RM 56-60	Iona Island Marsh	Haverstraw Bay	Orange County	Putnam County	Rockland County	Westchester County	State Listing, State/Global Rank	Federal Rank
Bald Eagle	*Haliaeetus leucocephalus*	X[1]		X	X	X	X	X	X	T, S2S3B,S2N/G5	
Virginia Rail	*Rallus limicola*			X[1]						Game	
Peregrine Falcon	*Falco peregrinus*	X				X	X		X	E, S3B/G4	
Northern Harrier	*Circus cyaneus*								X	T, S3B,S3N/G5	
Short-eared Owl	*Asio flammeus*								X	E, S2/G5	
Kentucky Warbler	*Oporornis formosus*							X		S2/G5	
Muskrat	*Ondatra zibethicus*			X[1]							
Mink	*Neovision vison*			X[1]							
Indiana Bat	*Myotis sodalis*					X	X	X	X	E, S1/G2	E
Eastern Small-footed Myotis	*Myotis leibii*						X			S2/G3	
Snapping Turtle	*Chelydra serpentina*			X[1]		X	X	X	X		
Northern Water Snake	*Nerodia sipedon*			X[1]		X	X	X	X		
Green Frog	*Rana clamitans*			X[1]		X	X	X	X		
Bog Turtle	*Glyptemys muhlenbergii*					X	X	X	X	E, S2/G3	T
Eastern Wormsnake	*Carphophis amoenus*					X	X	X		SC, S2/G5	

Table C-3 (cont'd)
Relevant Terrestrial Wildlife Within the Vicinity of IPEC

Common Name	Scientific Name	Hudson RM 44–56	Hudson RM 56-60	Iona Island Marsh	Haverstraw Bay	Orange County	Putnam County	Rockland County	Westchester County	State Listing, State/Global Rank	Federal Rank
Timber Rattlesnake	*Crotalus adamanteus*					X	X	X	X	T, S3/G4	
Fence Lizard	*Sceloporus undulatus*					H	X	H	X	T, S1/G5	
Needham's Skimmer	*Libellula needhami*			X			X			S2S3/G5	
Tiger Spiketail	*Corduegaster erronea*						X	X		S1/G4	
Spatterdock Darner	*Rhionaeschna mutata*					X				S2/G4	
Arrowhead Spiketail	*Cordulegaster obliqua*							X		S2S3/G4	
Gray Petaltail	*Tachopteryx thoreyi*							X		SC, S2/G4	
Mocha Emerald	*Somatochlora linearis*					X	X	X	X	S2S3/G5	
Appalachian Azure	*Celastrina neglectamajor*		X							S1S3/G4	

FIGURES

6.2.2010



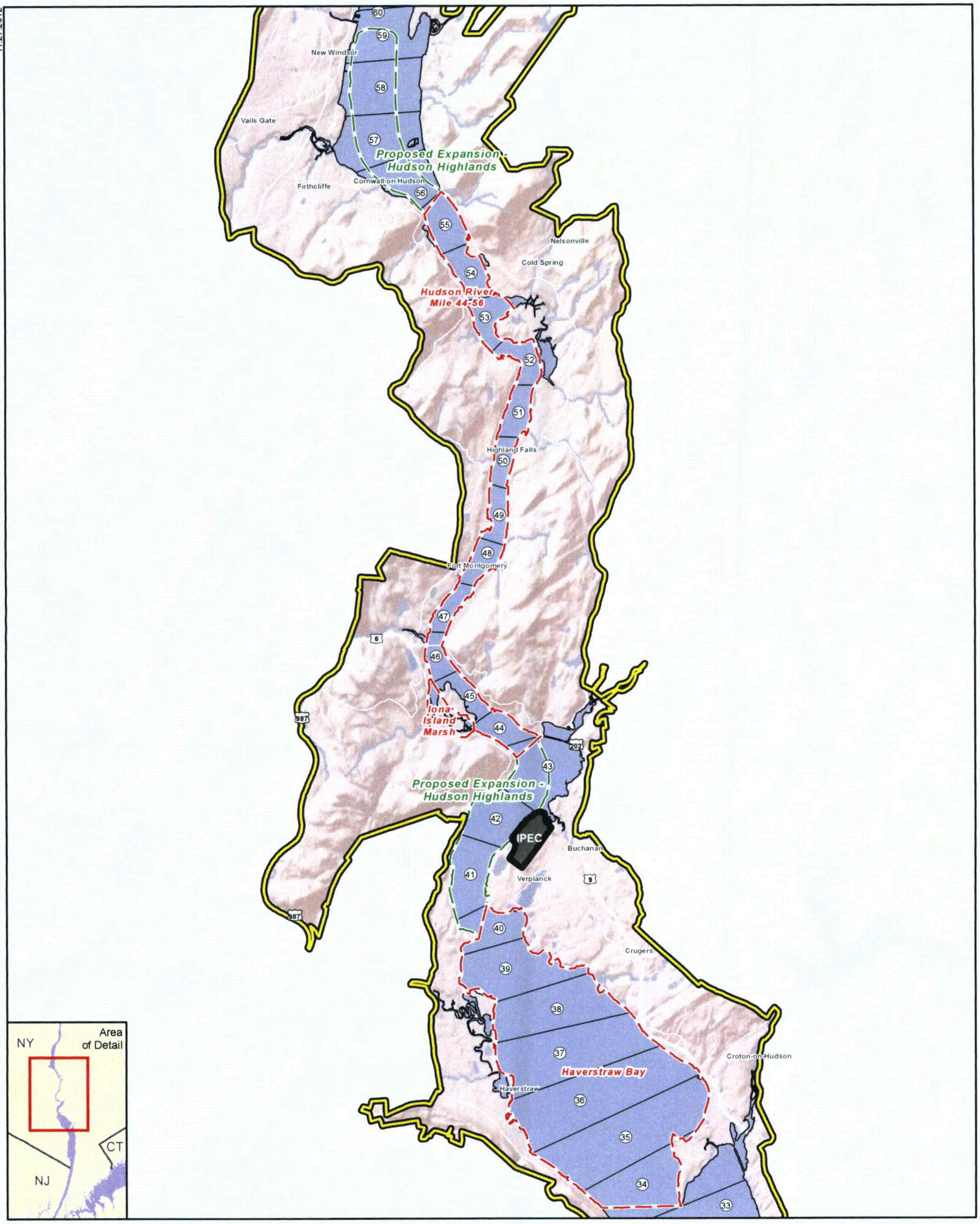
SOURCE: New York State Department of Environmental Conservation, 2003

NYS DOS Coastal Zone Boundary
NYSDOS Significant Coastal Habitat
River Mile

0 1 2 3 4 Miles

IPEC CZMA
Project Area
Figure C-1

11.27.2012



NYS DOS Coastal Zone Boundary
NYSDOS Significant Coastal Habitat
NYSDOS Proposed Significant Coastal Habitat
41 River Mile

IPEC CZMA
IPEC Coastal Zone - River Mile 34 to 60 (Proposed)
Figure C-1A

0 1 2 3 4 Miles
N

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollutant Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc.'s Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

**PREFILED TESTIMONY OF YAN KISHINEVSKY, P.E.
IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.**

CLOSED CYCLE COOLING

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

By its attorneys,

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April 30, 2014

Q: Please state your name, current position, and business address.

A: My name is Yan Kishinevsky. I am a Director for Nuclear Services and Advanced Technology at Burns and Roe Enterprises ("Burns and Roe"), a comprehensive engineering, procurement, construction, operations, and maintenance organization with specialized expertise in technically complex facilities. My business address is 800 Kinderkamack Road, Oradell, NJ 07649.

Q: Are you offering this testimony on behalf of Entergy in support of its application for renewal of State Pollutant Discharge Elimination System ("SPDES") Permit (DEC App. Nos. 3-5522-00011-00004 SPDES No. NY0004472) for Indian Point Units 2 and 3 and the corresponding issue in the associated Water Quality Certification ("WQC") proceeding, as it has been consolidated by this Tribunal (collectively, the "Proceedings")?

A: Yes. I am offering my testimony with respect to Issue for Adjudication No. 1 as it relates to the feasibility of constructing and operating closed-cycle cooling ("CCC") towers as proposed by NYSDEC Staff at Indian Point Energy Center ("IPEC"). I offer my expert testimony concerning whether, from an engineering perspective, the proposed retrofits of Indian Point Units 2 and 3 with CCC (and therefore cooling towers) can be successfully constructed and operated without material detriment impacts to IPEC during the license-renewal period on a site-specific basis.

Q: Please describe your academic background.

A: I earned a M.S. in 1972 in Applied Physics and Thermodynamics from Moscow State University, in what was then the USSR (now Russia). I am a Registered

Professional Engineer in the State of New York. My most recent curriculum vitae, including a list of my recent publications, is submitted as Entergy Exhibit 539.

Q: Please summarize your relevant specializations and work experience.

A: I have over 35 years of engineering experience working with nuclear power plants. As Director of Nuclear Services and Advanced Technology at Burns and Roe, I have been involved in the development and implementation of advanced nuclear fuel and reactor technology. Prior to working at Burns and Roe, I was a Special Projects Manager for the New York Power Authority ("NYPA") from 1980 to 2007. At NYPA, I was responsible for the design, engineering, procurement, installation and testing of major capital modifications and improvements for Indian Point Unit 3 and James A. Fitzpatrick Nuclear Power Plant. For example, I was in charge of the condenser modifications to Indian Point Unit 3, and involved in the modifications to the circulating water system, including the installation of the current variable speed pumps. Finally, I also worked on the decommissioning of the Shoreham Nuclear Power Plant.

Q: What was your role in evaluating potential alternative intake technologies for IPEC?

A: I was responsible for the preparation of the Burns and Roe report entitled *BREI Independent Review of the Proposed ClearSky© Cooling Towers Impact on the Indian Point Energy Center Main Condensers*, which is Attachment 3 to the Enercon report entitled *ENERCON Response to Tetra Tech's Indian Point Closed-Cycle Cooling System Retrofit Evaluation Report* (Entergy Ex. 296(A)).

In addition, and in preparation for my testimony in these Proceedings, I have also reviewed various materials, including the following reports:

- *Economic and Environmental Impacts Associated with Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration,* dated June 2003 (Entergy Ex. 7A);
- *Engineering Feasibility and Costs of Conversion of Indian Point Units 2and 3 to a Closed-Loop Condenser Cooling Water Configuration*, dated February 12, 2010 (Entergy Ex. 7);
- *Indian Point Closed-Cycle Cooling System Retrofit Evaluation*, dated June 2013 (Staff Ex. 214); and
- *ENERCON Response to Tetra Tech's Indian Point Closed-Cycle Cooling System Retrofit Evaluation Report*, dated December 2013 (Entergy Ex. 296A).

Q: **Have you reviewed the prefiled direct testimony of Sam Beaver, dated February 28, 2014, and the prefiled rebuttal testimony of Sam Beaver, dated March 28, 2014?**

A: Yes.

Q: **What was the nature of your review?**

A: I reviewed the reports and Mr. Beaver's prefiled direct and rebuttal testimony, focusing on aspects of Mr. Beaver's testimony that concerned the feasibility of construction and operation of cooling towers at IPEC.

Q: **Do you agree with Mr. Beaver's conclusion that the operation of cooling towers at IPEC would adversely impact plant performance?**

A: Yes. As Mr. Beaver stated in his prefiled rebuttal, "[r]etrofitting a nuclear plant constructed in the 1970s with a once-through cooling system to a closed-cycle cooling system will impact virtually every aspect of IPEC's circulating water system." *See* Beaver CCC Rebuttal at 9:12-14; *see also* Beaver CCC Rebuttal at 3:8-6:8, 7:1-8:17, 8:19-10:10, 26:5-26:22, 28:22-29:8, 37:1-10, 38:4-39:2, with which I agree and accept. I would also underscore three points: First, it took nearly 40 years of engineering work to produce IPEC's consistent current capacity factor of over 90 percent. That work will compromised by installing cooling towers. Not only will a cooling tower retrofit project adversely impact overall IPEC performance by reducing the flow rate of the circulating water and increasing the temperature of the circulating water, but any cooling tower retrofit will also necessarily change and disrupt many of the complex controls and interlocks that assure the reliable and safe operation of the plant, including its defense in depth systems. These impacts may extend to the Units' primary (or nuclear) and secondary (or electricity generation) systems. Second, a feasibility analysis would need to consider not only stable operations but also various operational transients evaluated under the regulatory regime in which nuclear power plants operate and under standard engineering practices. One of those transients is identified in Mr. Beaver's testimony, but as Mr. Beaver indicated, there are many others that would need to be identified and evaluated as a precursor to reaching a feasibility determination. *See* Beaver CCC Direct at 11:5-17. Third, as Mr. Beaver indicates, an engineer operating consistent with standard nuclear engineering practices could not reach a conclusion that retrofitting IPEC with cooling towers is feasible to a reasonable degree of engineering certainty. *See* Beaver CCC Rebuttal at 38:4-39:2.

Q: Please summarize the information that you relied on or considered for your testimony.

A: In addition to the testimony and reports identified above, I have also reviewed the prefiled direct, prefiled rebuttal, and live testimony of Tim Havey and Eduardo Ortiz de Zarate.

END OF TESTIMONY

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollutant Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc.'s Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

**PREFILED TESTIMONY OF RICHARD T. CLUBB, P.E.
IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY
NUCLEAR INDIAN POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.**

CLOSED CYCLE COOLING

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

By its attorneys,

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Fax: 617.523.1231

April 30, 2014

Q: Please state your name, current position, and business address.

A: My name is Richard Clubb. I am a Project Manager at Enercon Services, Inc. ("Enercon"), an engineering, environmental, and technical management services firm. My business address is 500 Townpark Lane, Kennesaw, Georgia 30144.

Q: Are you offering this testimony on behalf of Entergy in support of its application for renewal of State Pollutant Discharge Elimination System ("SPDES") Permit (DEC App. Nos. 3-5522-00011-00004 SPDES No. NY0004472) for Indian Point Units 2 and 3 and the corresponding issue in the associated Water Quality Certification ("WQC") proceeding, as it has been consolidated by this Tribunal (collectively, the "Proceedings")?

A: Yes. I am offering my testimony with respect to Issue for Adjudication No. 1 as it relates to the feasibility of constructing and operating closed-cycle cooling ("CCC") towers as proposed by NYSDEC Staff at Indian Point Energy Center ("IPEC"). I offer my expert testimony concerning whether, from an engineering perspective, the proposed retrofits of Indian Point Units 2 and 3 with CCC (and therefore cooling towers) can be successfully constructed and operated without material detriment impacts to Indian Point during the license-renewal period on a site-specific basis.

Q: Please describe your academic background.

A: I earned a B.S. in mechanical engineering and an MBA from the Georgia Institute of Technology. My undergraduate degree focused on thermodynamics, fluids, heat transfer, and failure analysis. I am a Registered Professional Engineer in the

State of Georgia. My most recent curriculum vitae, including a list of my recent publications, is submitted as Entergy Exhibit 540.

Q: Please summarize your relevant specializations and work experience.

A: I have over eight years of experience in nuclear power plant modifications, nuclear power plant circulating water system engineering, and nuclear power plant licensing. I have particular expertise in engineering assessments of CCC at various large-scale, base load, fossil fuel and nuclear electric-generating stations. As set forth in my CV, in addition to the work performed in this proceeding, I have worked on circulating water and service water systems and/or cooling tower projects at the following nuclear facilities: James A. Fitzpatrick Nuclear Power Plant; Pilgrim Nuclear Power Station; Quad Cities Nuclear Generating Station; Pickering Nuclear Generating Station; Diablo Canyon Power Plant; Dresden Generating Station; Robinson Nuclear Plant; and San Onofre Nuclear Generating Station.

Q: What was your role in evaluating potential CCC configurations for IPEC?

A: I was a principal author and responsible for managing day-to-day activities related to the development of the following reports: *Engineering Feasibility and Costs of Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration*, dated February 12, 2010 (Entergy Ex. 7); *Analysis of Closed-Loop Cooling Salinity Levels Indian Point Units 2 & 3*, dated November 2010 (Entergy Ex. 310); and *ENERCON Response to Tetra Tech's Indian Point Closed-Cycle Cooling System Retrofit Evaluation Report*, dated December 2013 (Entergy Ex. 296A). As part of my role preparing these reports, I worked hand-in-hand with Mr. Beaver, who was the Technical Lead on each of these projects.

Q: Have you reviewed the prefiled direct testimony of Sam Beaver, dated February 28, 2014, and the prefiled rebuttal testimony of Sam Beaver, dated March 28, 2014?

A: Yes.

Q: Do you adopt that testimony?

A: Yes. I hereby adopt the prefiled direct and rebuttal testimony of Sam Beaver as my own, and have attached both the prefiled direct and rebuttal testimony as Exhibit A and Exhibit B, respectively.

Q: Please summarize the information that you relied on or considered for your testimony.

A: I have reviewed and/or rely on a variety of information, including the following reports, studies and other documents:

- Enercon Services, Inc., *ENERCON Response to Tetra Tech's Indian Point Closed-Cycle Cooling System Retrofit Evaluation Report*, dated December 2013 (Entergy Ex. 296A);
- Enercon Services, Inc., *Analysis of Closed-Loop Cooling Salinity Levels Indian Point Units 2 & 3*, November 2010 (Entergy Ex. 310);
- Memorandum from John Sunda, SAIC and Kelly Meadows, to Paul Shriner and Jan Matuszko, USEPA, Re: Cooling Tower Noise, Plume and Drift Abatement Costs, dated June 11, 2010 (Entergy Ex. 346);
- SPX, Entergy Indian Point Units 2 & 3, ClearSky Selection Summary (Entergy Ex. 347);

- Tetra Tech, Inc., Glenwood Main Power Station Technical Review (Entergy Ex. 348);
- National Grid Generation LLC, Response to NYSDEC's Request for Additional Information Regarding Cooling Towers, dated July 1, 2010 (Entergy Ex. 349);
- Tetra Tech, Inc., Northport Generating Station Technical Review (Entergy Ex. 350, 354);
- Aerial photograph of IPEC site (Entergy Ex. 351);
- Mostafa H. Sharqawy, et al., *On Thermal Performance of Seawater Cooling Towers*, Journal of Engineering for Gas Turbines and Power, April 2011 (Entergy Ex. 352);
- Letter from Timothy Curt, National Grid Environmental Management, to Ms. Colleen Kimble, NYS Department of Environmental Conservation, dated July 1, 2010 (Entergy Ex. 353);
- Memorandum from John Sunda, Steve Geil and Kelly Meadows (Tt), to Chuck Nieder (NYSDEC) and Jamie Hurley (USEPA OWM), Re: Huntley Closed-Cycle Cooling System Evaluation, dated Oct. 5, 2011 (Entergy Ex. 355);
- Memorandum from Kelly Meadows, Tetra Tech, to Paul Shriner, EPA, Re: Space Constraints for Cooling Tower Retrofits, dated February 28, 2011 (Entergy Ex. 356);
- U.S. Department of Energy, Project Facts, Improvement to Air2Air® Technology to Reduce Fresh-Water Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants ProMIS/Project No.: DE-NT0005647 (Entergy Ex. 357);
- Bob Cashner, American Electric Power, *AEP's Experience with Polyester FRP*

Structure Cooling Towers, dated Feb. 2011 (Entergy Ex. 358);

- SPX Cooling Technologies, Inc., *Improvement to Air2Air™ Technology to Reduce Fresh-Water Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants*, Final Report, dated June 30, 2012 (Entergy Ex. 359);
- Overall Cost Summary for CWWS Installation Scenario Outlined in December 13, 2013 Memo to NERA (Entergy Ex. 372);
- Cooling Tower Siting Conflicts (Entergy Ex. 373);
- SPX Cooling Technologies, *Use of Air2Air™ Technology to Recover Fresh-Water from the Normal Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants*, Final Report, dated Sept. 30, 2009 (Entergy Ex. 383);
- Florida Power & Light August 3, 2011 Response to NRC's request for additional information (Turkey Point Nuclear Plant) (Entergy Ex. 390);
- U.S. Nuclear Regulatory Commission, Standard Review Plan § 10.4.5 Circulating Water System, NUREG-0800 (Entergy Ex. 391);
- Levy Nuclear Plant – Supplement to Response to Request for Additional Information (Entergy Ex. 463);
- V.C. Summer Nuclear Station, Units 2 and 3 COL Application Part 2, FSAR (Chapter 10) (Entergy Ex. 465);
- U.S. NRC letter regarding South Carolina Electric & Gas Co. response to request for additional information (Entergy Ex. 475);
- Technical Report: Operating Cooling Towers in Freezing Weather (Marley, April 2012) (Entergy Ex. 479);
- Cooling Technology Institute, *Common Industrial Cooling Tower Errors and*

Omissions, dated Feb. 2009 (Entergy Ex. 481);

- U.S. NRC: GEIS for Nuclear Plants (Entergy Ex. 486);
- Cooling Tower Institute, *Fill Fouling Control in Cooling Towers* (1998) (Entergy Ex. 532);
- SPX PowerPoint: Seawater Cooling Tower – District Cooling Symposium (Oct. 14, 2009) (Entergy Ex. 535).

END OF TESTIMONY

Exhibit A

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollutant Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc.'s Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

PREFILED TESTIMONY OF SAM BEAVER IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.

CLOSED CYCLE COOLING

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

By its attorneys,

Elise N. Zoli
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February 28, 2014

Table of Contents

I. INTRODUCTION

Q: Please state your name, current position, and business address.

A: My name is Sam Beaver. I am the Director of Project Management at Enercon Services, Inc. ("Enercon"), an engineering, environmental, and technical management services firm. My business address is 500 Townpark Lane, Kennesaw, Georgia 30144.

Q: Are you offering this testimony on behalf of Entergy in support of its application for renewal of State Pollutant Discharge Elimination System ("SPDES") Permit (DEC App. Nos. 3-5522-00011-00004 SPDES No. NY0004472) for Indian Point Units 2 and 3 and the corresponding issue in the associated Water Quality Certification ("WQC") proceeding, as it has been consolidated by this Tribunal (collectively, the "Proceedings")?

A: Yes. I am offering my testimony with respect to Issue for Adjudication No. 1 as it relates to the feasibility of constructing and operating closed-cycle cooling ("CCC") towers as proposed by NYSDEC Staff at Indian Point Energy Center ("IPEC"). I offer my expert testimony concerning whether NYSDEC Staff's proposed retrofits of Indian Point Units 2 and 3 with CCC towers can be constructed and operated efficiently and without material detriment impacts to the facilities' operation given the site specific constraints of IPEC.

Q: Have you previously submitted testimony in these Proceedings?

A: Yes. I previously submitted prefiled direct and rebuttal testimony in these Proceedings on July 22, 2011; September 30, 2011; May 30, 2012; June 29, 2012; May 31, 2013; and June 28, 2013. I testified in person before this Tribunal on October 17-18, 2011; August 1, 2012; and July 15-16, 2013.

Q: What is the purpose of this testimony?

A: This testimony describes the report prepared by Enercon entitled, *ENERCON Response to Tetra Tech's Indian Point Closed-Cycle Cooling System Retrofit Evaluation Report* ("2013 ENERCON CCC Response"), dated December 2013 (Entergy Ex. 296(A)), which is Appendix A to the TRC Environmental Corporation ("TRC") report entitled, *New York State Environmental Quality Review Act, Entergy Response Document to the Tetra Tech Report and the Powers Engineering Report* (Entergy Ex. 296). In addition, this testimony describes Enercon's report entitled, *Analysis of Closed-Loop Cooling Salinity Levels Indian Point Units 2 & 3*, with Appendices A-F, dated November 2010 (Entergy Ex. 310) ("Salinity Report"). I understand that the 2013 ENERCON CCC Response and the Salinity Report have been previously provided to the parties to the Proceedings, and I adopt both reports as part of my prefiled testimony.

Q: Please describe the purpose of the 2013 ENERCON CCC Response.

A: I understand that NYSDEC Staff has proposed the installation and operation of CCC as the best technology available to minimize adverse environmental impacts consistent with the requirements of 6 NYCRR § 704.5 and § 316(b) of the Clean Water Act. The purpose of the 2013 ENERCON CCC Response was to review the engineering feasibility of the CCC configurations selected by Tetra Tech in its report entitled, *Indian Point Closed-Cycle Cooling System Retrofit Evaluation*, dated June 2013 (the "Tetra Tech CCC Report"). The 2013 ENERCON CCC Response also assesses CCC proposals submitted by Powers Engineering on behalf of Riverkeeper, Inc., as presented in the *Revised Closed Cycle Cooling Feasibility Assessment for Indian Point Energy Center Unit 2 and Unit 3 for Best Technology Available Report*, dated October 24, 2012, and subsequently limited by the November 22, 2013 letter from Mark Lucas to ALJs Villa and O'Connell (the "Powers Report"). I understand that Riverkeeper has recently withdrawn the Powers Report and, in an email from Riverkeeper's counsel dated February 24 at 8:45 pm, declined to specify what CCC proposal it actually will be advancing. My testimony is therefore limited to addressing the Tetra Tech proposal. If Riverkeeper in fact advances some other CCC proposal, then to the extent necessary I will address such proposal in rebuttal.

Q: How did you go about preparing the 2013 ENERCON CCC Response?

A: I oversaw a team of engineers at Enercon that reviewed both reports submitted by NYSDEC Staff and Riverkeeper. The Enercon team consisted of twenty mechanical engineers, nuclear engineers, chemical engineers, civil engineers, and electrical engineers that were responsible for reviewing various aspects of each report within their specific area of expertise.

Under my supervision, the Enercon team conducted a thorough review of the reports submitted by NYSDEC Staff and Riverkeeper to determine whether those reports demonstrated the feasibility of retrofitting Unit 2 and Unit 3 with CCC and in addition, whether there existed any potential problems, errors, or omissions that (1) implicate essential equipment and/or nuclear station reliability; (2) represent high risk assumptions or unknowns; and (3) would significantly increase the estimated costs of construction or operation.

In addition to our in-house experts, Alden Research Laboratory ("Alden") was engaged by Entergy to conduct computational fluid dynamic ("CFD") modeling of Tetra Tech's proposed mechanical draft cooling towers and Burns and Roe Enterprises, Inc. ("Burns and Roe") was retained by Entergy to perform a review of the impacts of Tetra Tech's proposed cooling tower design on the Unit 2 and Unit 3 condensers.

II. SUMMARY OF TETRA TECH'S CCC CONFIGURATIONS

Q: Please describe the key elements of Tetra Tech's proposed conceptual design that were relevant to your review.

A: For its conceptual design, Tetra Tech has selected SPX ClearSky™ ("ClearSky") plume-abated cooling towers for use at IPEC based on the claim that the ClearSky cooling towers were the only practical alternative for a CCC-retrofit apart from circular hybrid cooling towers. *See* Tetra Tech CCC Report at 11. For each Unit, Tetra Tech has proposed that the towers would operate at a flow rate of 700,000 gallons per minute, a design wet-bulb temperature of 77°F, and an approach to wet-bulb temperature of 12°F. *See id.* at 13. Tetra Tech's cooling towers are configured "back-to-back," meaning that towers for each unit would be 2 cells wide and 22 cells long for a total of 44 cells per tower. *Id.* The overall dimensions of each tower block would be 1,408 ft x 151 ft (or approximately 5 acres). *Id.* The locations that Tetra Tech proposes to site the cooling towers would make the cooling water basins in the cooling towers 52.5 feet above mean sea level. *See id.* at 15. Finally, Tetra Tech assumes that the cooling towers would operate at three cycles of concentration, which means that the chemical or biological constituents in the Hudson River water will be raised to three times their initial levels in the close-cycle system, before being blown down or released from the tower. *See id.* at 13.

Q: What is a "design wet bulb temperature"?

A: The wet bulb temperature is a meteorological measurement which incorporates both moisture content and the temperature of the ambient air (referred to as the "dry bulb temperature"). Cooling tower performance depends on the wet bulb temperature of the air entering the cooling tower inlets because it determines the lowest temperature that the circulating water can be cooled using cooling towers, which reject heat through evaporation. When selecting cooling towers at a particular facility, the "design" wet bulb temperature should reflect the highest wet bulb temperature experienced in the area where the cooling towers will be sited allowing a small margin for infrequent exceedances (typically less than 1%).

Q: What is an "approach to wet bulb temperature"?

A: No cooling tower is capable of cooling water to the wet bulb temperature. Therefore, the approach to wet bulb temperature describes the number of degrees above the ambient wet bulb temperature by which the cooling tower can be expected to reduce the temperature of the cooling water after it passes through the condensers. It is a value based on the size and efficiency of the cooling towers and it represents the cooling ability of the towers. For example, Tetra Tech's selected cooling towers would be capable of cooling the CCC water to 89°F (77°F design wet bulb + 12°F approach) when the ambient wet bulb temperature at the cooling towers is 77°F. To understand how the approach temperature changes with changes to the wet bulb temperature, engineers use cooling tower performance curves. A single point is not adequate to determine the operational impacts of CCC over the entire range of expected wet bulb temperatures.

Q: How does the "approach to wet bulb temperature" affect cooling tower design?

A: There is an inherent trade-off between the size of a cooling tower and its ability to cool the circulating water. Increasing the approach to wet bulb temperature decreases the cooling tower size, but results in greater circulating water temperatures. Power plants operate less efficiently—that is, it will detrimentally affect power plant performance—when the temperature of the circulating water is increased, and indeed may result in a plant shut down if the temperatures exceed the condenser's operational limits.

III. <u>ENERCON RESPONSE TO TETRA TECH'S CCC REPORT</u>

Q: What conclusion, if any, did Enercon reach in its review of Tetra Tech's CCC Report?

A: There are two primary conclusions that Enercon reached after its review of the Tetra Tech CCC Report and which are discussed in detail in the 2013 ENERCON CCC Response. First, based on my and my team's experience and best professional judgment, NYSDEC Staff's proposed configuration for a CCC retrofit at IPEC as presented by Tetra Tech <u>cannot</u> be considered feasible. In particular, it is my opinion that NYSDEC Staff's proposed cooling towers cannot be installed and function efficiently within the operating constraints of IPEC. Second, at a minimum, Tetra Tech's CCC Report does not contain fundamental design detail that demonstrates that CCC are feasible at IPEC.

Q: What is your understanding of what it means for a technology to be feasible?

A: A technology is feasible where it can be installed and operated at a particular site, based on the relevant considerations at that site, with a reasonable level of engineering certainty.

Q: Please summarize the reasons for your conclusion that NYSDEC Staff's CCC proposal cannot be considered feasible at IPEC.

A: As set forth in the 2013 ENERCON CCC Response, there are three primary reasons Tetra Tech's proposal cannot be considered feasible from an engineering perspective.

First, ClearSky cooling towers are not a demonstrated, available technology for a large baseload nuclear power plant such as IPEC because there is inadequate design, construction, and operational history for ClearSky towers—measured both in the total number of installations of ClearSky towers and the diversity among the limited installations that do exist—to conclude they would be viable with a reasonable level of confidence. No nuclear stations designed solely for once-through cooling have been converted to closed-loop cooling, let alone converted using ClearSky cooling towers. In fact, there is only one very small ClearSky installation with any measurable operational experience (five years)—a one test cell cooling tower in New Mexico. Nowhere does Tetra Tech provide any operational history for that test cell operating in the New Mexico desert. After the submission of the 2013 ENERCON CCC Report three additional ClearSky cells became operational, two at a biomass facility in Wisconsin and one "demo" tower in South Korea. There are no ClearSky cooling towers operating at a nuclear power plant, and all three of the ClearSky configurations—in New Mexico, Wisconsin, and South Korea—are for in-line ClearSky cooling towers, not the back-to-back configurations selected by Tetra Tech for use at Units 2 and 3. Given the absence of any practical history of CCC retrofits at nuclear facilities using ClearSky cooling towers, engineering observations and conclusions regarding any such conversion are purely speculative and inherently subject to unforeseen challenges during the detailed design phase and the subsequent implementation. Indeed, the lack of installation and operational history presents a large potential risk, and under these circumstances, should have eliminated ClearSky cooling towers from serious consideration. Adding to the inherent risk of the ClearSky towers is the fact that they are only available in fiberglass and are therefore (1) susceptible to fire damage and (2) not necessarily designed to withstand the wind loading requirements at a nuclear facility like IPEC.

Second, there are several construction and siting issues that were not addressed by Tetra Tech. Most notably, there are existing, essential plant components and structures already located where Tetra Tech proposes siting the cooling towers. Among the structures and components that would need to be relocated are the Algonquin Natural Gas Pipeline, which is displaced by the proposed Unit 3 cooling tower; components containing radionuclides (in the form of spent nuclear fuel and low level radionuclide material); high voltage power transmission lines; and various security towers, fencing and facilities. In fact, with respect to radionuclide management, Tetra Tech acknowledged, "[i]f an acceptable method cannot be identified, construction and excavation could not proceed in this area, where the CT2 [Unit 2 cooling tower] pipe corridor would be sited. In this case, the proposed Unit 2 retrofit would be infeasible." *See* Tetra Tech CCC Report at 28. As set forth in the 2013 ENERCON CCC Response, many of the structures that would need to be relocated are currently relied upon for safe, secure and efficient power generation at IPEC. Taken together, the essential structures and components that are impacted by the Tetra Tech configuration represent major detrimental impacts to the IPEC site and raise serious concerns about the plant's ability to generate power in a safe and efficient manner. Further, the overall cost and schedule impacts of relocating these essential structures was not addressed by Tetra Tech, hence making its report substantially lacking relative to overall impacts of the proposed conversion.

Third, operation of Tetra Tech's ClearSky cooling towers would have a detrimental impact on plant operations. Tetra Tech's proposed ClearSky towers will discharge saturated salt-laden mist that will be concentrated and localized at ground levels rather than discharged and dispersed higher in the atmosphere, as is the case with round hybrid cooling towers. This will lead to increased salt deposition and moisture on the power blocks and electrical transmission facilities, creating a known risk of electrical arcing (discharging of current through the air) in the switchyard. The risk of electrical arcing is a workplace safety hazard, and may lead to a shutdown of the nuclear reactor via a reactor scram, which is the sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods. Unplanned reactor scrams upset plant stability and challenge critical safety functions during power operations. In addition, the plume from Tetra Tech's proposed ClearSky tower configuration would have an adverse impact on the electrical switchyard, heating/ventilation/air conditioning (HVAC) systems, and major outdoor equipment at IPEC that creates operability concerns. Finally, the low level plume would create significant recirculation of the saturated air which would increase operational power losses. In fact, operational and parasitic power losses combined due to the ClearSky CCC conversion represent as much as a 6% reduction in IPEC's net power output.

Q: Please summarize the basis for your conclusion that the Tetra Tech CCC Report did not demonstrate the feasibility of CCC at IPEC.

A: In addition to the known problems and risks associated with Tetra Tech's ClearSky proposal described above, important detail is missing from the Tetra Tech CCC Report, without which Tetra Tech's proposal cannot be considered feasible. Indeed, the missing information creates considerable uncertainty and raises fundamental reliability concerns that are unacceptable for any large-scale construction project in the nuclear industry. For example, the Tetra Tech CCC Report acknowledges that "[a] massive volume of blasting spoils, approximately 2 million cubic yards, will need to be removed from the site" over the course of a "3 to 4 year blasting and excavation period." *See* Tetra Tech CCC Report at 33. The Tetra Tech CCC Report, however, did not include any blasting plans for rock excavation, a detailed construction schedule, or a sufficiently robust assessment of expected plant impacts associated with such blasting and excavation. And, although Tetra Tech acknowledged that the Algonquin Pipeline would need to be relocated before blasting could begin for the Unit 3 tower, it did not identify how or where to relocate the pipeline. Without resolving this siting conflict, Tetra Tech's proposed location for the Unit 3 cooling towers cannot be considered feasible.

In addition, Tetra Tech failed to perform any transient or accident analysis for IPEC post-CCC retrofit. A review of the transient and accident analysis is necessary for any significant plant change to ensure that there are no potential impacts to the operation of any nuclear power plant. In fact, as set forth in 2013 ENERCON CCC Response, Burns and Roe identified and analyzed one transient condition—high pressure steam dump (50% load rejection) at Unit 3—that would exceed the condenser's operational limits and would require either additional ClearSky cells or other substantial means to reject additional heat load. The transient condition analyzed by Burns and Roe is just one of several transient conditions that must be evaluated prior to reaching a feasibility determination. Without identifying and resolving potential transient and accident conditions, the feasibility and operability of the Tetra Tech's CCC configuration has not been demonstrated.

Further, Tetra Tech did not provide basic details needed to validate whether its assumptions about the number of cells and size of its proposed cooling towers are valid. Most notably, Tetra Tech did not identify the type of fill material and/or address fill degradation impacts over time for the proposed ClearSky towers. "Fill" is installed into the cooling towers themselves and is used to increase the surface area and the contact time between the heated water and the cooling air. In other words, fill is the medium that facilitates and determines the heat transfer from the towers, and the selection and identification of the proper fill is one of the most critical components in any cooling tower design. In addition, the fill selected by Tetra Tech may be susceptible to fouling, which will degrade cooling tower performance and potentially jeopardize the structural integrity of the cooling towers. The potential for fill fouling is a particular concern with Tetra Tech's proposal because, as I stated above, it proposes to operate the cooling towers at three (3) cycles of concentration, which means that the level of total dissolved solids ("TDS") in the cooling water will be three times as high as the level in the Hudson River, thereby increasing the risk for fouling and operational impacts. Without a cooling tower fill selection, it is simply not possible to determine if the cooling towers proposed by Tetra Tech are feasible for continuous operation at IPEC or if the size, performance, cost and schedule information for the cooling towers is appropriate.

Finally, there is the potential for detrimental operational impacts on the plant that were not adequately analyzed by Tetra Tech. Tetra Tech's report did not include any Performance Evaluation of Power System Efficiency (PEPSE) model results or Seasonal Annual Cooling Tower Impact (SACTI) model results. PEPSE is the industry standard heat balancing and hydraulic modeling software used at nuclear power plants to evaluate potential operational impacts associated with changes to the design of the plant. SACTI is a modeling software used to model where the cooling tower plume migrates after being exhausted from the towers and therefore allows better understanding of the operational impacts of that moist, hot plume. While other models can be employed, Tetra Tech used no modeling to establish the scope and scale of operational impacts, a real concern—particularly at a nuclear facility—that must be addressed before feasibility can be determined. Moreover, with respect to Tetra Tech's claim that the ClearSky towers are "plume abated," ClearSky towers rely on novel and proprietary PVC heat exchanger packs to re-condense moisture that would otherwise exit in the exhaust. Tetra Tech failed to provide any information regarding the tower's heat exchangers or associated maintenance history, and no corroborating information has been provided that such plume-abatement technology would be an appropriate choice at IPEC.

IV. SALINITY REPORT AND CONCLUSIONS

Q: Please describe the purpose of the Salinity Report.

A: Generally speaking, the purpose of the Salinity Report was to evaluate how the salt content of the Hudson River at IPEC would lead to exceedances of applicable air quality limits based on the operation of the circular hybrid mechanical draft cooling tower arrangement discussed in the reports entitled, *Economic and Environmental Impacts Associated with Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration*, dated June 2003 (Entergy Ex. 7A) and *Engineering Feasibility and Costs of Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration,* dated February 12, 2010 (Entergy Ex. 7). I understand that no party to the Proceedings is advancing the circular hybrid mechanical draft cooling towers discussed in those reports. However, because no air quality impact analysis has been conducted by Tetra Tech or provided by NYSDEC Staff, here I summarize the conclusions in the Salinity Report that Enercon drew with respect the site-specific barriers to large-scale CCC conversion at IPEC based on the relevant, available information concerning the salinity of the Hudson River.

Q: Why would the salt content of the Hudson River affect cooling tower performance at IPEC?

A: Although conversion of Unit 2 and Unit 3 to CCC would reduce the water intake currently required by the facilities, a continuous supply of water would still need to be withdrawn from the Hudson River for CCC makeup and blowdown requirements. I understand from Theodore Main at TRC that the salinity of the makeup water in a CCC system is a primary contributing factor to air emissions, which can lead to violations of national ambient air quality standards ("NAAQS") and Significant Impact Levels ("SIL"). In addition, the manufacturer of the cooling towers evaluated in Enercon's 2010 CCC report, SPX, recommends that the TDS (i.e., salt) concentration remain below 5000 ppm, and notes that concentrations above those levels can affect thermal performance of the cooling towers. *See* Entergy Ex. 310 at 52.

Q: How was the concentration of salt in the Hudson River in the vicinity of IPEC calculated in the Salinity Report?

A: As set forth in Appendix F to the Salinity Report, Applied Science Associates, Inc. (now RPS ASA) ("ASA/RPS") provided a long-term data set of Hudson River salinity in the vicinity of IPEC based upon 10 years of modeled Hudson River salinity data for the period 2000 – 2009 in one hour increments. Because direct measurements of salinity at IPEC are not made, ASA/RPS developed a statistical analysis of data collected every 15 minutes by the U.S. Geological Survey (USGS) at three locations: Hastings-on-Hudson, Tomkins Cove, and West Point. The Hastings station is located 21 miles downstream of IPEC and has been continuously operating since 1992. The West Point station is located 9 miles upstream of IPEC and has been operating since 1991. The Tomkins station was located 1 mile downstream of IPEC, but was discontinued in 2001. Based on that statistical analysis, a decadal (2000-2009) salinity time series at IPEC (which was assumed to be equivalent to that at Tomkins) was generated to provide a long-term estimate of salinity under a variety of environmental conditions.

Q: What did Enercon do with the results from ASA/RPS's salinity analysis?

A: First, Enercon determined that the most practical flow scenario for CCC would utilize 1.5 cycles of concentration (not the three cycles of concentration selected by Tetra Tech). Second, TRC calculated the maximum salt concentration of CCC water that would allow cooling tower emissions at a drift rate of 0.001% to not violate PM_{10} and $PM_{2.5}$ NAAQS and SILs. Enercon then used the information provided by ASA/RPS and TRC to determine whether CCC could be operated in a manner to keep the concentration of salinity in the cooling water below the thresholds identified by TRC.

Q: Briefly summarize the conclusions of the Salinity Report.

A: Based on the salinity information provided by ASA/RPS and the emissions limits provided by TRC, CCC cannot be operated year round at IPEC without violating air emission limitations. For purposes of our analysis, we assumed that it would be feasible to revert from closed-loop to once-through operation when salinity levels would lead to air quality exceedances and that such a determination could be made on a weekly basis—although the Tetra Tech CCC Report does not contemplate that type of switch-over mechanism and a weekly switch-over would be impractical for actual station operation based on input from Entergy. Nevertheless, and with those assumptions, the Salinity Report concluded that in order to avoid exceeding the $PM_{2.5}$ NAAQS and $PM_{2.5}$ SIL, operation of closed-loop cooling would be expected to occur no more than 43% and 13% of the year, respectively. Although it would be operationally and economically infeasible to run a nuclear facility under such restrictions, Dr. Young has used this information to update the estimated reductions in entrainment and impingement losses that would be achievable under these scenarios, provided as Appendix D to the Salinity Report.

V. QUALIFICATIONS AND SUFFICIENCY OF METHODS, DATA AND CONCLUSIONS

Q: Please describe your educational and professional qualifications, including relevant professional activities.

A: I previously described my academic background, relevant specializations and work experience in prefiled direct testimony that I have submitted in these Proceedings during administrative hearings in Albany, New York on October 17, 2011. I refer to and incorporate that testimony by reference in this prefiled testimony. In addition, I have previously provided a copy of my curriculum vitae (Entergy Ex. 49).

Q: In your professional opinion, did Enercon's review of Tetra Tech's proposed CCC configuration reliably apply procedures and methodologies generally

accepted in the engineering community concerned with evaluating the ability to successfully install and operate a technology?

A: Yes, the engineering review performed by Enercon of Tetra Tech's proposal was no different than numerous other engineering reviews Enercon has performed for nuclear facilities in the past.

Q: In your professional opinion, did the Salinity Report reliably apply scientifically accepted principles to estimate CCC operational limitations due to air quality exceedances based on the salinity of the Hudson River?

A: Yes, as is typical in engineering projects, the Salinity Report relies on input from specialized experts—TRC (air quality and regulations), ASA/RPS (salinity in the Hudson River) and Enercon (operation of CCC)—to reach a conclusion concerning the limitations with operating CCC due to Hudson River salinity and air quality regulations.

Q: In your professional opinion, did the Salinity Report have sufficient data to reach reliable and scientifically sound conclusions to estimate CCC operational limitations due to air quality exceedances based on the salinity of the Hudson River?

A: Yes.

Q: Do you hold your opinions to a reasonable degree of engineering certainty?

A: Yes.

END OF TESTIMONY

Exhibit B

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollutant Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc.'s Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

PREFILED REBUTTAL TESTIMONY OF SAM BEAVER IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.

CLOSED CYCLE COOLING

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

By its attorneys,

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March 28, 2014

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I. INTRODUCTION

Q: Please state your name, current position, and business address.

A: My name is Sam Beaver. I am the Director of Project Management at Enercon Services, Inc. ("Enercon"), an engineering, environmental, and technical management services firm. My business address is 500 Townpark Lane, Kennesaw, Georgia 30144.

Q: Are you the same Sam Beaver who provided prefiled direct testimony on February 28, 2014 on behalf of Entergy in support of its application for renewal of State Pollutant Discharge Elimination System ("SPDES") Permit (DEC App. Nos. 3-5522-00011-00004 SPDES No. NY0004472) for Indian Point Units 2 and 3 and the corresponding issue in the associated Water Quality Certification ("WQC") proceeding, as it has been consolidated by this Tribunal (collectively, the "Proceedings")?

A: Yes.

Q: Please state the purpose of your prefiled rebuttal testimony.

A: The purpose of my prefiled rebuttal testimony is to address certain portions of the prefiled direct testimony of Eduardo Ortiz (Hatch) ("Ortiz Direct"), Tim Havey (Tetra Tech) ("Havey Direct"), and William Charles Nieder (NYSDEC Staff) ("Nieder Direct"). Specifically, my rebuttal testimony responds to the prefiled direct testimony of Mr. Ortiz and Mr. Havey that relates to the engineering feasibility of retrofitting either or both Indian Point Energy Center, Unit 2 and Unit 3 (collectively, "IPEC"), with eighty-eight (88) back-to-back ClearSky cooling towers, forty-four (44) cells at each of Unit 2 and Unit 3, as described in the report prepared by Tetra Tech entitled *Indian Point Closed-*

Cycle Cooling System Retrofit Evaluation, dated June 2013 (the "Tetra Tech CCC Report"); and two (2) round hybrid cooling towers, one at Unit 2 and Unit 3 respectively, as described in the initial report prepared by Enercon entitled, *Economic and Environmental Impacts Associated with Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration*, dated June 2003 (Entergy Ex. 7A) ("ENERCON 2003") and as more intensively reviewed in the report entitled *Engineering Feasibility and Costs of Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration*, dated February 12, 2010 (Entergy Ex. 7) ("ENERCON 2010"; collectively, the "ENERCON Closed-Loop Cooling Reports"). My rebuttal testimony also responds to the portion of Mr. Nieder's testimony that discusses the expected operational and maintenance ("O&M") costs of Entergy's cylindrical wedgewire screen ("CWWS") proposal. I have reviewed the prefiled direct testimony of each of these individuals, as well as the identified materials on which each of these individuals relies (to the extent it was provided).

Q: How is your rebuttal testimony organized?

A: First, I provide some general background and context about how engineers address feasibility questions at nuclear power plants, and how this context relates to my conclusions regarding the inherent challenges to the feasibility of retrofitting Unit 2 and Unit 3 with a closed-cycle cooling system during the license renewal period. Second, I address specific statements in Messrs. Ortiz and Havey's testimony concerning the feasibility of Tetra Tech's ClearSky cooling tower configuration, with a focus on misimpressions and errors in that testimony and therefore their respective conclusions. Third, I address Messrs. Ortiz and Havey's testimony as it relates to the feasibility of retrofitting IPEC with round hybrid cooling towers, with the same focus. Finally, I respond to Mr. Nieder's argument that O&M costs for Entergy's proposed array of CWWS are likely to be significant.

II. BACKGROUND AND CONTEXT FOR RETROFITTING IPEC WITH CLOSED-CYCLE COOLING

Q: Please describe what engineering feasibility means in the context of retrofitting a nuclear power plant with a new cooling water system?

A: The "feasibility" of retrofitting power plants with a new cooling water system depends on two related considerations. First, the *technology* that is chosen for the retrofit must be available. As I testified in October 2011, "availability" means that technology is used in the industry for which it is intended on a regular basis, with an adequate design, construction and operational history to allow an engineering assessment with a reasonable level of confidence. The second consideration is whether an otherwise "available" technology can be installed and operated at a particular site, based on the relevant considerations at that site, with a reasonable level of engineering certainty.

The need for a reasonable level of engineering certainty is particularly acute in the nuclear industry for two reasons. First, nuclear powered electric generating power plants—as baseload suppliers—are designed to operate (to produce power in the form of electricity) on a consistent, reliable basis. Second, the regulatory structure for nuclear power plants and the safety consciousness of nuclear engineers and operators place a high priority on consistent operations in accordance with design parameters. Excursions (that is, atypical operations), including conditions that may increase the likelihood of excursions, are strongly disfavored by NRC and plant personnel alike. This has two direct implications for the major retrofit proposed by NYSDEC Staff for IPEC: (1) relevant, demonstrated operational experience in a comparable dynamic is typically necessary for a technology to be installed, particularly major equipment essential for plant operation; and (2) actual retrofitting history is preferred before reaching an "engineering feasibility" conclusion. At nuclear power plants, novel and unproven technologies are generally not considered available.

As it is relevant to this phase of the Proceedings, to reach a conclusion about the engineering feasibility of retrofitting IPEC with closed-cycle cooling, an engineer with nuclear design and operational experience would have to conclude that it is likely that the retrofit can be completed and function without major adverse impacts within the remaining plant operational period (that is, the twenty-year license renewal period). If, for instance, it is reasonably foreseeable that construction will not be completed in a timeframe to allow operation of the equipment for a substantial period of time before the end (respectively, in 2033 and 2035) of the license renewal period; that construction will result in unit shut-downs of substantial duration; that operation will result in measurable and significant power losses; or that there is a heightened risk of incidence of excursions, then an experienced nuclear engineer would not consider the closed-cycle cooling retrofit to be a practically feasible.

Q: To understand the implications of an engineering feasibility determination for retrofitting IPEC with cooling towers, is it helpful to understand the physical constraints of the IPEC site?

A: Yes. Background information is essential to understanding how disruptive and intrusive it would be to retrofit the existing IPEC stations.

Both IPEC Units sit on a combined 239 acres, which represents one of the most site-constrained nuclear power plants that I have worked on in my over thirty years of experience. The site topography is challenging, spanning an elevation from the River up to approximately 150 feet. As a result of the topography challenges and the substantial subsurface rock shelf that rises beneath and behind the Stations, within the 239 acre site only 128 acres is readily usable for major structures, and that area already has been developed. Further, all major structures and equipment representing the main power block are contained in a central area of approximately 25 acres located along the Riverfront. Because the two operating unit and one shut down unit share the Riverfront area and given the number of plant systems located in this area, there is a very high density of equipment and structures in this defined area – in fact, the density is visible to even the casual observer. Entergy Ex. 351 is a recent aerial photograph of the IPEC site. The Unit 2 and Unit 3 containment buildings are the two tallest domed structures, with their respective power house unit immediately in front of (closest to the River) the containment buildings. Unit 1 is the shorter domed-building between Unit 2 and Unit 3. What is not visible, but is as important, is the substantial underground network of major piping, ranging up to 8-feet in diameter, as well as numerous cabling duct banks and conduits, that runs throughout the Riverfront area. What this means is that the addition at IPEC of any new large-scale structures, particularly those involving the addition of new underground piping, is a challenge from the outset. As a result, any comparisons to "greenfield" design and construction projects for similar components (i.e., usage of cooling towers for new nuclear units currently under construction) would be inappropriate and misleading from an engineering perspective.

In fact, even Tetra Tech has recognized the "important role" the size of the property plays in determining whether a retrofit to cooling towers is feasible. *See* Memorandum from Kelly Meadows, Tetra Tech to Paul Shriner, EPA, dated Feb. 28, 2011, at 1 (Entergy Ex. 356). In a memorandum from Tetra Tech to EPA, dated February 28, 2011, Tetra Tech documented the approximately 73 sites visited by EPA in 2011 as part of the proposed § 316(b) rulemaking. Tetra Tech noted that facilities that have a ratio of 160 acres per 1,000 MWs "should have ample space to construct retrofit cooling towers." *Id.* at 1-2. Here, assuming all of IPEC's 239 acres is available for a retrofit, IPEC's "ratio" is 110 acres per 1000 MW, which by EPA's and Tetra Tech's own definition would make it among the most space-constrained site visited by in the Tetra Tech review. As stated above, only 128 acres of the IPEC site is readily useable for major structures, making the site even more constrained in Tetra Tech's terms further lowering the sites effective acreage. *See id.* at 3 (discussing the "effective acreage" of the McDonough Power Plant).

Q: Is there any additional background information that informs your analysis of the feasibility of retrofitting IPEC with closed-cycle cooling?

A: Yes. It is also essential to consider the way nuclear units, such as IPEC, are designed and operated. Nuclear power plants, like IPEC, generate electricity through the use of two major categories of systems which convert heat generated in the reactor core into electrical power for commercial use: (1) a closed, pressurized "Reactor Coolant System" (primary systems), (2) and a "Steam and Power Conversion System" (secondary systems). Figure 1.1 in Entergy Exhibit 7 (pg. 2) depicts the basic configuration of IPEC-type pressurized water reactors. In the primary system, reactor coolant is heated by nuclear fission in the reactor. The thermal energy generated in the reactor core is then transferred to steam generators where steam is generated in the secondary system and utilized to drive the turbine generator, where it is converted into electricity. The primary and secondary systems are physically separated in the steam generator, minimizing radioisotope transfer to the secondary system.

At IPEC, each unit has a multistage turbine comprised of one high-pressure turbine and three low-pressure turbines. After passing through the turbines, the steam passes to the main condenser to allow it to be cooled and condensed back into feedwater that can be pumped back through the steam-generators in what is effectively a closed loop system.

Importantly, the Unit 2 and Unit 3 main condensers are operated in a vacuum in order to optimize plant performance by facilitating the flow of steam through the low-pressure turbines. Even a slight increase in pressure in the condensers, referred to as condenser "backpressure," can have an appreciable impact on the efficiency of the plant and, in some instances, lead to excursions or forced plant shutdowns.

Q: How do the Unit 2 and Unit 3 condensers convert the steam exhaust back into feedwater?

A: The purpose of the main condenser is to absorb heat contained in the expanded exhaust steam after exiting the low pressure turbines. Cold circulating water flows through the condenser tubes to condense the steam back into water. Unit 2 and Unit 3 were designed and constructed with a once-through circulating water system, and reflect a highly specialized design analysis, a "heat balance" that accounted for the qualities of the existing cooling water source, here the Hudson River, to accommodate the heat rejection of the main steam system for each Unit. In other words, the turbines and condenser design rely on the low-temperature of the River water, as does efficient performance of the plant. The design rate for each Unit's circulating water system is 840,000 gallons per minute ("gpm"). For obvious reasons, the IPEC condenser cooling systems are essential plant equipment. As I stated in my previous prefiled testimony, dated July 22, 2011, which I fully incorporate by reference here, and by way of analogy, if the reactor is the heart of IPEC, then the cooling system is its lungs—providing the necessary cooling for the system to function properly.

Given that IPEC's condensers and turbines were specifically designed and constructed as a once-through cooling system utilizing cold River water, ***any*** retrofit of IPEC to a closed-loop cooling system that results in higher circulating water temperatures and/or lower flows will result in inherent impacts to the plant. Here, it is unavoidable that a shift to closed-cycle cooling will result in higher circulating water temperatures and lower flows that challenge plant performance and operations. For this reason, any proposal for closed-cycle cooling must rely on the requisite heat balance analysis to demonstrate that performance and operational impacts are known, manageable and not too significant. The twin dynamic of higher circulating water temperature and lower flows (as discussed below) represents a particular challenge to Station performance and functionality.

Q: What are the inherent impacts with retrofitting IPEC to a closed-cycle cooling system?

A: Retrofitting a nuclear plant constructed in the 1970s with a once-through cooling system to a closed-cycle cooling system will impact virtually every aspect of IPEC's circulating water system. First, less water will be available to run through the condensers. The design of both the ClearSky and round hybrid towers decrease the maximum available circulating water from 840,000 gpm to 700,000 gpm—a 16.7% reduction. Second, the temperature of the circulating water entering the condensers to cool the steam will be higher at the most critical times, namely during the summer when cooling need is the greatest. The reduction in water and increase in circulating water inlet temperatures increase condenser back pressure of both Unit 2 and Unit 3. *See* Entergy Ex. 7A at 20 (Figure 3.2 and 3.3). Third, the water pressure in the condenser tubing will be measurably higher in a closed-cycle cooling configuration as compared to the existing once-through cooling system. This is a particular concern with the Tetra Tech proposal which, while within the technical design limits for the condenser, calls for the circulating water to be at a materially higher pressure than the Stations have ever operated under, which introduces additional uncertainty in plant operations and equipment service life.

Finally, closed-cycle cooling creates significant and costly parasitic losses that further affect the ability of the plant to generate power efficiently. These losses are attributable to the extra energy required to pump the circulating water to the elevated cooling towers and operate the fans in the cooling towers themselves.

Q: **Please briefly summarize what would be required in order to retrofit IPEC with closed-cycle cooling.**

A: In addition to the construction of the cooling towers themselves and the extensive piping that would be needed to supply and return circulating water to and from those towers, retrofitting IPEC to closed-cycle cooling will require reconfiguring the current circulating water system to hold the considerable volume of water necessary to ensure reliable operation of the cooling towers. In the current once-through configuration, after the circulating water passes through the condensers, it is discharged into a canal that runs along the shoreline in front of the Unit 2 and Unit 3 power houses, eventually joining the River on south end of the facility. The discharge canal extends from the Unit 2 power house, where circulating water from the Unit 2 condenser and Unit 2 service water is discharged. The Unit 2 discharged water flows past Unit 3 where the Unit 3 service and circulating water is discharged, and the combined flow is returned to the River.

In order to retrofit IPEC to a closed-cycle cooling configuration and to hold sufficient water to meet the Unit's combined flow rate of 1.4 million gpm (assuming 700,000 gpm per Unit) of circulating water, the existing discharge canal must be converted into a hot water reservoir that can hold approximately 10.7 million gallons of water. *See* Entergy Ex. 7 at 12. After modification, the Unit 2 and Unit 3 reservoirs would hold over 4.2 million and 6.5 million gallons of circulating water, respectively. *Id.* The makeup water source for the hot water reservoir is the service water discharge, with Unit 2's service water discharged into the Unit 2 reservoir, and Unit 3's service water discharged into the Unit 3 reservoir. New circulating water pumps would be installed in each reservoir that would pump the hot water from each reservoir to its respective cooling tower. To accommodate the additional capacity and to meet the new circulating pump submergence requirements, the current discharge canal in front of Units 2 and 3 will need to be excavated. The excavation and construction of the new reservoirs requires a 42 week concurrent construction outage for both IPEC units. As Tetra Tech acknowledged in its July 6, 2010 memorandum, "[t]he obstacles presented by reconfiguring the existing discharge canal to function as a main component of the new cooling system are correctly cited by Enercon as unavoidable. There do not appear to be any practical means to significantly decrease this estimate." Memorandum from Tim Havey, Tetra Tech, Inc. to Chuck Nieder and Chris

Hogan, NYS Department of Environmental Conservation, dated July 6, 2010, at 3 (Staff Ex. 214, Appendix B).

As noted above, the discharge canal is also used by the service water system, which serves a nuclear safety function, and which cannot be impacted by the proposed retrofit. Because the design utilizes services water to provide cooling tower makeup at IPEC, and the combined service water discharge will likely exceed the cooling towers' make-up water needs, the reservoir weirs will facilitate the overflow of excess water (that is, water not pumped to the cooling towers) back to the River. The excess water that overflows the Unit 2 and Unit 3 reservoirs is in essence the cooling tower "blowdown," which is the intentional release of circulating water used to control the cycles of concentration of the system (i.e., the number of times suspended and dissolved sediment are concentrated above ambient River levels). Thus, when the service water discharge exceeds the makeup needs of the closed-cycle system, water will overflow from the reservoirs, which will represent the blowdown of the system. For both the round hybrid towers and Tetra Tech's ClearSky towers, there is no method by which the blowdown rate (or content of the blowdown) can be controlled. I understand that Tetra Tech has also included additional piping that will siphon cooling water from the pipes running from the cooling towers to the condensers and discharge it in the discharge canal beyond the Unit 3 weir.

Q: Are there any examples of operating nuclear power plants that were designed for once-through cooling that were retrofitted as a closed-cycle cooling?

A: No. No nuclear power plant that has been designed, constructed, and operated with a once-through cooling system has ever been retrofitted into a closed-loop cooling system. While certain individuals may occasionally reference Palisades Nuclear Power Plant as a "retrofit," as Tetra Tech explains in its November 18, 2009 memorandum on page 5, the so-called retrofit was "planned and completed before initial operation." *See* Memorandum from Tim Havey, Tetra Tech, Inc. to Chris Hogan, NYS Department of Environmental Conservation, dated Nov. 18, 2009 at 5 (Staff Ex. 214, Appendix B). The importance of the absence of any successful conversion from once-through to closed-cycle cooling to a feasibility assessment cannot be overstated. Unless a given unit's condenser is specifically designed to utilize cooling water temperatures as provided by cooling towers, there will be a compromise in unit operating efficiency and hence performance. The complete absence of any practical history of closed-loop cooling retrofits at nuclear facilities and the associated impacts on the circulating water system and condensers renders such a project subject to an unacceptably high degree of uncertainty.

III. <u>REBUTTAL TO NYSDEC'S TESTIMONY CONCERNING THE FEASIBILITY OF RETROFITTING IPEC WITH CLEARSKY COOLING TOWERS</u>

Q: With that background, let us now discuss some of the specific challenges to the Tetra Tech ClearSky cooling tower configuration discussed by Messrs. Havey and Ortiz in their prefiled direct testimony. First, did Messrs. Havey and Ortiz offer any opinion(s) concerning the feasibility of retrofitting IPEC Units 2 and 3 with ClearSky cooling towers?

A: Yes. Mr. Havey testified that Tetra Tech's proposal to retrofit IPEC Units 2 and 3 with 44 ClearSky plume-abated cooling towers is a "***practical*** alternative for a closed-cycle cooling retrofit at IPEC apart from the circular hybrid cooling towers initially proposed by Enercon." Havey Direct at p. 13, l. 9-13 (emphasis added). Mr. Ortiz similarly testifies that "[b]ased on a preliminary review, and subject to the limitations previously stated, the installation of a closed loop system was determined to be technically feasible," Ortiz Direct at p. 6, l. 17-19, and "[b]ased on the conclusions of the Hatch 2012 Report and subject to the limitations previously outlined, no major issues or deficiencies were identified by Hatch with respect to the technical feasibility of transferring from a once-through cooling system to a closed loop cooling system using the ClearSky™ cooling tower system." *Id.* at p. 8, l. 21 – p. 9, l. 2.

Q: Do you agree with Mr. Havey that Tetra Tech's ClearSky cooling towers are a "practical alternative" at IPEC?

A: No. Mr. Havey is not an engineer, and it does not appear that he has any relevant engineering experience with large-scale modifications to power plants, let alone nuclear power plants. His degree is in environmental science and public policy and it appears the extent of his relevant experience consists of performing reviews of similar "feasibility analys[e]s" in California. To an engineer, there is nothing "practical" about retrofitting a forty-year-old baseload nuclear power plant on a constrained site with challenging topography with closed-cycle cooling. As I testified above, no nuclear facility originally designed for and operated with once-through cooling has been retrofitted with a closed-loop cooling system. Here, Unit 2 and Unit 3 were both designed and constructed in the mid-1970s with turbines and condensers that were specifically designed for cold Hudson River water that cannot be replicated with closed-cycle cooling under maximum thermal load conditions.

Even more problematically, Tetra Tech has selected novel and unproven ClearSky cooling towers as the centerpiece of its proposed retrofit. Mr. Havey provides no performance data from the test cell that has operated approximately seven (7) years in the New Mexico desert at the San Juan Generating Station. In fact, the only study of ClearSky cooling towers is from a Department of Energy ("DOE") grant for that single test cell, and even the DOE recognized, in 2009, the unproven nature of the technology. At the time, the towers were referred to as Air2Air®:

> SPX Cooling Technologies is ***presently investigating*** the Air2Air® for evaporative cooling towers (Figure 1) under the U.S. Department of Energy (DOE) Grant No. DE-FC26-06NT42725. The ***preliminary findings*** from the research are encouraging in that the basic principles behind the technology are sound and the water savings are substantial. However, in the course of executing this project, ***construction costs of the validation cell (Figure 2) exceeded expectations. To be economically viable, more research is required to develop an efficient heat transfer***

> ***pack and redesign the overall geometry of the tower including pack orientation and superstructure.***

U.S. Dept. of Energy, *Improvement to Air2Air® Technology to Reduce Fresh-Water Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants, ProMIS/Project No.: DE-NT0005647* (Jan. 2009) (Entergy Ex. 357) (emphasis added). As evident from the title of the study, the experimental ClearSky technology originally had a specific focus which was to promote cooling tower applications in arid areas via reduction of fresh water evaporative cooling loss, which is largely irrelevant to the IPEC application.

Accordingly, SPX undertook a second study under a DOE grant award from October 1, 2008 through December 31, 2011 with the objective to "further enable Air2Air® becoming a commercially viable water savings and plume abatement technology by researching a re-engineered pack, testing improvement provided by modification, and prototyping the pack manufacture to improve pack economy, as it relates to superstructure volume, cost, pack orientation, and ducting details." *See* Final Report, Improvement to Air2Air™ Technology to Reduce Fresh-Water Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants (June 30, 2012) (Entergy Ex. 359) at 5. The final report, dated June 30, 2012, detailed SPX's efforts under the research grant to "prototype" and "adjust our design and propose new experiments as we proceeded in the program." *Id.* at 24, 30. Based on these adjustments, even SPX acknowledged that its first commercial products were not available until 2012. *See id.* at 25-26.

As I stated in my prefiled direct, only two ClearSky installations recently (i.e., within the last six months) became operational.

Further, none of the small-scale operational ClearSky towers are representative of the 44 back-to-back cells proposed for each Unit at IPEC. Although no operational information has been provided by Tetra Tech for SPX's test cell, it is apparent that the water quality and environmental conditions at the location of the test cell in New Mexico are very different than water quality of the Hudson River and environmental conditions in Buchanan, New York. In fact, as far as I know, there is no operating brackish water application of a ClearSky cooling tower. Tetra Tech, therefore, is not only proposing a modification that has never been done at a nuclear facility before—converting from once-through to closed-cycle cooling—but it proposes to do so using unproven cooling tower technology.

Q: **Do you agree with Mr. Ortiz's testimony that the ClearSky configuration proposed by Tetra Tech "was determined to be technically feasible"?**

A: It is not clear to me how Mr. Ortiz can offer this opinion. Mr. Ortiz does not appear to have any relevant engineering experience performing modifications at a nuclear power plant, much less modifications associated with cooling tower applications. Rather, Mr. Ortiz is a "Piping Engineer" who has "worked in the pulp and paper, petrochemical and mining industries." Staff Ex. 247 at 1. Moreover, the basis for Mr. Ortiz's opinion is unclear in light of the admission in the first page of his testimony that he "ha[d] no firsthand knowledge of this project...." Ortiz Direct at p. 1, l. 19-23. As a result, all of his direct testimony is "based on [his] personal observations and interpretations of the project files, reports, and conversations with former members of this project." *Id.* Mr. Ortiz never identifies any employees at Hatch that actually have firsthand knowledge of Hatch's review of the ENERCON Closed-Loop Cooling Reports or the Tetra Tech CCC Report, nor does he identify any of the "project files" other than the four reports provided by the parties in this proceeding—ENERCON 2003, ENERCON 2010, Tetra Tech CCC Report, and Hatch 2012. Throughout his testimony, Mr. Ortiz offers opinions based upon his "review of ... report[s] presented to [him]" or his "interpretation of the documents [he has] reviewed," and he acknowledges that "varying interpretations of [Hatch's] services may exist." *Id.* Mr. Ortiz nevertheless goes on to say that, "based on [his] research the direct testimony being provided is a ***reasonable interpretation*** of Hatch's methods and findings." *Id.* at p. 1, l. 21-23 (emphasis added).

Accordingly, Mr. Ortiz does not appear to be offering his own opinion on the feasibility of a closed-cycle cooling retrofit of IPEC, but his interpretation of documents authored by and containing the opinions of unidentified Hatch personnel. Further, Mr. Havey indicates that Hatch did not review ENERCON 2010 (SAIC did). *See* Havey Direct at p. 8, l. 20-22.

In addition, Mr. Ortiz's opinion and his review of the Tetra Tech proposal is heavily caveated and "limited" in a manner that does not allow a reasonable feasibility determination of the sort that represents the industry standard or expectation. According to his testimony, Hatch expressly "did not analyze the Algonquin pipeline feasibility assessment, nor did they review issues related to potential groundwater radiological contamination, nor any visual assessment, blasting, building or equipment relocations, the modification or addition of site services, and air quality." Ortiz Direct at p. 6, l. 6-10. These "limitations" represent the majority of the most obvious and most significant challenges to the feasibility of retrofitting IPEC with closed-cycle cooling. No reasonable engineer could conclude that any closed-cycle cooling retrofit of IPEC is technically feasible without addressing these items.

Q: You mentioned earlier that the ClearSky cooling towers represented a novel and unproven technology. What response, if any, did Messrs. Havey and Ortiz have to Enercon's concern about the novelty of Tetra Tech's ClearSky cooling towers?

A: Neither Mr. Havey nor Mr. Ortiz address the fact that ClearSky cooling towers employ novel technology with limited operating experience that presents a large potential risk for a nuclear baseload facility, which should have eliminated the ClearSky towers from consideration as a feasible technology. This lack of response to a fundamental concern is unacceptable in the nuclear power industry, which generally requires that technology choices be supported by demonstrated and reliable operational experience.

In fact, Tetra Tech repeatedly and contemporaneously has rejected ClearSky cooling towers as an unproven technology in reviews it has performed for NYSDEC and the U.S. EPA for other non-nuclear power plants that operate at a much smaller-scale than IPEC. For example:

- **Section 316(b) Rulemaking**. As part of its § 316(b) rulemaking, EPA tasked

Tetra Tech and SAIC (who, according to Mr. Havey reviewed ENERCON 2010 in lieu of Hatch) with evaluating how costs for plume and drift abatement technology, among other things, may be developed for a universe of facilities potentially subject to CCC retrofits under the proposed existing facility rulemaking. As part of that review, Tetra Tech evaluated ClearSky cooling towers, and in its June 11, 2010 memorandum to EPA, concluded that SPX ClearSky "technology has only been demonstrated on a full-scale basis at a single location in New Mexico and ***remains a somewhat unproven technology*** and may require time to develop acceptance within the industry." Memorandum from John Sunda, SAIC, and Kelly Meadows, Tetra Tech to Paul Shriner and Jan Matuszko, USEPA, dated June 11, 2010, at 8 (Entergy Ex. 346) (emphasis added).

- **Glenwood Main Power Station.** Tetra Tech was asked by NYSDEC to conduct a technical review and evaluate the feasibility of various alternatives at the Glenwood fossil fuel steam electric facility. In rejecting a cooling tower configuration proposed by Powers Engineering (Riverkeeper's expert) that would require only 12 ClearSky cells, Tetra Tech's technical review repeated its EPA finding that ClearSky towers "ha[ve] only been demonstrated on a full-scale basis at a single location in New Mexico and ***remain[] an unproven technology for applications such as this***." Tetra Tech, Inc., Glenwood Technical Review, at 4 (Entergy Ex. 348) (emphasis added). Although the Tetra Tech's review of the Glenwood facility is undated, it references documents there were published as late as 2010.

- **Northport Power Station.** On January 28, 2010, NYSDEC requested Northport's owner (National Grid) to provide "...an assessment of a back-to-back, linear array of towers, such as the SPX/Marley ClearSky™ tower configuration for all four units." Washington Group International, Inc., *National Grid Generation LLC, Response to NYSDEC's Request for Additional Information Regarding Cooling Towers* (July 1, 2010), at 1-1 (Entergy Ex. 349). In response, Washington Group International, a division of URS Corporation, submitted a report concluding "the cooling tower technology identified by NYSDEC for further study [ClearSky towers], is yet unproven for application to generating stations such as Northport..." *Id.* at 2-1 ("[A] plume abatement cooling tower using an array of back-to-back cells, such as the system referenced by the NYSDEC, is an unproven technology for a generating station such as Northport. Therefore, there is a high degree of uncertainty associated with its environmental impacts."); Letter from Timothy Curt, National Grid Environmental Management to Colleen Kimble, NYS Department of Environmental Conservation, dated July 1, 2010 at 4 (Entergy Ex. 353) (same). The Washington Group went on to assert that "the tower suggested by DEC is an unproven technology with no identified commercially comparable installations to Northport." Entergy Ex. 349 at 2-6. Tetra Tech performed the technical review of the Washington Group's report and concluded, "[t]he report's conclusion that the Clear Sky Plume Abatement System remains an unproven technology in this application has some merit, but the analysis demonstrates that alternative cooling tower locations for towers arranged in a linear configuration could be found on-site albeit at increased costs." Tetra Tech, Inc., Northport Technical Review at 3 (Entergy Ex. 350) at 3.

Q: Earlier you mentioned site constraints at IPEC that would render retrofitting the facility with closed-cycle cooling problematic. Did Messrs. Havey and Ortiz address the site disruption of the Tetra Tech closed-cycle cooling configuration?

A: No. Neither Mr. Havey nor Mr. Ortiz addressed how Tetra Tech or Hatch plans to relocate the several existing essential structures that conflict with Tetra Tech's proposed ClearSky towers. Mr. Havey testified that, with respect to siting conflicts, the Tetra Tech CCC Report was "not intended to enumerate all potential items that would be addressed in a final engineering and construction plan. Their exclusion from the Tetra Tech 2013 report does not imply they are immaterial or irrelevant for final design and cost estimates." Havey Direct at pg. 19, l. 20 – pg. 20, l. 3. Mr. Ortiz specifically testifies that Hatch did not analyze "building or equipment relocations, [and] the modification or addition of site services." Ortiz Direct at p. 6, l. 6-9. Mr. Ortiz went on to inexplicably assert that such conflicts "cannot be studied in detail during the limited scope of a feasibility report." *Id.* at p. 9, l. 21 – p. 10, l. 3.

Enercon has prepared Exhibit 373 which is an overhead aerial photograph of the IPEC site showing the footprint of Tetra Tech's proposed cooling towers for Unit 2 and Unit 3. As reflected on Exhibit 373, Tetra Tech proposes to locate its cooling towers effectively on top of many essential buildings and structures.

Without these structures, IPEC would be unable to operate. By not acknowledging these siting conflicts and developing a plan for relocating essential structures, Tetra Tech's ClearSky towers cannot be considered feasible at IPEC.

Q: I would like to focus on some of the specific site disruptions that were identified by Enercon in the ENERCON 2013 CCC Response. First, how, if at all, do Messrs. Havey and Ortiz propose resolving the potential issues with groundwater contamination?

A: They do not address the issue. As I explained earlier, Tetra Tech's proposed configuration calls for the existing discharge canal, which is parallel to the River and the Unit 2 and Unit 3 power houses, to be converted into a hot water reservoir and pump pit. In order for the reservoir to provide the necessary submergence for proper operation of the new circulating water pumps, the current Unit 2 discharge canal will need to be deepened considerably. As set forth in the ENERCON 2013 CCC Response, this excavation is in the very location where groundwater containing Tritium and Strontium has been observed. *See* Entergy Ex. 42. To maintain dry conditions required for pipe construction and backfilling, contaminated groundwater would need to be continually pumped from the excavation area below the groundwater table (i.e., dewatering), which will have to be continued until completion of the excavation.

In fact, Mr. Havey admits that "the retrofit project for Unit 2 is heavily dependent on finding an acceptable solution for dewatering the area during excavation and construction" and "[i]t is my opinion that the plume area will likely require sampling to determine what disposal and/or treatment methods, ***if any***, are most appropriate to manage dewatered groundwater and excavated material." Havey Direct at p. 21, l. 19 – p. 22, l. 1 (emphasis added). Despite Mr. Havey's acknowledgement that groundwater radiological contamination may render the Unit 2 tower infeasible, both Tetra Tech and Hatch inexplicably excluded "issues related to potential groundwater radiological contamination" from their feasibility assessment. *See, e.g., id.* at p 13, l. 1-3. No feasibility determination can be reached for retrofitting Unit 2 with closed-cycle cooling unless and until Tetra Tech addresses impacts from the groundwater plume.

Q: Continuing with specific site disruptions discussed in the ENERCON 2013 CCC Response, how, if at all, does Tetra Tech's ClearSky configuration proposed for Unit 2 account for IPEC's Independent Spent Fuel Storage Installation ("ISFSI")?

A: It does not. One of the most apparent and problematic aspects of Tetra Tech's proposal for Unit 2 is that the excavation for the Unit 2 towers and associated piping interferes directly with IPEC's ISFSI. The ISFSI is a critical component of the IPEC site for dry cask spent nuclear fuel storage. IPEC's ISFSI is a three-foot thick concrete pad that is approximately 100 ft by 200 ft designed to store large, sealed casks containing spent fuel rods. Construction of the ISFSI lasted three years and cost over $13 million dollars. As of February 2014, there were twenty-six (26) casks contained within the ISFSI. The casks are made of steel and concrete and are 18-20 feet high, 11 feet in diameter, and have 2 foot thick concrete walls. Each cask weighs over 300,000 pounds when loaded.

IPEC's ISFSI and the spent-fuel casks that it stores are heavily regulated and subject to intensive oversight by NRC. In order to construct the proposed towers for Unit 2, the current ISFSI must be decommissioned and demolished. Before that work can start, however, IPEC must obtain permits for and construct an entirely new ISFSI at a different location to store the spent fuel casks. The Tetra Tech CCC Report and the prefiled testimony of Messrs. Havey and Ortiz completely fail to address the significant impact on the feasibility of the Unit 2 cooling towers, not to mention its schedule, of the need to: (1) identify a viable location for, permit and construct a new ISFSI; (2) transfer the existing casks to that new ISFSI; and (3) decommission and demolish the existing ISFSI, all before commencing construction of the Unit 2 tower. In fact, Tetra Tech has performed no analysis to determine if a new ISFSI can be built at IPEC. Another significant obstacle is that the extremely heavy loads restrict what roads can be used to transport the 300,000 pound spent fuel casks. Given these restrictions, there is a risk that there will be no suitable right-of-way to transfer the spent fuel from the reactors to the new ISFSI location. Without resolving this siting conflict and others that may arise relative to the need for a new ISFSI, the Unit 2 towers cannot be considered feasible.

Q: Third, focusing now on Unit 3, how, if at all, do Messrs. Havey and Ortiz address the feasibility issues associated with the Algonquin Pipeline?

A: They do not. Neither Hatch nor Tetra Tech "analyze[d] the Algonquin pipeline feasibility assessment," *see* Ortiz Direct at p. 6, l. 6-12; Havey Direct at p. 13, l. 1-7, or provided any solution to resolve the conflict. In fact, the relocation of the

Algonquin Pipeline and feasibility assessment was expressly excluded from both Hatch and Tetra Tech's review. As I stated in my prefiled direct testimony, Tetra Tech's closed-cycle cooling reconfiguration at Unit 3 cannot be considered feasible without resolving the Algonquin pipeline conflict.

Q: **Your testimony thus far has focused on site-specific challenges to the feasibility of constructing Tetra Tech's ClearSky cooling towers at IPEC. Assuming the towers can be constructed, have Messrs. Havey and Ortiz reasonably demonstrated that the towers will function efficiently at IPEC without significantly degrading IPEC's performance?**

A: No. Mr. Havey does not address the impacts associated with Tetra Tech's proposal on the ability of IPEC's condensers to efficiently reject heat, nor does he address the Burns and Roe condenser analysis described in the ENERCON 2013 CCC Response and my prefiled direct testimony that demonstrated that additional capacity is likely needed to reduce the pressure in the condenser during at least one of IPEC's transient conditions. For his part, Mr. Ortiz concedes in his testimony that it "was ***impossible to accurately assess*** the impact on condenser thermal performance with a higher inlet cooling water temperature resulting from use of the cooling towers." Ortiz Direct at p. 10, l. 20-22 (emphasis added). Based on what Tetra Tech has reported, however, there are several known issues with the ClearSky towers that will detrimentally and materially impact IPEC's performance, including its ability to generate electricity reliably and efficiently.

Q: What are those known issues?

A: The current closed-cycle cooling retrofit alternatives at IPEC will both (1) reduce the amount of available circulating available to cool the condensers and (2) increase the temperature of the cooling water. These are both major operating constraints that will mean that IPEC will not be able to generate as much electricity as it does in the current once-through system, and in some cases, could lead to excursions and unplanned outages.

Significantly, Tetra Tech has failed to address its decision to reduce IPEC's maximum flow rate from 840,000 gpm to 700,000 gpm for each Unit. In fact, one of Tetra Tech's criticisms of the ENERCON Closed-Loop Cooling Reports was the decision to reduce maximum flow to 700,000 gpm for each Unit. Tetra Tech stated:

> This discussion not only implies that each condenser has a throughput capacity of 840,000 gpm, but that the maximum capacity is actually needed during peak summer periods. Consequently, each unit's replacement cooling tower should be designed to meet the most critical operating conditions that would be expected during the year, i.e., 840,000 rather than the 700,000 gpm used in the design criteria.

Memorandum from Tim Havey, Tetra Tech, Inc. to Chuck Nieder and Chris Hogan, NYS Department of Environmental Conservation, dated July 6, 2010, at 6 (Appendix B to Staff Ex. 214). Tetra Tech went on to note that "[i]f correct, the tower as designed appears to be insufficiently sized to accommodate the higher summertime volumes that are sometimes needed." *Id.* Enercon's decision to reduce the maximum flow to 700,000 gpm was appropriate at the time because it reflected a balance between the parasitic loss associated with pumping the extra circulating water up to the cooling towers and additional fans required to cool that water with the expected degradation in power performance based on the then-current PEPSE models for IPEC Units 2 and 3. Because Tetra Tech's proposal has a different pump and fan dynamics than the round hybrid towers with less parasitic losses, Tetra Tech ought to have reanalyzed whether 700,000 gpm was an appropriate design choice for its towers. Instead, Tetra Tech simply copied design decisions from the round hybrid towers described in ENERCON 2010 without properly considering whether those design choices are appropriate for the ClearSky towers.

As part of the preparation for this testimony, Enercon was informed by Entergy that the PEPSE model used in ENERCON 2010 and the ENERCON 2013 CCC Response had been updated and re-benchmarked. Preliminary analysis of the updated model shows higher power losses when the Units are run at 700,000 gpm, particularly at Unit 2 and particularly during the critical summer months, than what has been reported previously. Based on the results of this preliminary analysis, it is clear that the ClearSky towers proposed by Tetra Tech are significantly undersized. This analysis emphasizes why it was incumbent on Tetra Tech to perform and include PEPSE modeling, as well as other critical thermal performance data, such as cooling tower performance curves, in its report in order to validate its design choices and establish post-modification operating power losses.

Q: **You also mentioned that in addition to reducing the maximum amount of available water, closed-cycle cooling would also increase the temperature of**

the circulating water used to cool the condensers. How will that affect plant performance?

A: The increased temperature of the circulating water, combined with the reduced flow, will lead to increased condenser backpressure that will reduce the facility's ability to generate power. These effects will be felt most in the summer, when the cooling need is the highest and the demand for electricity is the greatest. But there are additional aspects of the ClearSky towers that amplify the inherent and detrimental impact associated with a closed-cycle cooling retrofit at IPEC.

First, as I stated in my prefiled direct, the cooling towers are susceptible to recirculation of the hot, humid exhaust back into the intake, which will increase the entering wet-bulb temperature and reduce the towers' ability to cool the water. Mr. Havey does not address Enercon's concern that the configuration and orientation of the ClearSky towers will likely result in recirculation thereby decreasing their performance and detrimentally affect plant operations. Mr. Ortiz states only that "to better simulate recirculation effects created by different wind conditions a more detailed analysis is required," but he defers this important consideration to later in the "engineering phase of the project" where "adjustments, if required can be implemented...." Ortiz Direct at p. 11, l. 12-19. This is not sufficient; the impact recirculation will have on cooling tower performance affects threshold design decisions, such as the number of cooling cells required and the size of those cells. It would be inappropriate to make a "feasibility" determination of a configuration that calls for forty-four (44) cells per unit, only to find out later in the process that, for example, fifty (50) or more cells per unit were actually needed. By way of example, SPX has provided to Enercon a "ClearSky Selection Summary" that proposes a different configuration ClearSky towers for IPEC, consisting of sixty-two (62) smaller ClearSky cells per Unit. The selection summary provided to Enercon explicitly assumes recirculation would increase the inlet wet bulb temperature by 2°F (changing the design wet-bulb temperature from 77°F to 79°F), and as much as 5°F "under certain wind conditions." *See* SPX, Entergy Indian Point Units 2 & 3, ClearSky Selection Summary (Entergy Ex. 347).

Second, Tetra Tech proposes aligning the ClearSky cooling towers in a back-to-back configuration. It is well understood that linear, mechanical draft cooling towers do not perform well in a back-to-back configuration. In fact, this is a point that Tetra Tech has made in several other technical reviews it has made. For example, in a review Tetra Tech performed for NYSDEC for the Northport Generating Station, Tetra Tech noted that "[c]onventional hybrid wet/dry mechanical draft cooling towers must be configured in an in-line (single row) arrangement and cannot be placed in a back-to-back configuration because of issues with poor mixing of the wet and dry section exhaust in the back-to-back configuration." Tetra Tech, Inc., Northport Technical Review at 2 (Entergy Ex. 354). Tetra Tech made a similar statement in the review of the Huntley facility: "[d]oubled-up towers are also referred to as back-to-back configurations and are generally not compatible with hybrid wet/dry plume abatement cooling towers." Memorandum from John Sunda, Steve Geil, and Kelly Meadows, to Chuck Nieder, NYSDEC, and Jamie Hurley, USEPA, dated Oct. 5, 2011, at 6-7

(Entergy Ex. 355). I understand that SPX advertises that, conceptually, ClearSky cooling towers can be designed and operated in a back-to-back configuration, but there is no operational experience showing this to be the case. Indeed, the Air2Air test cell at the San Juan Generating Station in New Mexico cannot be used in a back-to-back configuration because it has air intakes on two sides, which is another reason that it is not representative of NYSDEC's proposal to construct two towers of 44 back-to-back ClearSky cells at IPEC.

Third, in addition to known operational problems associated with using cooling towers in salt water applications (e.g., salt deposition, electric arcing, etc.), the thermophysical properties of salt water degrades cooling tower performance as compared to cooling towers that use freshwater. Recent studies have shown that increased salt concentrations materially alter the efficiency of cooling towers to a substantial degree. *See* Mostafa H. Sharqawy et al., *On Thermal Performance of Seawater Cooling Towers*, 133 J. Eng. Gas Turbines & Power (Apr. 2011), at 6 (Entergy Ex. 352) ("It is found that an increase in salinity decreases the air effectiveness by 5-20% relative to freshwater cooling tower."). Here, Tetra Tech proposes concentrating the salt level in the Hudson River three times in its closed-cycle system, which will amplify degradation of thermal performance attributable to increased salinity. Although Mr. Havey asserts in his prefiled testimony that Tetra Tech's proposed ClearSky towers are designed to reject the maximum thermal load under the "most stringent conditions," including "highest salinity" (Havey Direct at p. 29, l. 10-13), Tetra Tech does not identify the salinity levels that were provided to SPX or how (or even whether) SPX adjusted the size of its cooling towers to account for the increased salinity of the Hudson River. Without this information, there is a substantial risk that Tetra Tech has further undersized its cooling towers.

Q: Aside from and in addition to the impacts that will reduce IPEC's ability to generate power, are there any significant operational problems associated with the proposed ClearSky towers that are not addressed by Messrs. Havey and Ortiz and need to be to reach a feasibility determination?

A: Yes. Mr. Havey and Mr. Ortiz fail to address the potential site impacts that could result from the localized plume of humid, salt-laden air that is exhausted from Tetra Tech's ClearSky cooling towers. Importantly, the ClearSky towers discharge at lower velocities, at a lower height, and with less thermal buoyancy than the round hybrid towers described in the ENERCON Closed-Loop Cooling Reports. As a result, the ClearSky towers have more concentrated and localized plumes at ground level, which increases salt deposition and temperature/humidity effects on electrical equipment and components in close proximity to the towers. This creates a number of personnel and station safety-related issues, such as electrical arcing, icing during the winter, and fogging due to the cooling tower plume on occasion. Ground level icing and salt deposition poses serious workplace safety, maintenance, and environmental concerns, with the potential to render certain areas of the site treacherous during winter months, as well as creating substantial local vegetation impacts. Fogging that would lead to reduce visibility creates associated security risks at the facility.

The risk of icing poses unique operational concerns for ClearSky towers, which use proprietary "ClearSky heat exchangers" that are designed to condense moisture from the cooling tower's exhaust in the form of "high purity water—approaching distilled water quality." Entergy Ex. 359 at 10. As SPX noted in its 2012 DOE Report, imperfect seals will cause leakage within the ClearSky heat exchanger that will cause icing in the heat exchanger in cold weather. SPX correctly acknowledged that "[t]his behavior is unacceptable in the commercial market place." *See id.* at 19. Although SPX advertises that it has performed laboratory testing on its condensing modules in "all four seasons," tellingly, the test data it selected to include in its 2012 DOE Report only includes results for spring and summer, not the cooler seasons of fall and winter. *See id.* at 14-15. At this point, it is simply unknown whether SPX's ClearSky heat exchangers are appropriate for the IPEC site conditions.

Another aspect of cooling tower operation not addressed by Mr. Havey or Mr. Ortiz is the potential operational impacts associated with sedimentation in the closed-cycle system. Evaporation of water and drift will elevate the concentration of sediments in the closed-loop system above ambient Hudson River conditions. In addition, it is well known that cooling towers act as air scrubbers, which flush airborne contaminates into the closed loop system further elevating sediment concentrations. It can be expected that this sediment will settle and accumulate in the modified discharge canal and in the cooling tower basins, and it will need to be periodically removed. Tetra Tech provides no explanation for how it proposes to control and/or remove sedimentation in its closed-system configuration.

Q: On the subject of security considerations, is IPEC required to utilize flood lighting for security purposes that would illuminate any visible plume at night?

A: Yes. IPEC's security procedures require the site to be fully lighted at night, which would illuminate any visible plume.

Q: Finally, assuming they can be constructed, did Messrs. Havey and Ortiz account for the inherent concerns with fiberglass towers?

A: No. Mr. Havey argues at page 20 of his prefiled testimony that fiberglass towers generally are "structurally sound" and can be reinforced to "meet higher wind load requirements." Havey Direct at p. 20, l. 4-20. There is evidence, however, that raises serious concerns of fiberglass towers' structural integrity. Most notably, in the 2011 Cooling Technology Institute Annual Conference, American Electric Power presented a paper entitled, *AEP's Experience with Polyester FRP Structure Cooling Towers,* that described significant structural failures with five fiberglass towers constructed with pultruded fiberglass. Of the 15 hyperbolic and 30 mechanical draft cooling towers on the AEP system, the five towers constructed from 2008 through 2010 were AEP's first fiberglass towers. AEP's experience is a cautionary tale insofar as four of the five towers experienced failed or cracked fiberglass columns and surface blisters were noticed in two of the new towers after 2 to 18 months of operation. *See* Bob Cashner, *AEP's Experience with Polyester FRP Structure Cooling Towers,* Cooling Tower

Institute (Feb. 6-10, 2011), at 2 (Entergy Ex. 358). These failures caused AEP to conduct additional testing of the fiberglass material in 2009. *See id.* at 11. The testing involved repeated exposure to saturation and then freezing or drying or both. In sum, a total of 83 defects were documented in all sixteen samples representing the four different test conditions. *Id.*

IV. REBUTTAL TO NYSDEC'S TESTIMONY CONCERNING THE FEASIBILITY OF RETROFITTING IPEC WITH ROUND HYBRID COOLING TOWERS

Q: Turning now to the round hybrid mechanical draft cooling towers described in the ENERCON Closed-Loop Cooling Reports, as a preliminary matter, has Enercon or Entergy proposed the circular hybrid cooling towers described in the ENERCON Closed-Loop Cooling Reports as the best technology available for IPEC under 7 NYCRR § 704.5 and § 316(b) of the Clean Water Act?

A: No. Entergy was required by NYSDEC to evaluate the possible conversion of the existing system to a closed-loop circulation water system configuration. In response to that mandate, Enercon selected a closed-loop configuration utilizing hybrid round towers, which are the only cooling towers that could "reasonably be considered" at IPEC. As I stated in my prefiled testimony dated July 22, 2011:

> In the Closed-Loop Cooling Report, ENERCON concluded that the absence of a history of closed-cycle cooling retrofits and site-specific conditions at Indian Point would challenge the feasibility of such an installation. The several reasons for the conclusion are explained in detail in the Closed-Loop Cooling Report. Briefly,

conversion of Indian Point to closed-loop cooling would be an unprecedented undertaking that would encounter numerous significant identified siting and construction challenges, some of which may not be successfully surmounted. Such a conversion is unprecedented, because no nuclear stations designed solely for once-through cooling have been converted to closed-loop cooling. This nuclear experience is critical, because conversion of the condenser cooling system of an existing plant presents fundamental design problems that result in plant performance impacts or require redesign of the essential plant equipment, e.g., the condenser. Moreover, absent any practical history of closed-loop cooling retrofits at nuclear facilities, engineering observations and conclusions regarding any such conversion must be made on a purely speculative basis and are inherently subject to unforeseen challenges during the detailed design and the subsequent construction phases. Only upon successful operation of a completed closed-loop cooling retrofit at a representative number of comparable facilities could this type of conversion be conclusively considered feasible.

Prefiled Testimony of Sam Beaver in Support of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations, Inc. at 21:5-22, dated July 22, 2011.

Q: Are there any examples of round hybrid towers at nuclear facilities of the size contemplated in the ENERCON Closed-Loop Cooling Reports?

A: There is only one round hybrid tower of a size that approaches what would be required for each of IPEC Unit 2 and Unit 3, located at the Neckarwestheim nuclear power plant (Unit 2) in Germany. There are, however, several important differences between the Neckarwestheim facility and IPEC. Most significantly, the Neckarwestheim Unit 2 cooling tower was constructed as part of a *new* facility, not a retrofit of an existing facility. The Neckarwestheim Unit 2 cooling tower is also subject to different environmental and water quality conditions than what would be experienced at IPEC.

Q: Did Messrs. Ortiz and Havey offer any analysis concerning the feasibility of retrofitting IPEC Units 2 and 3 with round hybrid cooling towers?

A: No. While Mr. Havey testifies that the circular hybrid cooling towers described in ENERCON 2003 "could be constructed, installed, and operated at the Indian Point nuclear facilities," Havey Direct at p. 3, l. 19-21, and that "Enercon's circular hybrid cooling tower proposal was available and generally feasible for the IPEC facilities in order to satisfy the BTA requirements of 6 NYCRR § 704.5," *id.* at p. 10, l. 8-10, he offers ***no*** additional analysis. Likewise, Mr. Ortiz offers no analysis nor justification. Further, Mr. Ortiz's opinion as to the feasibility of retrofitting Units 2 and 3 with round hybrid towers is even less clear. In response to a question as to whether the circular hybrid cooling tower configuration described by Enercon in its 2003 and 2010 is "available and generally feasible," Mr. Ortiz testifies that "[b]ased on the limited scope and analysis of the study [the round hybrid towers] ***may be*** feasible, ***but a more in depth study would be necessary to obtain a final conclusion***." Ortiz Direct at p. 5, l. 1-2 (emphasis added).

Q: Do you agree with Mr. Havey's opinion that the circular hybrid cooling towers described in the ENERCON Closed-Loop Cooling Reports "could be constructed, installed, and operated at the Indian Point nuclear facilities" and Mr. Ortiz's testimony that such a retrofit "may be feasible"?

A: No. While retrofitting IPEC Units 2 and 3 may be theoretically possible (and cost over two billion dollars and take over eight years in construction time alone), the ENERCON Closed-Loop Cooling Reports identified numerous significant challenges to the feasibility of retrofitting IPEC Units 2 and 3 with circular hybrid cooling tower. These include, but are not limited to, appreciable elevation changes, a general lack of available space, a subsurface primarily composed of solid rock, the location of a major interstate gas pipeline, local air quality, archeological and aesthetic considerations, etc. Given the sizeable challenges and level of unknowns, based upon my best professional judgment, I could not in good conscience recommend round hybrid cooling towers for IPEC as a practical or reasonable alternative for compliance with regulatory requirements associated with the Clean Water Act.

To reach any other conclusion about the feasibility of round hybrid towers, the challenges identified in the ENERCON Closed-Loop Cooling Report would need to be fully addressed. Neither Mr. Havey nor Mr. Ortiz resolved any of the uncertainties described in the ENERCON Closed-Loop Cooling Reports, and as a result, are not in a position to conclude that round hybrid towers are feasible at IPEC.

Q: Did Tetra Tech or Hatch materially dispute any of the conclusions of the ENERCON Closed-Loop Cooling Reports?

A: No. According to Mr. Ortiz, Hatch's review of the Enercon Closed-Loop Cooling Reports was limited to reviewing the reports by unidentified Hatch employees and providing "comments" to Mr. Havey at Tetra Tech. Hatch's review of ENERCON 2003 was reportedly limited to "challenging certain assumptions on the prevailing winds, soil conditions, some contradictions on the wet bulb temperatures used, and identified minor discrepancies." Ortiz Direct at p. 3, l. 17-19. Given this context, Mr. Ortiz's testimony that in Hatch's review of ENERCON 2010, "no major issues or deficiencies were identified ***by Hatch*** with respect to the technical feasibility of transferring from a once-through cooling system to a closed loop cooling system" is not helpful to me as an engineer. *See id.* at p. 4, l. 15-28 (emphasis added). It is further complicated by the fact that Mr. Havey states in his testimony that SAIC, not Hatch, reviewed ENERCON 2010. *See* Havey Direct, at p. 8, l. 20-22. Mr. Ortiz does not even discuss the major issues and challenges identified ***by Enercon*** in its report.

There is nothing in Mr. Ortiz's testimony that shows a basis for ***any*** engineering conclusions as to feasibility of round hybrid cooling towers at IPEC. Similarly, Tetra Tech did not dispute and in fact, validated, many of the major conclusions of the ENERCON Closed-Loop Cooling Reports. For example, Tetra Tech agreed:

1. Enercon's estimate for direct capital costs of $1.19 ***billion*** and ongoing operation and maintenance costs of $2.0 to $4.0 million per year per unit were "well within the range of comparable project estimates developed for other nuclear facilities when adjusted for the unique considerations at IPEC (found hybrid towers, transmission pipeline relocation, etc.)." Memorandum from Tim Havey, Tetra Tech, Inc. to Chuck Nieder and Chris Hogan, NYS Department of Environmental Conservation, dated July 6, 2010 at 3 (Staff Ex. 214, Appendix B).
2. Enercon's estimate of 12 to 13 years for construction was "not unreasonable given the volume of blasting and spoils removal that would have to occur, and the limitations placed on construction activities by local ordinances and seasonal weather concerns." *Id.*
3. Enercon's estimate that construction of closed-cycle cooling would require taking both IPEC units offline for up to 42 concurrent weeks was "reasonable and acceptable." In fact, Tetra Tech concluded that "[t]he obstacles presented by reconfiguring the existing discharge canal to function as a main component of the new cooling system are correctly cited by Enercon as unavoidable. There do not appear to be any practical means to significantly decrease this estimate." *Id.*
4. Enercon's estimate of thermal efficiency losses were reasonable when compared to other similar projects. *Id.*

Q: Were there any limitations or caveats in the prefiled testimony of Messrs. Havey and Ortiz with respect to Tetra Tech and Hatch's review of the ENERCON Closed-Loop Cooling Reports?

A: Yes. Although both Mr. Havey and Mr. Ortiz suggest that hybrid round cooling towers may be generally feasible, both Hatch and Tetra Tech again excluded from consideration (1) the Algonquin pipeline relocation and feasibility assessment and (2) "issues related to potential groundwater radiological contamination." *See* Havey Direct at p. 8, l. 10-17; *see also* Ortiz Direct at 4:11-18. In short, and for the same reasons I testified earlier, relocating the Algonquin pipeline and issues related to potential groundwater radiological contamination must be resolved prior to any feasibility determination being made.

V. <u>REBUTTAL TO CHARLES NIEDER</u>

Q: Have you had an opportunity to review Mr. Nieder's testimony regarding capital costs of operating CWWS at IPEC?

A: Yes. Mr. Nieder suggests that Enercon did not provide enough detail to support its estimate of the capital costs for constructing the proposed array of CWWS. I have submitted as Entergy Exhibit 372 additional details that support Enercon's estimate of capital costs which should address Mr. Nieder's concern.

Q: Have you had an opportunity to review Mr. Nieder's testimony regarding the O&M costs of operating cylindrical wedgewire screens at IPEC?

A: Yes. Mr. Nieder contends that he was not able to calculate the proportional costs of Entergy's proposed CWWS array because it did not include annual O&M costs of the CWWS array. He further disputes NERA's conclusion that the O&M costs for CWWS would be insignificant based on other estimates he had received for CWWS O&M costs from other facilities because the "median O&M costs represented 38 percent of the total costs for constructing and operating CWWSs for 20 years. This percentage level of the overall costs for constructing and operating CWWSs for 20 years is significant." Nieder Direct at p. 17, l. 8-10.

Q: As a preliminary matter, is it appropriate to calculate O&M costs for the CWWS for a 20 year life period?

A: No. CWWS will not be operating for the full twenty years of Entergy's renewed license. Entergy's NRC renewed operating licenses for Unit 2 and Unit 3 would expire in 2033 and 2035, respectively. We have estimated that the design phase of the CWWS project would extend for approximately two years and in-river construction activities would occur over three successive years, with the final tie-in occurring in the sixth year. Accordingly, assuming design and construction begin after these proceedings and any associated court proceedings end, which I understand NERA assumed would be 2018, construction would not be complete, and therefore Entergy would not be incurring O&M costs for each Unit, until roughly 2024. As a result, O&M costs would only be incurred for 9-11 years until the operating license respectively expire, or an average of 10 years per unit. That is only half the period assumed by Mr. Nieder.

Q: Do you agree with Mr. Nieder's estimate that potential O&M costs for CWWS would render the overall costs significant?

A: No. As Mr. Nieder acknowledges, the principal O&M cost associated with any CWWS proposal is the cost associated with cleaning the screens. Entergy has specifically made design choices to minimize the risk of fouling and therefore reduce the need for cleanings, including constructing the screens out of Johnson Screen's Z-Alloy, which has been demonstrated to resist biofouling in the Hudson River, and selecting a conservative through-slot velocity of 0.25 feet per second. In addition to these design choices, during the summer months when the potential for fouling is at its highest and when the biological need is the greatest, Entergy can use divers to regularly—and even continually—clean the screens. From Entergy's past experience with cleaning the Ristroph screens, the average cost for a dive team at IPEC is $7,000 per day. There is no reason to conclude that the per day cost of dive teams would be any different for CWWS than the current intake structure. For the rest of the year (i.e., fall through spring), when the risk of fouling is considerably lower, monitoring in the intake bays would alert the operators of any potential fouling issues with the screens, and divers can be deployed on an "as needed" basis.

VI. <u>CONCLUSION</u>

Q: Has anything that you have read in the testimonies of Messrs. Havey, Ortiz, and Nieder or in the documentary exhibits attached to their testimony affected the opinions you previously testified to in your February 28, 2014 prefiled testimony?

A: No. For the reasons detailed above, nothing that I have reviewed alters my bottom-line conclusion that the given the numerous and significant site-specific challenges associated with retrofitting IPEC with closed-cycle cooling documented by Enercon, the considerable uncertainty inherent in such a retrofit project, and the detrimental impact that a closed-cycle cooling retrofit would have on the facility's ability to generate electricity, NYSDEC Staff has failed to demonstrate that cooling towers are feasible at IPEC.

END OF TESTIMONY

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollutant Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc.'s Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

PREFILED REBUTTAL TESTIMONY OF SAM BEAVER IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.

CLOSED CYCLE COOLING

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

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I. INTRODUCTION

Q: Please state your name, current position, and business address.

A: My name is Sam Beaver. I am the Director of Project Management at Enercon Services, Inc. ("Enercon"), an engineering, environmental, and technical management services firm. My business address is 500 Townpark Lane, Kennesaw, Georgia 30144.

Q: Are you the same Sam Beaver who provided prefiled direct testimony on February 28, 2014 on behalf of Entergy in support of its application for renewal of State Pollutant Discharge Elimination System ("SPDES") Permit (DEC App. Nos. 3-5522-00011-00004 SPDES No. NY0004472) for Indian Point Units 2 and 3 and the corresponding issue in the associated Water Quality Certification ("WQC") proceeding, as it has been consolidated by this Tribunal (collectively, the "Proceedings")?

A: Yes.

Q: Please state the purpose of your prefiled rebuttal testimony.

A: The purpose of my prefiled rebuttal testimony is to address certain portions of the prefiled direct testimony of Eduardo Ortiz (Hatch) ("Ortiz Direct"), Tim Havey (Tetra Tech) ("Havey Direct"), and William Charles Nieder (NYSDEC Staff) ("Nieder Direct"). Specifically, my rebuttal testimony responds to the prefiled direct testimony of Mr. Ortiz and Mr. Havey that relates to the engineering feasibility of retrofitting either or both Indian Point Energy Center, Unit 2 and Unit 3 (collectively, "IPEC"), with eighty-eight (88) back-to-back ClearSky cooling towers, forty-four (44) cells at each of Unit 2 and Unit 3, as described in the report prepared by Tetra Tech entitled *Indian Point Closed-*

Cycle Cooling System Retrofit Evaluation, dated June 2013 (the "Tetra Tech CCC Report"); and two (2) round hybrid cooling towers, one at Unit 2 and Unit 3 respectively, as described in the initial report prepared by Enercon entitled, *Economic and Environmental Impacts Associated with Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration,* dated June 2003 (Entergy Ex. 7A) ("ENERCON 2003") and as more intensively reviewed in the report entitled *Engineering Feasibility and Costs of Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration,* dated February 12, 2010 (Entergy Ex. 7) ("ENERCON 2010"; collectively, the "ENERCON Closed-Loop Cooling Reports"). My rebuttal testimony also responds to the portion of Mr. Nieder's testimony that discusses the expected operational and maintenance ("O&M") costs of Entergy's cylindrical wedgewire screen ("CWWS") proposal. I have reviewed the prefiled direct testimony of each of these individuals, as well as the identified materials on which each of these individuals relies (to the extent it was provided).

Q: How is your rebuttal testimony organized?

A: First, I provide some general background and context about how engineers address feasibility questions at nuclear power plants, and how this context relates to my conclusions regarding the inherent challenges to the feasibility of retrofitting Unit 2 and Unit 3 with a closed-cycle cooling system during the license renewal period. Second, I address specific statements in Messrs. Ortiz and Havey's testimony concerning the feasibility of Tetra Tech's ClearSky cooling tower configuration, with a focus on misimpressions and errors in that testimony and therefore their respective conclusions. Third, I address Messrs. Ortiz and Havey's testimony as it relates to the feasibility of retrofitting IPEC with round hybrid cooling towers, with the same focus. Finally, I respond to Mr. Nieder's argument that O&M costs for Entergy's proposed array of CWWS are likely to be significant.

II. BACKGROUND AND CONTEXT FOR RETROFITTING IPEC WITH CLOSED-CYCLE COOLING

Q: Please describe what engineering feasibility means in the context of retrofitting a nuclear power plant with a new cooling water system?

A: The "feasibility" of retrofitting power plants with a new cooling water system depends on two related considerations. First, the *technology* that is chosen for the retrofit must be available. As I testified in October 2011, "availability" means that technology is used in the industry for which it is intended on a regular basis, with an adequate design, construction and operational history to allow an engineering assessment with a reasonable level of confidence. The second consideration is whether an otherwise "available" technology can be installed and operated at a particular site, based on the relevant considerations at that site, with a reasonable level of engineering certainty.

The need for a reasonable level of engineering certainty is particularly acute in the nuclear industry for two reasons. First, nuclear powered electric generating power plants—as baseload suppliers—are designed to operate (to produce power in the form of electricity) on a consistent, reliable basis. Second, the regulatory structure for nuclear power plants and the safety consciousness of nuclear engineers and operators place a high priority on consistent operations in accordance with design parameters. Excursions (that is, atypical operations), including conditions that may increase the likelihood of excursions, are strongly disfavored by NRC and plant personnel alike. This has two direct implications for the major retrofit proposed by NYSDEC Staff for IPEC: (1) relevant, demonstrated operational experience in a comparable dynamic is typically necessary for a technology to be installed, particularly major equipment essential for plant operation; and (2) actual retrofitting history is preferred before reaching an "engineering feasibility" conclusion. At nuclear power plants, novel and unproven technologies are generally not considered available.

As it is relevant to this phase of the Proceedings, to reach a conclusion about the engineering feasibility of retrofitting IPEC with closed-cycle cooling, an engineer with nuclear design and operational experience would have to conclude that it is likely that the retrofit can be completed and function without major adverse impacts within the remaining plant operational period (that is, the twenty-year license renewal period). If, for instance, it is reasonably foreseeable that construction will not be completed in a timeframe to allow operation of the equipment for a substantial period of time before the end (respectively, in 2033 and 2035) of the license renewal period; that construction will result in unit shut-downs of substantial duration; that operation will result in measurable and significant power losses; or that there is a heightened risk of incidence of excursions, then an experienced nuclear engineer would not consider the closed-cycle cooling retrofit to be a practically feasible.

Q: To understand the implications of an engineering feasibility determination for retrofitting IPEC with cooling towers, is it helpful to understand the physical constraints of the IPEC site?

A: Yes. Background information is essential to understanding how disruptive and intrusive it would be to retrofit the existing IPEC stations.

Both IPEC Units sit on a combined 239 acres, which represents one of the most site-constrained nuclear power plants that I have worked on in my over thirty years of experience. The site topography is challenging, spanning an elevation from the River up to approximately 150 feet. As a result of the topography challenges and the substantial subsurface rock shelf that rises beneath and behind the Stations, within the 239 acre site only 128 acres is readily usable for major structures, and that area already has been developed. Further, all major structures and equipment representing the main power block are contained in a central area of approximately 25 acres located along the Riverfront. Because the two operating unit and one shut down unit share the Riverfront area and given the number of plant systems located in this area, there is a very high density of equipment and structures in this defined area – in fact, the density is visible to even the casual observer. Entergy Ex. 351 is a recent aerial photograph of the IPEC site. The Unit 2 and Unit 3 containment buildings are the two tallest domed structures, with their respective power house unit immediately in front of (closest to the River) the containment buildings. Unit 1 is the shorter domed-building between Unit 2 and Unit 3. What is not visible, but is as important, is the substantial underground network of major piping, ranging up to 8-feet in diameter, as well as numerous cabling duct banks and conduits, that runs throughout the Riverfront area. What this means is that the addition at IPEC of any new large-scale structures, particularly those involving the addition of new underground piping, is a challenge from the outset. As a result, any comparisons to "greenfield" design and construction projects for similar components (i.e., usage of cooling towers for new nuclear units currently under construction) would be inappropriate and misleading from an engineering perspective.

In fact, even Tetra Tech has recognized the "important role" the size of the property plays in determining whether a retrofit to cooling towers is feasible. *See* Memorandum from Kelly Meadows, Tetra Tech to Paul Shriner, EPA, dated Feb. 28, 2011, at 1 (Entergy Ex. 356). In a memorandum from Tetra Tech to EPA, dated February 28, 2011, Tetra Tech documented the approximately 73 sites visited by EPA in 2011 as part of the proposed § 316(b) rulemaking. Tetra Tech noted that facilities that have a ratio of 160 acres per 1,000 MWs "should have ample space to construct retrofit cooling towers." *Id.* at 1-2. Here, assuming all of IPEC's 239 acres is available for a retrofit, IPEC's "ratio" is 110 acres per 1000 MW, which by EPA's and Tetra Tech's own definition would make it among the most space-constrained site visited by in the Tetra Tech review. As stated above, only 128 acres of the IPEC site is readily useable for major structures, making the site even more constrained in Tetra Tech's terms further lowering the sites effective acreage. *See id.* at 3 (discussing the "effective acreage" of the McDonough Power Plant).

Q: Is there any additional background information that informs your analysis of the feasibility of retrofitting IPEC with closed-cycle cooling?

A: Yes. It is also essential to consider the way nuclear units, such as IPEC, are designed and operated. Nuclear power plants, like IPEC, generate electricity through the use of two major categories of systems which convert heat generated in the reactor core into electrical power for commercial use: (1) a closed, pressurized "Reactor Coolant System" (primary systems), (2) and a "Steam and Power Conversion System" (secondary systems). Figure 1.1 in Entergy Exhibit 7 (pg. 2) depicts the basic configuration of IPEC-type pressurized water reactors. In the primary system, reactor coolant is heated by nuclear fission in the reactor. The thermal energy generated in the reactor core is then transferred to steam generators where steam is generated in the secondary system and utilized to drive the turbine generator, where it is converted into electricity. The primary and secondary systems are physically separated in the steam generator, minimizing radioisotope transfer to the secondary system.

At IPEC, each unit has a multistage turbine comprised of one high-pressure turbine and three low-pressure turbines. After passing through the turbines, the steam passes to the main condenser to allow it to be cooled and condensed back into feedwater that can be pumped back through the steam-generators in what is effectively a closed loop system.

Importantly, the Unit 2 and Unit 3 main condensers are operated in a vacuum in order to optimize plant performance by facilitating the flow of steam through the low-pressure turbines. Even a slight increase in pressure in the condensers, referred to as condenser "backpressure," can have an appreciable impact on the efficiency of the plant and, in some instances, lead to excursions or forced plant shutdowns.

Q: How do the Unit 2 and Unit 3 condensers convert the steam exhaust back into feedwater?

A: The purpose of the main condenser is to absorb heat contained in the expanded exhaust steam after exiting the low pressure turbines. Cold circulating water flows through the condenser tubes to condense the steam back into water. Unit 2 and Unit 3 were designed and constructed with a once-through circulating water system, and reflect a highly specialized design analysis, a "heat balance" that accounted for the qualities of the existing cooling water source, here the Hudson River, to accommodate the heat rejection of the main steam system for each Unit. In other words, the turbines and condenser design rely on the low-temperature of the River water, as does efficient performance of the plant. The design rate for each Unit's circulating water system is 840,000 gallons per minute ("gpm"). For obvious reasons, the IPEC condenser cooling systems are essential plant equipment. As I stated in my previous prefiled testimony, dated July 22, 2011, which I fully incorporate by reference here, and by way of analogy, if the reactor is the heart of IPEC, then the cooling system is its lungs—providing the necessary cooling for the system to function properly.

Given that IPEC's condensers and turbines were specifically designed and constructed as a once-through cooling system utilizing cold River water, ***any*** retrofit of IPEC to a closed-loop cooling system that results in higher circulating water temperatures and/or lower flows will result in inherent impacts to the plant. Here, it is unavoidable that a shift to closed-cycle cooling will result in higher circulating water temperatures and lower flows that challenge plant performance and operations. For this reason, any proposal for closed-cycle cooling must rely on the requisite heat balance analysis to demonstrate that performance and operational impacts are known, manageable and not too significant. The twin dynamic of higher circulating water temperature and lower flows (as discussed below) represents a particular challenge to Station performance and functionality.

Q: What are the inherent impacts with retrofitting IPEC to a closed-cycle cooling system?

A: Retrofitting a nuclear plant constructed in the 1970s with a once-through cooling system to a closed-cycle cooling system will impact virtually every aspect of IPEC's circulating water system. First, less water will be available to run through the condensers. The design of both the ClearSky and round hybrid towers decrease the maximum available circulating water from 840,000 gpm to 700,000 gpm—a 16.7% reduction. Second, the temperature of the circulating water entering the condensers to cool the steam will be higher at the most critical times, namely during the summer when cooling need is the greatest. The reduction in water and increase in circulating water inlet temperatures increase condenser back pressure of both Unit 2 and Unit 3. *See* Entergy Ex. 7A at 20 (Figure 3.2 and 3.3). Third, the water pressure in the condenser tubing will be measurably higher in a closed-cycle cooling configuration as compared to the existing once-through cooling system. This is a particular concern with the Tetra Tech proposal which, while within the technical design limits for the condenser, calls for the circulating water to be at a materially higher pressure than the Stations have ever operated under, which introduces additional uncertainty in plant operations and equipment service life.

Finally, closed-cycle cooling creates significant and costly parasitic losses that further affect the ability of the plant to generate power efficiently. These losses are attributable to the extra energy required to pump the circulating water to the elevated cooling towers and operate the fans in the cooling towers themselves.

Q: Please briefly summarize what would be required in order to retrofit IPEC with closed-cycle cooling.

A: In addition to the construction of the cooling towers themselves and the extensive piping that would be needed to supply and return circulating water to and from those towers, retrofitting IPEC to closed-cycle cooling will require reconfiguring the current circulating water system to hold the considerable volume of water necessary to ensure reliable operation of the cooling towers. In the current once-through configuration, after the circulating water passes through the condensers, it is discharged into a canal that runs along the shoreline in front of the Unit 2 and Unit 3 power houses, eventually joining the River on south end of the facility. The discharge canal extends from the Unit 2 power house, where circulating water from the Unit 2 condenser and Unit 2 service water is discharged. The Unit 2 discharged water flows past Unit 3 where the Unit 3 service and circulating water is discharged, and the combined flow is returned to the River.

In order to retrofit IPEC to a closed-cycle cooling configuration and to hold sufficient water to meet the Unit's combined flow rate of 1.4 million gpm (assuming 700,000 gpm per Unit) of circulating water, the existing discharge canal must be converted into a hot water reservoir that can hold approximately 10.7 million gallons of water. *See* Entergy Ex. 7 at 12. After modification, the Unit 2 and Unit 3 reservoirs would hold over 4.2 million and 6.5 million gallons of circulating water, respectively. *Id.* The makeup water source for the hot water reservoir is the service water discharge, with Unit 2's service water discharged into the Unit 2 reservoir, and Unit 3's service water discharged into the Unit 3 reservoir. New circulating water pumps would be installed in each reservoir that would pump the hot water from each reservoir to its respective cooling tower. To accommodate the additional capacity and to meet the new circulating pump submergence requirements, the current discharge canal in front of Units 2 and 3 will need to be excavated. The excavation and construction of the new reservoirs requires a 42 week concurrent construction outage for both IPEC units. As Tetra Tech acknowledged in its July 6, 2010 memorandum, "[t]he obstacles presented by reconfiguring the existing discharge canal to function as a main component of the new cooling system are correctly cited by Enercon as unavoidable. There do not appear to be any practical means to significantly decrease this estimate." Memorandum from Tim Havey, Tetra Tech, Inc. to Chuck Nieder and Chris

Hogan, NYS Department of Environmental Conservation, dated July 6, 2010, at 3 (Staff Ex. 214, Appendix B).

As noted above, the discharge canal is also used by the service water system, which serves a nuclear safety function, and which cannot be impacted by the proposed retrofit. Because the design utilizes services water to provide cooling tower makeup at IPEC, and the combined service water discharge will likely exceed the cooling towers' make-up water needs, the reservoir weirs will facilitate the overflow of excess water (that is, water not pumped to the cooling towers) back to the River. The excess water that overflows the Unit 2 and Unit 3 reservoirs is in essence the cooling tower "blowdown," which is the intentional release of circulating water used to control the cycles of concentration of the system (i.e., the number of times suspended and dissolved sediment are concentrated above ambient River levels). Thus, when the service water discharge exceeds the makeup needs of the closed-cycle system, water will overflow from the reservoirs, which will represent the blowdown of the system. For both the round hybrid towers and Tetra Tech's ClearSky towers, there is no method by which the blowdown rate (or content of the blowdown) can be controlled. I understand that Tetra Tech has also included additional piping that will siphon cooling water from the pipes running from the cooling towers to the condensers and discharge it in the discharge canal beyond the Unit 3 weir.

Q: Are there any examples of operating nuclear power plants that were designed for once-through cooling that were retrofitted as a closed-cycle cooling?

A: No. No nuclear power plant that has been designed, constructed, and operated with a once-through cooling system has ever been retrofitted into a closed-loop cooling system. While certain individuals may occasionally reference Palisades Nuclear Power Plant as a "retrofit," as Tetra Tech explains in its November 18, 2009 memorandum on page 5, the so-called retrofit was "planned and completed before initial operation." *See* Memorandum from Tim Havey, Tetra Tech, Inc. to Chris Hogan, NYS Department of Environmental Conservation, dated Nov. 18, 2009 at 5 (Staff Ex. 214, Appendix B). The importance of the absence of any successful conversion from once-through to closed-cycle cooling to a feasibility assessment cannot be overstated. Unless a given unit's condenser is specifically designed to utilize cooling water temperatures as provided by cooling towers, there will be a compromise in unit operating efficiency and hence performance. The complete absence of any practical history of closed-loop cooling retrofits at nuclear facilities and the associated impacts on the circulating water system and condensers renders such a project subject to an unacceptably high degree of uncertainty.

III. REBUTTAL TO NYSDEC'S TESTIMONY CONCERNING THE FEASIBILITY OF RETROFITTING IPEC WITH CLEARSKY COOLING TOWERS

Q: With that background, let us now discuss some of the specific challenges to the Tetra Tech ClearSky cooling tower configuration discussed by Messrs. Havey and Ortiz in their prefiled direct testimony. First, did Messrs. Havey and Ortiz offer any opinion(s) concerning the feasibility of retrofitting IPEC Units 2 and 3 with ClearSky cooling towers?

A: Yes. Mr. Havey testified that Tetra Tech's proposal to retrofit IPEC Units 2 and 3 with 44 ClearSky plume-abated cooling towers is a "***practical*** alternative for a closed-cycle cooling retrofit at IPEC apart from the circular hybrid cooling towers initially proposed by Enercon." Havey Direct at p. 13, l. 9-13 (emphasis added). Mr. Ortiz similarly testifies that "[b]ased on a preliminary review, and subject to the limitations previously stated, the installation of a closed loop system was determined to be technically feasible," Ortiz Direct at p. 6, l. 17-19, and "[b]ased on the conclusions of the Hatch 2012 Report and subject to the limitations previously outlined, no major issues or deficiencies were identified by Hatch with respect to the technical feasibility of transferring from a once-through cooling system to a closed loop cooling system using the ClearSky™ cooling tower system." *Id.* at p. 8, l. 21 – p. 9, l. 2.

Q: Do you agree with Mr. Havey that Tetra Tech's ClearSky cooling towers are a "practical alternative" at IPEC?

A: No. Mr. Havey is not an engineer, and it does not appear that he has any relevant engineering experience with large-scale modifications to power plants, let alone nuclear power plants. His degree is in environmental science and public policy and it appears the extent of his relevant experience consists of performing reviews of similar "feasibility analys[e]s" in California. To an engineer, there is nothing "practical" about retrofitting a forty-year-old baseload nuclear power plant on a constrained site with challenging topography with closed-cycle cooling. As I testified above, no nuclear facility originally designed for and operated with once-through cooling has been retrofitted with a closed-loop cooling system. Here, Unit 2 and Unit 3 were both designed and constructed in the mid-1970s with turbines and condensers that were specifically designed for cold Hudson River water that cannot be replicated with closed-cycle cooling under maximum thermal load conditions.

Even more problematically, Tetra Tech has selected novel and unproven ClearSky cooling towers as the centerpiece of its proposed retrofit. Mr. Havey provides no performance data from the test cell that has operated approximately seven (7) years in the New Mexico desert at the San Juan Generating Station. In fact, the only study of ClearSky cooling towers is from a Department of Energy ("DOE") grant for that single test cell, and even the DOE recognized, in 2009, the unproven nature of the technology. At the time, the towers were referred to as Air2Air®:

> SPX Cooling Technologies is ***presently investigating*** the Air2Air® for evaporative cooling towers (Figure 1) under the U.S. Department of Energy (DOE) Grant No. DE-FC26-06NT42725. The ***preliminary findings*** from the research are encouraging in that the basic principles behind the technology are sound and the water savings are substantial. However, in the course of executing this project, ***construction costs of the validation cell (Figure 2) exceeded expectations. To be economically viable, more research is required to develop an efficient heat transfer***

pack and redesign the overall geometry of the tower including pack orientation and superstructure.

U.S. Dept. of Energy, *Improvement to Air2Air® Technology to Reduce Fresh-Water Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants, ProMIS/Project No.: DE-NT0005647* (Jan. 2009) (Entergy Ex. 357) (emphasis added). As evident from the title of the study, the experimental ClearSky technology originally had a specific focus which was to promote cooling tower applications in arid areas via reduction of fresh water evaporative cooling loss, which is largely irrelevant to the IPEC application.

Accordingly, SPX undertook a second study under a DOE grant award from October 1, 2008 through December 31, 2011 with the objective to "further enable Air2Air® becoming a commercially viable water savings and plume abatement technology by researching a re-engineered pack, testing improvement provided by modification, and prototyping the pack manufacture to improve pack economy, as it relates to superstructure volume, cost, pack orientation, and ducting details." *See* Final Report, Improvement to Air2Air™ Technology to Reduce Fresh-Water Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants (June 30, 2012) (Entergy Ex. 359) at 5. The final report, dated June 30, 2012, detailed SPX's efforts under the research grant to "prototype" and "adjust our design and propose new experiments as we proceeded in the program." *Id.* at 24, 30. Based on these adjustments, even SPX acknowledged that its first commercial products were not available until 2012. *See id.* at 25-26.

As I stated in my prefiled direct, only two ClearSky installations recently (i.e., within the last six months) became operational.

Further, none of the small-scale operational ClearSky towers are representative of the 44 back-to-back cells proposed for each Unit at IPEC. Although no operational information has been provided by Tetra Tech for SPX's test cell, it is apparent that the water quality and environmental conditions at the location of the test cell in New Mexico are very different than water quality of the Hudson River and environmental conditions in Buchanan, New York. In fact, as far as I know, there is no operating brackish water application of a ClearSky cooling tower. Tetra Tech, therefore, is not only proposing a modification that has never been done at a nuclear facility before—converting from once-through to closed-cycle cooling—but it proposes to do so using unproven cooling tower technology.

Q: Do you agree with Mr. Ortiz's testimony that the ClearSky configuration proposed by Tetra Tech "was determined to be technically feasible"?

A: It is not clear to me how Mr. Ortiz can offer this opinion. Mr. Ortiz does not appear to have any relevant engineering experience performing modifications at a nuclear power plant, much less modifications associated with cooling tower applications. Rather, Mr. Ortiz is a "Piping Engineer" who has "worked in the pulp and paper, petrochemical and mining industries." Staff Ex. 247 at 1. Moreover, the basis for Mr. Ortiz's opinion is unclear in light of the admission in the first page of his testimony that he "ha[d] no firsthand knowledge of this project…." Ortiz Direct at p. 1, l. 19-23. As a result, all of his direct testimony is "based on [his] personal observations and interpretations of the project files, reports, and conversations with former members of this project." *Id.* Mr. Ortiz never identifies any employees at Hatch that actually have firsthand knowledge of Hatch's review of the ENERCON Closed-Loop Cooling Reports or the Tetra Tech CCC Report, nor does he identify any of the "project files" other than the four reports provided by the parties in this proceeding—ENERCON 2003, ENERCON 2010, Tetra Tech CCC Report, and Hatch 2012. Throughout his testimony, Mr. Ortiz offers opinions based upon his "review of ... report[s] presented to [him]" or his "interpretation of the documents [he has] reviewed," and he acknowledges that "varying interpretations of [Hatch's] services may exist." *Id.* Mr. Ortiz nevertheless goes on to say that, "based on [his] research the direct testimony being provided is a ***reasonable interpretation*** of Hatch's methods and findings." *Id.* at p. 1, l. 21-23 (emphasis added).

Accordingly, Mr. Ortiz does not appear to be offering his own opinion on the feasibility of a closed-cycle cooling retrofit of IPEC, but his interpretation of documents authored by and containing the opinions of unidentified Hatch personnel. Further, Mr. Havey indicates that Hatch did not review ENERCON 2010 (SAIC did). *See* Havey Direct at p. 8, l. 20-22.

In addition, Mr. Ortiz's opinion and his review of the Tetra Tech proposal is heavily caveated and "limited" in a manner that does not allow a reasonable feasibility determination of the sort that represents the industry standard or expectation. According to his testimony, Hatch expressly "did not analyze the Algonquin pipeline feasibility assessment, nor did they review issues related to potential groundwater radiological contamination, nor any visual assessment, blasting, building or equipment relocations, the modification or addition of site services, and air quality." Ortiz Direct at p. 6, l. 6-10. These "limitations" represent the majority of the most obvious and most significant challenges to the feasibility of retrofitting IPEC with closed-cycle cooling. No reasonable engineer could conclude that any closed-cycle cooling retrofit of IPEC is technically feasible without addressing these items.

Q: You mentioned earlier that the ClearSky cooling towers represented a novel and unproven technology. What response, if any, did Messrs. Havey and Ortiz have to Enercon's concern about the novelty of Tetra Tech's ClearSky cooling towers?

A: Neither Mr. Havey nor Mr. Ortiz address the fact that ClearSky cooling towers employ novel technology with limited operating experience that presents a large potential risk for a nuclear baseload facility, which should have eliminated the ClearSky towers from consideration as a feasible technology. This lack of response to a fundamental concern is unacceptable in the nuclear power industry, which generally requires that technology choices be supported by demonstrated and reliable operational experience.

In fact, Tetra Tech repeatedly and contemporaneously has rejected ClearSky cooling towers as an unproven technology in reviews it has performed for NYSDEC and the U.S. EPA for other non-nuclear power plants that operate at a much smaller-scale than IPEC. For example:

- **Section 316(b) Rulemaking.** As part of its § 316(b) rulemaking, EPA tasked

Tetra Tech and SAIC (who, according to Mr. Havey reviewed ENERCON 2010 in lieu of Hatch) with evaluating how costs for plume and drift abatement technology, among other things, may be developed for a universe of facilities potentially subject to CCC retrofits under the proposed existing facility rulemaking. As part of that review, Tetra Tech evaluated ClearSky cooling towers, and in its June 11, 2010 memorandum to EPA, concluded that SPX ClearSky "technology has only been demonstrated on a full-scale basis at a single location in New Mexico and ***remains a somewhat unproven technology*** and may require time to develop acceptance within the industry." Memorandum from John Sunda, SAIC, and Kelly Meadows, Tetra Tech to Paul Shriner and Jan Matuszko, USEPA, dated June 11, 2010, at 8 (Entergy Ex. 346) (emphasis added).

- **Glenwood Main Power Station.** Tetra Tech was asked by NYSDEC to conduct a technical review and evaluate the feasibility of various alternatives at the Glenwood fossil fuel steam electric facility. In rejecting a cooling tower configuration proposed by Powers Engineering (Riverkeeper's expert) that would require only 12 ClearSky cells, Tetra Tech's technical review repeated its EPA finding that ClearSky towers "ha[ve] only been demonstrated on a full-scale basis at a single location in New Mexico and ***remain[] an unproven technology for applications such as this***." Tetra Tech, Inc., Glenwood Technical Review, at 4 (Entergy Ex. 348) (emphasis added). Although the Tetra Tech's review of the Glenwood facility is undated, it references documents there were published as late as 2010.

- **Northport Power Station.** On January 28, 2010, NYSDEC requested Northport's owner (National Grid) to provide "...an assessment of a back-to-back, linear array of towers, such as the SPX/Marley ClearSky™ tower configuration for all four units." Washington Group International, Inc., *National Grid Generation LLC, Response to NYSDEC's Request for Additional Information Regarding Cooling Towers* (July 1, 2010), at 1-1 (Entergy Ex. 349). In response, Washington Group International, a division of URS Corporation, submitted a report concluding "the cooling tower technology identified by NYSDEC for further study [ClearSky towers], is yet unproven for application to generating stations such as Northport..." *Id.* at 2-1 ("[A] plume abatement cooling tower using an array of back-to-back cells, such as the system referenced by the NYSDEC, is an unproven technology for a generating station such as Northport. Therefore, there is a high degree of uncertainty associated with its environmental impacts."); Letter from Timothy Curt, National Grid Environmental Management to Colleen Kimble, NYS Department of Environmental Conservation, dated July 1, 2010 at 4 (Entergy Ex. 353) (same). The Washington Group went on to assert that "the tower suggested by DEC is an unproven technology with no identified commercially comparable installations to Northport." Entergy Ex. 349 at 2-6. Tetra Tech performed the technical review of the Washington Group's report and concluded, "[t]he report's conclusion that the Clear Sky Plume Abatement System remains an unproven technology in this application has some merit, but the analysis demonstrates that alternative cooling tower locations for towers arranged in a linear configuration could be found on-site albeit at increased costs." Tetra Tech, Inc., Northport Technical Review at 3 (Entergy Ex. 350) at 3.

Q: Earlier you mentioned site constraints at IPEC that would render retrofitting the facility with closed-cycle cooling problematic. Did Messrs. Havey and Ortiz address the site disruption of the Tetra Tech closed-cycle cooling configuration?

A: No. Neither Mr. Havey nor Mr. Ortiz addressed how Tetra Tech or Hatch plans to relocate the several existing essential structures that conflict with Tetra Tech's proposed ClearSky towers. Mr. Havey testified that, with respect to siting conflicts, the Tetra Tech CCC Report was "not intended to enumerate all potential items that would be addressed in a final engineering and construction plan. Their exclusion from the Tetra Tech 2013 report does not imply they are immaterial or irrelevant for final design and cost estimates." Havey Direct at pg. 19, l. 20 – pg. 20, l. 3. Mr. Ortiz specifically testifies that Hatch did not analyze "building or equipment relocations, [and] the modification or addition of site services." Ortiz Direct at p. 6, l. 6-9. Mr. Ortiz went on to inexplicably assert that such conflicts "cannot be studied in detail during the limited scope of a feasibility report." *Id.* at p. 9, l. 21 – p. 10, l. 3.

Enercon has prepared Exhibit 373 which is an overhead aerial photograph of the IPEC site showing the footprint of Tetra Tech's proposed cooling towers for Unit 2 and Unit 3. As reflected on Exhibit 373, Tetra Tech proposes to locate its cooling towers effectively on top of many essential buildings and structures.

Without these structures, IPEC would be unable to operate. By not acknowledging these siting conflicts and developing a plan for relocating essential structures, Tetra Tech's ClearSky towers cannot be considered feasible at IPEC.

Q: I would like to focus on some of the specific site disruptions that were identified by Enercon in the ENERCON 2013 CCC Response. First, how, if at all, do Messrs. Havey and Ortiz propose resolving the potential issues with groundwater contamination?

A: They do not address the issue. As I explained earlier, Tetra Tech's proposed configuration calls for the existing discharge canal, which is parallel to the River and the Unit 2 and Unit 3 power houses, to be converted into a hot water reservoir and pump pit. In order for the reservoir to provide the necessary submergence for proper operation of the new circulating water pumps, the current Unit 2 discharge canal will need to be deepened considerably. As set forth in the ENERCON 2013 CCC Response, this excavation is in the very location where groundwater containing Tritium and Strontium has been observed. *See* Entergy Ex. 42. To maintain dry conditions required for pipe construction and backfilling, contaminated groundwater would need to be continually pumped from the excavation area below the groundwater table (i.e., dewatering), which will have to be continued until completion of the excavation.

In fact, Mr. Havey admits that "the retrofit project for Unit 2 is heavily dependent on finding an acceptable solution for dewatering the area during excavation and construction" and "[i]t is my opinion that the plume area will likely require sampling to determine what disposal and/or treatment methods, ***if any***, are most appropriate to manage dewatered groundwater and excavated material." Havey Direct at p. 21, l. 19 – p. 22, l. 1 (emphasis added). Despite Mr. Havey's acknowledgement that groundwater radiological contamination may render the Unit 2 tower infeasible, both Tetra Tech and Hatch inexplicably excluded "issues related to potential groundwater radiological contamination" from their feasibility assessment. *See, e.g., id.* at p 13, l. 1-3. No feasibility determination can be reached for retrofitting Unit 2 with closed-cycle cooling unless and until Tetra Tech addresses impacts from the groundwater plume.

Q: Continuing with specific site disruptions discussed in the ENERCON 2013 CCC Response, how, if at all, does Tetra Tech's ClearSky configuration proposed for Unit 2 account for IPEC's Independent Spent Fuel Storage Installation ("ISFSI")?

A: It does not. One of the most apparent and problematic aspects of Tetra Tech's proposal for Unit 2 is that the excavation for the Unit 2 towers and associated piping interferes directly with IPEC's ISFSI. The ISFSI is a critical component of the IPEC site for dry cask spent nuclear fuel storage. IPEC's ISFSI is a three-foot thick concrete pad that is approximately 100 ft by 200 ft designed to store large, sealed casks containing spent fuel rods. Construction of the ISFSI lasted three years and cost over $13 million dollars. As of February 2014, there were twenty-six (26) casks contained within the ISFSI. The casks are made of steel and concrete and are 18-20 feet high, 11 feet in diameter, and have 2 foot thick concrete walls. Each cask weighs over 300,000 pounds when loaded.

IPEC's ISFSI and the spent-fuel casks that it stores are heavily regulated and subject to intensive oversight by NRC. In order to construct the proposed towers for Unit 2, the current ISFSI must be decommissioned and demolished. Before that work can start, however, IPEC must obtain permits for and construct an entirely new ISFSI at a different location to store the spent fuel casks. The Tetra Tech CCC Report and the prefiled testimony of Messrs. Havey and Ortiz completely fail to address the significant impact on the feasibility of the Unit 2 cooling towers, not to mention its schedule, of the need to: (1) identify a viable location for, permit and construct a new ISFSI; (2) transfer the existing casks to that new ISFSI; and (3) decommission and demolish the existing ISFSI, all before commencing construction of the Unit 2 tower. In fact, Tetra Tech has performed no analysis to determine if a new ISFSI can be built at IPEC. Another significant obstacle is that the extremely heavy loads restrict what roads can be used to transport the 300,000 pound spent fuel casks. Given these restrictions, there is a risk that there will be no suitable right-of-way to transfer the spent fuel from the reactors to the new ISFSI location. Without resolving this siting conflict and others that may arise relative to the need for a new ISFSI, the Unit 2 towers cannot be considered feasible.

Q: Third, focusing now on Unit 3, how, if at all, do Messrs. Havey and Ortiz address the feasibility issues associated with the Algonquin Pipeline?

A: They do not. Neither Hatch nor Tetra Tech "analyze[d] the Algonquin pipeline feasibility assessment," *see* Ortiz Direct at p. 6, l. 6-12; Havey Direct at p. 13, l. 1-7, or provided any solution to resolve the conflict. In fact, the relocation of the

Algonquin Pipeline and feasibility assessment was expressly excluded from both Hatch and Tetra Tech's review. As I stated in my prefiled direct testimony, Tetra Tech's closed-cycle cooling reconfiguration at Unit 3 cannot be considered feasible without resolving the Algonquin pipeline conflict.

Q: **Your testimony thus far has focused on site-specific challenges to the feasibility of constructing Tetra Tech's ClearSky cooling towers at IPEC. Assuming the towers can be constructed, have Messrs. Havey and Ortiz reasonably demonstrated that the towers will function efficiently at IPEC without significantly degrading IPEC's performance?**

A: No. Mr. Havey does not address the impacts associated with Tetra Tech's proposal on the ability of IPEC's condensers to efficiently reject heat, nor does he address the Burns and Roe condenser analysis described in the ENERCON 2013 CCC Response and my prefiled direct testimony that demonstrated that additional capacity is likely needed to reduce the pressure in the condenser during at least one of IPEC's transient conditions. For his part, Mr. Ortiz concedes in his testimony that it "was ***impossible to accurately assess*** the impact on condenser thermal performance with a higher inlet cooling water temperature resulting from use of the cooling towers." Ortiz Direct at p. 10, l. 20-22 (emphasis added). Based on what Tetra Tech has reported, however, there are several known issues with the ClearSky towers that will detrimentally and materially impact IPEC's performance, including its ability to generate electricity reliably and efficiently.

Q: What are those known issues?

A: The current closed-cycle cooling retrofit alternatives at IPEC will both (1) reduce the amount of available circulating available to cool the condensers and (2) increase the temperature of the cooling water. These are both major operating constraints that will mean that IPEC will not be able to generate as much electricity as it does in the current once-through system, and in some cases, could lead to excursions and unplanned outages.

Significantly, Tetra Tech has failed to address its decision to reduce IPEC's maximum flow rate from 840,000 gpm to 700,000 gpm for each Unit. In fact, one of Tetra Tech's criticisms of the ENERCON Closed-Loop Cooling Reports was the decision to reduce maximum flow to 700,000 gpm for each Unit. Tetra Tech stated:

> This discussion not only implies that each condenser has a throughput capacity of 840,000 gpm, but that the maximum capacity is actually needed during peak summer periods. Consequently, each unit's replacement cooling tower should be designed to meet the most critical operating conditions that would be expected during the year, i.e., 840,000 rather than the 700,000 gpm used in the design criteria.

Memorandum from Tim Havey, Tetra Tech, Inc. to Chuck Nieder and Chris Hogan, NYS Department of Environmental Conservation, dated July 6, 2010, at 6 (Appendix B to Staff Ex. 214). Tetra Tech went on to note that "[i]f correct, the tower as designed appears to be insufficiently sized to accommodate the higher summertime volumes that are sometimes needed." *Id.* Enercon's decision to reduce the maximum flow to 700,000 gpm was appropriate at the time because it reflected a balance between the parasitic loss associated with pumping the extra circulating water up to the cooling towers and additional fans required to cool that water with the expected degradation in power performance based on the then-current PEPSE models for IPEC Units 2 and 3. Because Tetra Tech's proposal has a different pump and fan dynamics than the round hybrid towers with less parasitic losses, Tetra Tech ought to have reanalyzed whether 700,000 gpm was an appropriate design choice for its towers. Instead, Tetra Tech simply copied design decisions from the round hybrid towers described in ENERCON 2010 without properly considering whether those design choices are appropriate for the ClearSky towers.

As part of the preparation for this testimony, Enercon was informed by Entergy that the PEPSE model used in ENERCON 2010 and the ENERCON 2013 CCC Response had been updated and re-benchmarked. Preliminary analysis of the updated model shows higher power losses when the Units are run at 700,000 gpm, particularly at Unit 2 and particularly during the critical summer months, than what has been reported previously. Based on the results of this preliminary analysis, it is clear that the ClearSky towers proposed by Tetra Tech are significantly undersized. This analysis emphasizes why it was incumbent on Tetra Tech to perform and include PEPSE modeling, as well as other critical thermal performance data, such as cooling tower performance curves, in its report in order to validate its design choices and establish post-modification operating power losses.

Q: You also mentioned that in addition to reducing the maximum amount of available water, closed-cycle cooling would also increase the temperature of

the circulating water used to cool the condensers. How will that affect plant performance?

A: The increased temperature of the circulating water, combined with the reduced flow, will lead to increased condenser backpressure that will reduce the facility's ability to generate power. These effects will be felt most in the summer, when the cooling need is the highest and the demand for electricity is the greatest. But there are additional aspects of the ClearSky towers that amplify the inherent and detrimental impact associated with a closed-cycle cooling retrofit at IPEC.

First, as I stated in my prefiled direct, the cooling towers are susceptible to recirculation of the hot, humid exhaust back into the intake, which will increase the entering wet-bulb temperature and reduce the towers' ability to cool the water. Mr. Havey does not address Enercon's concern that the configuration and orientation of the ClearSky towers will likely result in recirculation thereby decreasing their performance and detrimentally affect plant operations. Mr. Ortiz states only that "to better simulate recirculation effects created by different wind conditions a more detailed analysis is required," but he defers this important consideration to later in the "engineering phase of the project" where "adjustments, if required can be implemented…." Ortiz Direct at p. 11, l. 12-19. This is not sufficient; the impact recirculation will have on cooling tower performance affects threshold design decisions, such as the number of cooling cells required and the size of those cells. It would be inappropriate to make a "feasibility" determination of a configuration that calls for forty-four (44) cells per unit, only to find out later in the process that, for example, fifty (50) or more cells per unit were actually needed. By way of example, SPX has provided to Enercon a "ClearSky Selection Summary" that proposes a different configuration ClearSky towers for IPEC, consisting of sixty-two (62) smaller ClearSky cells per Unit. The selection summary provided to Enercon explicitly assumes recirculation would increase the inlet wet bulb temperature by 2^{o}F (changing the design wet-bulb temperature from 77^{o}F to 79^{o}F), and as much as 5^{o}F "under certain wind conditions." *See* SPX, Entergy Indian Point Units 2 & 3, ClearSky Selection Summary (Entergy Ex. 347).

Second, Tetra Tech proposes aligning the ClearSky cooling towers in a back-to-back configuration. It is well understood that linear, mechanical draft cooling towers do not perform well in a back-to-back configuration. In fact, this is a point that Tetra Tech has made in several other technical reviews it has made. For example, in a review Tetra Tech performed for NYSDEC for the Northport Generating Station, Tetra Tech noted that "[c]onventional hybrid wet/dry mechanical draft cooling towers must be configured in an in-line (single row) arrangement and cannot be placed in a back-to-back configuration because of issues with poor mixing of the wet and dry section exhaust in the back-to-back configuration." Tetra Tech, Inc., Northport Technical Review at 2 (Entergy Ex. 354). Tetra Tech made a similar statement in the review of the Huntley facility: "[d]oubled-up towers are also referred to as back-to-back configurations and are generally not compatible with hybrid wet/dry plume abatement cooling towers." Memorandum from John Sunda, Steve Geil, and Kelly Meadows, to Chuck Nieder, NYSDEC, and Jamie Hurley, USEPA, dated Oct. 5, 2011, at 6-7

(Entergy Ex. 355). I understand that SPX advertises that, conceptually, ClearSky cooling towers can be designed and operated in a back-to-back configuration, but there is no operational experience showing this to be the case. Indeed, the Air2Air test cell at the San Juan Generating Station in New Mexico cannot be used in a back-to-back configuration because it has air intakes on two sides, which is another reason that it is not representative of NYSDEC's proposal to construct two towers of 44 back-to-back ClearSky cells at IPEC.

Third, in addition to known operational problems associated with using cooling towers in salt water applications (e.g., salt deposition, electric arcing, etc.), the thermophysical properties of salt water degrades cooling tower performance as compared to cooling towers that use freshwater. Recent studies have shown that increased salt concentrations materially alter the efficiency of cooling towers to a substantial degree. *See* Mostafa H. Sharqawy et al., *On Thermal Performance of Seawater Cooling Towers*, 133 J. Eng. Gas Turbines & Power (Apr. 2011), at 6 (Entergy Ex. 352) ("It is found that an increase in salinity decreases the air effectiveness by 5-20% relative to freshwater cooling tower."). Here, Tetra Tech proposes concentrating the salt level in the Hudson River three times in its closed-cycle system, which will amplify degradation of thermal performance attributable to increased salinity. Although Mr. Havey asserts in his prefiled testimony that Tetra Tech's proposed ClearSky towers are designed to reject the maximum thermal load under the "most stringent conditions," including "highest salinity" (Havey Direct at p. 29, l. 10-13), Tetra Tech does not identify the salinity levels that were provided to SPX or how (or even whether) SPX adjusted the size of its cooling towers to account for the increased salinity of the Hudson River. Without this information, there is a substantial risk that Tetra Tech has further undersized its cooling towers.

Q: Aside from and in addition to the impacts that will reduce IPEC's ability to generate power, are there any significant operational problems associated with the proposed ClearSky towers that are not addressed by Messrs. Havey and Ortiz and need to be to reach a feasibility determination?

A: Yes. Mr. Havey and Mr. Ortiz fail to address the potential site impacts that could result from the localized plume of humid, salt-laden air that is exhausted from Tetra Tech's ClearSky cooling towers. Importantly, the ClearSky towers discharge at lower velocities, at a lower height, and with less thermal buoyancy than the round hybrid towers described in the ENERCON Closed-Loop Cooling Reports. As a result, the ClearSky towers have more concentrated and localized plumes at ground level, which increases salt deposition and temperature/humidity effects on electrical equipment and components in close proximity to the towers. This creates a number of personnel and station safety-related issues, such as electrical arcing, icing during the winter, and fogging due to the cooling tower plume on occasion. Ground level icing and salt deposition poses serious workplace safety, maintenance, and environmental concerns, with the potential to render certain areas of the site treacherous during winter months, as well as creating substantial local vegetation impacts. Fogging that would lead to reduce visibility creates associated security risks at the facility.

The risk of icing poses unique operational concerns for ClearSky towers, which use proprietary "ClearSky heat exchangers" that are designed to condense moisture from the cooling tower's exhaust in the form of "high purity water—approaching distilled water quality." Entergy Ex. 359 at 10. As SPX noted in its 2012 DOE Report, imperfect seals will cause leakage within the ClearSky heat exchanger that will cause icing in the heat exchanger in cold weather. SPX correctly acknowledged that "[t]his behavior is unacceptable in the commercial market place." *See id.* at 19. Although SPX advertises that it has performed laboratory testing on its condensing modules in "all four seasons," tellingly, the test data it selected to include in its 2012 DOE Report only includes results for spring and summer, not the cooler seasons of fall and winter. *See id.* at 14-15. At this point, it is simply unknown whether SPX's ClearSky heat exchangers are appropriate for the IPEC site conditions.

Another aspect of cooling tower operation not addressed by Mr. Havey or Mr. Ortiz is the potential operational impacts associated with sedimentation in the closed-cycle system. Evaporation of water and drift will elevate the concentration of sediments in the closed-loop system above ambient Hudson River conditions. In addition, it is well known that cooling towers act as air scrubbers, which flush airborne contaminates into the closed loop system further elevating sediment concentrations. It can be expected that this sediment will settle and accumulate in the modified discharge canal and in the cooling tower basins, and it will need to be periodically removed. Tetra Tech provides no explanation for how it proposes to control and/or remove sedimentation in its closed-system configuration.

Q: **On the subject of security considerations, is IPEC required to utilize flood lighting for security purposes that would illuminate any visible plume at night?**

A: Yes. IPEC's security procedures require the site to be fully lighted at night, which would illuminate any visible plume.

Q: **Finally, assuming they can be constructed, did Messrs. Havey and Ortiz account for the inherent concerns with fiberglass towers?**

A: No. Mr. Havey argues at page 20 of his prefiled testimony that fiberglass towers generally are "structurally sound" and can be reinforced to "meet higher wind load requirements." Havey Direct at p. 20, l. 4-20. There is evidence, however, that raises serious concerns of fiberglass towers' structural integrity. Most notably, in the 2011 Cooling Technology Institute Annual Conference, American Electric Power presented a paper entitled, *AEP's Experience with Polyester FRP Structure Cooling Towers,* that described significant structural failures with five fiberglass towers constructed with pultruded fiberglass. Of the 15 hyperbolic and 30 mechanical draft cooling towers on the AEP system, the five towers constructed from 2008 through 2010 were AEP's first fiberglass towers. AEP's experience is a cautionary tale insofar as four of the five towers experienced failed or cracked fiberglass columns and surface blisters were noticed in two of the new towers after 2 to 18 months of operation. *See* Bob Cashner, *AEP's Experience with Polyester FRP Structure Cooling Towers,* Cooling Tower

Institute (Feb. 6-10, 2011), at 2 (Entergy Ex. 358). These failures caused AEP to conduct additional testing of the fiberglass material in 2009. *See id.* at 11. The testing involved repeated exposure to saturation and then freezing or drying or both. In sum, a total of 83 defects were documented in all sixteen samples representing the four different test conditions. *Id.*

IV. REBUTTAL TO NYSDEC'S TESTIMONY CONCERNING THE FEASIBILITY OF RETROFITTING IPEC WITH ROUND HYBRID COOLING TOWERS

Q: Turning now to the round hybrid mechanical draft cooling towers described in the ENERCON Closed-Loop Cooling Reports, as a preliminary matter, has Enercon or Entergy proposed the circular hybrid cooling towers described in the ENERCON Closed-Loop Cooling Reports as the best technology available for IPEC under 7 NYCRR § 704.5 and § 316(b) of the Clean Water Act?

A: No. Entergy was required by NYSDEC to evaluate the possible conversion of the existing system to a closed-loop circulation water system configuration. In response to that mandate, Enercon selected a closed-loop configuration utilizing hybrid round towers, which are the only cooling towers that could "reasonably be considered" at IPEC. As I stated in my prefiled testimony dated July 22, 2011:

> In the Closed-Loop Cooling Report, ENERCON concluded that the absence of a history of closed-cycle cooling retrofits and site-specific conditions at Indian Point would challenge the feasibility of such an installation. The several reasons for the conclusion are explained in detail in the Closed-Loop Cooling Report. Briefly,

> conversion of Indian Point to closed-loop cooling would be an unprecedented undertaking that would encounter numerous significant identified siting and construction challenges, some of which may not be successfully surmounted. Such a conversion is unprecedented, because no nuclear stations designed solely for once-through cooling have been converted to closed-loop cooling. This nuclear experience is critical, because conversion of the condenser cooling system of an existing plant presents fundamental design problems that result in plant performance impacts or require redesign of the essential plant equipment, e.g., the condenser. Moreover, absent any practical history of closed-loop cooling retrofits at nuclear facilities, engineering observations and conclusions regarding any such conversion must be made on a purely speculative basis and are inherently subject to unforeseen challenges during the detailed design and the subsequent construction phases. Only upon successful operation of a completed closed-loop cooling retrofit at a representative number of comparable facilities could this type of conversion be conclusively considered feasible.

Prefiled Testimony of Sam Beaver in Support of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations, Inc. at 21:5-22, dated July 22, 2011.

Q: Are there any examples of round hybrid towers at nuclear facilities of the size contemplated in the ENERCON Closed-Loop Cooling Reports?

A: There is only one round hybrid tower of a size that approaches what would be required for each of IPEC Unit 2 and Unit 3, located at the Neckarwestheim nuclear power plant (Unit 2) in Germany. There are, however, several important differences between the Neckarwestheim facility and IPEC. Most significantly, the Neckarwestheim Unit 2 cooling tower was constructed as part of a *new* facility, not a retrofit of an existing facility. The Neckarwestheim Unit 2 cooling tower is also subject to different environmental and water quality conditions than what would be experienced at IPEC.

Q: Did Messrs. Ortiz and Havey offer any analysis concerning the feasibility of retrofitting IPEC Units 2 and 3 with round hybrid cooling towers?

A: No. While Mr. Havey testifies that the circular hybrid cooling towers described in ENERCON 2003 "could be constructed, installed, and operated at the Indian Point nuclear facilities," Havey Direct at p. 3, l. 19-21, and that "Enercon's circular hybrid cooling tower proposal was available and generally feasible for the IPEC facilities in order to satisfy the BTA requirements of 6 NYCRR § 704.5," *id.* at p. 10, l. 8-10, he offers ***no*** additional analysis. Likewise, Mr. Ortiz offers no analysis nor justification. Further, Mr. Ortiz's opinion as to the feasibility of retrofitting Units 2 and 3 with round hybrid towers is even less clear. In response to a question as to whether the circular hybrid cooling tower configuration described by Enercon in its 2003 and 2010 is "available and generally feasible," Mr. Ortiz testifies that "[b]ased on the limited scope and analysis of the study [the round hybrid towers] ***may be*** feasible, ***but a more in depth study would be necessary to obtain a final conclusion.***" Ortiz Direct at p. 5, l. 1-2 (emphasis added).

Q: Do you agree with Mr. Havey's opinion that the circular hybrid cooling towers described in the ENERCON Closed-Loop Cooling Reports "could be constructed, installed, and operated at the Indian Point nuclear facilities" and Mr. Ortiz's testimony that such a retrofit "may be feasible"?

A: No. While retrofitting IPEC Units 2 and 3 may be theoretically possible (and cost over two billion dollars and take over eight years in construction time alone), the ENERCON Closed-Loop Cooling Reports identified numerous significant challenges to the feasibility of retrofitting IPEC Units 2 and 3 with circular hybrid cooling tower. These include, but are not limited to, appreciable elevation changes, a general lack of available space, a subsurface primarily composed of solid rock, the location of a major interstate gas pipeline, local air quality, archeological and aesthetic considerations, etc. Given the sizeable challenges and level of unknowns, based upon my best professional judgment, I could not in good conscience recommend round hybrid cooling towers for IPEC as a practical or reasonable alternative for compliance with regulatory requirements associated with the Clean Water Act.

To reach any other conclusion about the feasibility of round hybrid towers, the challenges identified in the ENERCON Closed-Loop Cooling Report would need to be fully addressed. Neither Mr. Havey nor Mr. Ortiz resolved any of the uncertainties described in the ENERCON Closed-Loop Cooling Reports, and as a result, are not in a position to conclude that round hybrid towers are feasible at IPEC.

Q: Did Tetra Tech or Hatch materially dispute any of the conclusions of the ENERCON Closed-Loop Cooling Reports?

A: No. According to Mr. Ortiz, Hatch's review of the Enercon Closed-Loop Cooling Reports was limited to reviewing the reports by unidentified Hatch employees and providing "comments" to Mr. Havey at Tetra Tech. Hatch's review of ENERCON 2003 was reportedly limited to "challenging certain assumptions on the prevailing winds, soil conditions, some contradictions on the wet bulb temperatures used, and identified minor discrepancies." Ortiz Direct at p. 3, l. 17-19. Given this context, Mr. Ortiz's testimony that in Hatch's review of ENERCON 2010, "no major issues or deficiencies were identified ***by Hatch*** with respect to the technical feasibility of transferring from a once-through cooling system to a closed loop cooling system" is not helpful to me as an engineer. *See id.* at p. 4, l. 15-28 (emphasis added). It is further complicated by the fact that Mr. Havey states in his testimony that SAIC, not Hatch, reviewed ENERCON 2010. *See* Havey Direct, at p. 8, l. 20-22. Mr. Ortiz does not even discuss the major issues and challenges identified ***by Enercon*** in its report.

There is nothing in Mr. Ortiz's testimony that shows a basis for ***any*** engineering conclusions as to feasibility of round hybrid cooling towers at IPEC. Similarly, Tetra Tech did not dispute and in fact, validated, many of the major conclusions of the ENERCON Closed-Loop Cooling Reports. For example, Tetra Tech agreed:

1. Enercon's estimate for direct capital costs of $1.19 ***billion*** and ongoing operation and maintenance costs of $2.0 to $4.0 million per year per unit were "well within the range of comparable project estimates developed for other nuclear facilities when adjusted for the unique considerations at IPEC (found hybrid towers, transmission pipeline relocation, etc.)." Memorandum from Tim Havey, Tetra Tech, Inc. to Chuck Nieder and Chris Hogan, NYS Department of Environmental Conservation, dated July 6, 2010 at 3 (Staff Ex. 214, Appendix B).
2. Enercon's estimate of 12 to 13 years for construction was "not unreasonable given the volume of blasting and spoils removal that would have to occur, and the limitations placed on construction activities by local ordinances and seasonal weather concerns." *Id.*
3. Enercon's estimate that construction of closed-cycle cooling would require taking both IPEC units offline for up to 42 concurrent weeks was "reasonable and acceptable." In fact, Tetra Tech concluded that "[t]he obstacles presented by reconfiguring the existing discharge canal to function as a main component of the new cooling system are correctly cited by Enercon as unavoidable. There do not appear to be any practical means to significantly decrease this estimate." *Id.*
4. Enercon's estimate of thermal efficiency losses were reasonable when compared to other similar projects. *Id.*

Q: Were there any limitations or caveats in the prefiled testimony of Messrs. Havey and Ortiz with respect to Tetra Tech and Hatch's review of the ENERCON Closed-Loop Cooling Reports?

A: Yes. Although both Mr. Havey and Mr. Ortiz suggest that hybrid round cooling towers may be generally feasible, both Hatch and Tetra Tech again excluded from consideration (1) the Algonquin pipeline relocation and feasibility assessment and (2) "issues related to potential groundwater radiological contamination." *See* Havey Direct at p. 8, l. 10-17; *see also* Ortiz Direct at 4:11-18. In short, and for the same reasons I testified earlier, relocating the Algonquin pipeline and issues related to potential groundwater radiological contamination must be resolved prior to any feasibility determination being made.

V. <u>REBUTTAL TO CHARLES NIEDER</u>

Q: Have you had an opportunity to review Mr. Nieder's testimony regarding capital costs of operating CWWS at IPEC?

A: Yes. Mr. Nieder suggests that Enercon did not provide enough detail to support its estimate of the capital costs for constructing the proposed array of CWWS. I have submitted as Entergy Exhibit 372 additional details that support Enercon's estimate of capital costs which should address Mr. Nieder's concern.

Q: Have you had an opportunity to review Mr. Nieder's testimony regarding the O&M costs of operating cylindrical wedgewire screens at IPEC?

A: Yes. Mr. Nieder contends that he was not able to calculate the proportional costs of Entergy's proposed CWWS array because it did not include annual O&M costs of the CWWS array. He further disputes NERA's conclusion that the O&M costs for CWWS would be insignificant based on other estimates he had received for CWWS O&M costs from other facilities because the "median O&M costs represented 38 percent of the total costs for constructing and operating CWWSs for 20 years. This percentage level of the overall costs for constructing and operating CWWSs for 20 years is significant." Nieder Direct at p. 17, l. 8-10.

Q: As a preliminary matter, is it appropriate to calculate O&M costs for the CWWS for a 20 year life period?

A: No. CWWS will not be operating for the full twenty years of Entergy's renewed license. Entergy's NRC renewed operating licenses for Unit 2 and Unit 3 would expire in 2033 and 2035, respectively. We have estimated that the design phase of the CWWS project would extend for approximately two years and in-river construction activities would occur over three successive years, with the final tie-in occurring in the sixth year. Accordingly, assuming design and construction begin after these proceedings and any associated court proceedings end, which I understand NERA assumed would be 2018, construction would not be complete, and therefore Entergy would not be incurring O&M costs for each Unit, until roughly 2024. As a result, O&M costs would only be incurred for 9-11 years until the operating license respectively expire, or an average of 10 years per unit. That is only half the period assumed by Mr. Nieder.

Q: Do you agree with Mr. Nieder's estimate that potential O&M costs for CWWS would render the overall costs significant?

A: No. As Mr. Nieder acknowledges, the principal O&M cost associated with any CWWS proposal is the cost associated with cleaning the screens. Entergy has specifically made design choices to minimize the risk of fouling and therefore reduce the need for cleanings, including constructing the screens out of Johnson Screen's Z-Alloy, which has been demonstrated to resist biofouling in the Hudson River, and selecting a conservative through-slot velocity of 0.25 feet per second. In addition to these design choices, during the summer months when the potential for fouling is at its highest and when the biological need is the greatest, Entergy can use divers to regularly—and even continually—clean the screens. From Entergy's past experience with cleaning the Ristroph screens, the average cost for a dive team at IPEC is $7,000 per day. There is no reason to conclude that the per day cost of dive teams would be any different for CWWS than the current intake structure. For the rest of the year (i.e., fall through spring), when the risk of fouling is considerably lower, monitoring in the intake bays would alert the operators of any potential fouling issues with the screens, and divers can be deployed on an "as needed" basis.

VI. <u>CONCLUSION</u>

Q: **Has anything that you have read in the testimonies of Messrs. Havey, Ortiz, and Nieder or in the documentary exhibits attached to their testimony affected the opinions you previously testified to in your February 28, 2014 prefiled testimony?**

A: No. For the reasons detailed above, nothing that I have reviewed alters my bottom-line conclusion that the given the numerous and significant site-specific challenges associated with retrofitting IPEC with closed-cycle cooling documented by Enercon, the considerable uncertainty inherent in such a retrofit project, and the detrimental impact that a closed-cycle cooling retrofit would have on the facility's ability to generate electricity, NYSDEC Staff has failed to demonstrate that cooling towers are feasible at IPEC.

END OF TESTIMONY

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollutant Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc.'s Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

PREFILED REBUTTAL TESTIMONY OF JOHN R. YOUNG IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.

CLOSED CYCLE COOLING

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

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March 28, 2014

TABLE OF CONTENTS

I. INTRODUCTION

Q: Please identify yourself.

A: My name is John R. Young, Ph.D. I am a Senior Scientist and Vice President at ASA Analysis & Communications, Inc. ("ASA"), an environmental consulting firm based in Lemont, Pennsylvania. In this capacity, I provide technical direction for ASA's applied statistics and environmental monitoring services. My business address is 921 Pike Street, Lemont, PA 16851-0303.

Q: Are you the same John Young who provided prefiled direct testimony on February 28, 2014, on behalf of Entergy in support of its application for SPDES Permit Renewal (DEC No.: 3-5522-00011/00004, SPDES No.: NY-0004472) and a Water Quality Certification (DEC App. Nos. 3-5522-00011/00030 (IP2) and 3-5522-00105/00031 (IP3)) for Indian Point Units 2 and 3 (the "Proceedings")?

A: Yes.

Q: Please state the purpose of your prefiled rebuttal testimony.

A: The purpose of my prefiled rebuttal testimony is to address certain portions of the prefiled direct testimony of New York State Department of Environmental Conservation ("NYSDEC") Staff members Charles Nieder ("Nieder Direct") and Christopher Hogan ("Hogan Direct") submitted as part of these Proceedings on February 28, 2014. I have reviewed the prefiled testimony of these individuals and the relevant materials on which each relies.

Q: How is your rebuttal testimony organized?

A: My testimony is organized into three sections. First, I respond to statements by Mr. Hogan about CCC furthering recreational and commercial fishing and Mr.

Nieder's testimony that the theoretical harvest impacts presented in the reports produced by NERA Economic Consulting ("NERA") entitled *"Wholly Disproportionate" Assessments of Cylindrical Wedgewire Screens and Cooling Towers at IPEC* (December 2013) (Entergy Ex. 297) and *Benefits and Costs of Cylindrical Wedgewire Screens or Cooling Towers at IPEC* (December 2013) (Entergy Ex. 296D) (collectively, the "NERA Reports") are inconsistent with the previous testimony of Entergy's biology team that reducing impingement and entrainment mortality at Indian Point would not increase fish populations in the Hudson River. Second, I respond to Mr. Nieder's testimony understating the reductions in entrainment mortality, or efficacy, associated with Entergy's proposed Cylindrical Wedgewire Screen ("CWWS") array. Third, I address NYSDEC Staff's continued lack of analysis of potential impacts of its proposed CCC retrofit on endangered sturgeon.

II. CALCULATION OF THEORETICAL HARVEST IMPACTS DOES NOT INDICATE FISH POPULATION EFFECTS

Q: Let's begin with Mr. Hogan's testimony. On pages 36-39 of his prefiled testimony, Mr. Hogan discusses the report he prepared entitled *Indian Point Energy Center Unit 2 and Unit 3 Cooling System Retrofit Alternative: State Environmental Quality Review Act Preliminary Assessment of Consistency with Applicable State Coastal Policies* (the "Hogan CMP Report"), Staff Ex. 243. Have you reviewed the Hogan CMP Report?

A: Yes. I have reviewed relevant portions of the Hogan CMP Report.

Q: On page 11 of the Hogan CMP Report, Mr. Hogan states that installing the "closed cycle cooling retrofit alternative would restore the viability of habitat

in the water column" and "further commercial and recreational fishing activities" in the Hudson River. Do you agree with his assessment?

A: No. As Entergy's Biology Team testified at length in the Best Usages portion of these Proceedings, multiple lines of analysis of more than 30 years of Hudson River fish population data have shown that Indian Point impingement and entrainment have no effect on the populations (or the community) of fish in the Hudson River. *See*, *e.g.*, Hearing Tr. at 3379:7-86:4 (Heimbuch); 3386:5-92:14 (J. Young); 3393:15-3407:13 (Barnthouse); 3409:4-13:5 (J. Young); 3413:14-21 (J. Young, Barnthouse, Heimbuch). Therefore, installing a CCC retrofit, or any other cooling water intake structure technology, at Indian Point would have no impact on the "viability of habitat in the water column," nor would it "further commercial and recreational fishing activities" in the Hudson River.

Q: Now let's turn to Mr. Nieder's testimony. On page 25 of his testimony, Mr. Nieder states that "Entergy's experts have previously opined that no amount of impingement mortality and entrainment reduction would increase the abundance of any Hudson River fish population but in the December 2013 NERA reports, Entergy's biologists present a fisheries harvest benefit for striped bass, American shad, white perch, and river herring as a result of reducing impingement and entrainment at IPEC." Is the "fisheries harvest benefit" presented in the NERA Reports inconsistent with the Biology Team's conclusions that impingement and entrainment at Indian Point have no effect on Hudson River fish populations?

A: The "fisheries harvest benefit" calculated in NERA's reports for both CWWS and

CCC technologies appears inconsistent with the Biology Team's conclusions that impingement and entrainment at Indian Point have no effect on Hudson River fish populations. However, as is stated in my reports providing biological inputs for NERA's benefits and costs analyses (Entergy Exs. 185B, 300) and "wholly disproportionate" analysis (Entergy Ex. 301), as well as in my prefiled testimony regarding these reports (*see* J. Young May 31, 2013 Direct at 3-4; J. Young Feb. 28, 2014 Direct at 12-13), in calculating the theoretical increased harvests that would result from installation of the proposed CWWS or CCC systems, we are attempting to be highly conservative by maximizing our estimate of potential benefits for both CWWS and for CCC. Accordingly, we give appropriate weight to the impingement and entrainment losses on a theoretical basis consistent with their expected contribution to the fishery, if we ignore the scientific evidence that impingement and entrainment at Indian Point do not affect Hudson River fish populations. Our doing so does not favor either of these two technology alternatives – CWWS and CCC – over the other; rather, it favors both alternative technologies over the no-action alternative, reflecting a conservative approach to the issue. The Biology Team continues to believe there would be no positive impacts from elimination of impingement and entrainment at Indian Point, but to be very conservative in comparing the two proposed alternatives to the no-action alternative, we present the potential increases in harvest that would be expected if 30+ years of empirical data were ignored.

III. MR. NIEDER UNDERSTATES THE BENEFITS (EFFICACY) OF THE PROPOSED CWWS ARRAY

Q: In the fourth step of his best technology available ("BTA") analysis, Mr.

Nieder presents the benefits associated with Entergy's proposed CWWS system as an efficacy of 54%; do you agree with his estimate?

A: No. The 54% figure used by Mr. Nieder as an estimate of the efficacy of the proposed CWWS in the fourth step of his BTA analysis significantly understates the actual entrainment reduction associated with the proposed CWWS. Indeed, the 54% figure Mr. Nieder presents in his most recent prefiled testimony on page 14 is even lower than the 60% figure NYSDEC Staff has advanced in previous testimony in these Proceedings. *See e.g.*, Nieder June 29, 2012 Rebuttal at 30 ("the results . . . suggest that the T-12 2.0 mm slot-width CWWS tested in-river from a barge resulted in approximately 60% reduction in entrainment density from that measured by the control port."). Mr. Nieder does not address this inconsistency between his prior testimony and his present testimony regarding CWWS efficacy.

In addition to being inconsistent with his prior testimony, Mr. Nieder's 54% figure also is inconsistent with the scientific evidence, which Mr. Nieder likewise has failed to address. Mr. Nieder, referring back to his August 3, 2012 live hearing testimony (Hearing Tr. at 5140-45), states that the "best estimate" of the efficacy of the proposed CWWS array is 54% when accounting for actual intake flows during the "entrainment season" (averaging 93.9% of design capacity), which he describes as being from May 10 through August 10 each year. *See* Nieder Direct at 14:6-19; 27:1-20; *see also* Staff Ex. 215 at 15, 16. While we appreciate and agree with NYSDEC that most entrainment occurs within that May 10 to August 10 timeframe, we would note that some entrainment is known to occur outside of that window when average flows may be less than 93.9% of full flow, and that to the extent Mr. Nieder's entrainment reduction calculation does not include entrainment reductions that occur outside the May 10 to August 10 time period, it under-represents the actual reduction.

Mr. Nieder's 54% estimate of efficacy is based on his interpretation of the data in the report prepared by Entergy's Biology Team entitled *Wedgewire Screen In-River Efficacy Study at Indian Point Energy Center* (January 2012) (the "In River Study") (Entergy Ex. 163). *See* Nieder Direct at 14:8-11. However, Mr. Nieder's estimate is based on a comparison of the density of ichthyoplankton entrained through the In-River Study's 2.0 mm slot width T-12 test screen against the control port used in the In-River Study, and not against ambient density estimated via the Tucker trawl. *See* Hearing Tr. at 5140-5141. Entergy's Biology Team has explained at length that the Tucker trawl provides a more accurate and appropriate estimate of ambient ichthyoplankton density for the calculation of efficacy because it less susceptible than a control port to avoidance by larval and juvenile fish. *See, e.g.*, June 29, 2012 Panel Prefiled Rebuttal at 4-33; Hearing Tr. at 4871-88: Entergy Ex. 17. Thus, Mr. Nieder's assessment is understated.

Rather, as set forth in the 2011 Update, the proposed CWWS will reduce the entrainment of all representative important species ("RIS") by an average of 75.4%, taking into account average annual intake water flows, and without taking into account entrainment survival. *See* Entergy Exs. 21 at 3 (case 4.1); *see also* Entergy Ex. 96C, case 4.1 (reporting average entrainment reductions for age-1 equivalents of 89.7% from regulatory baseline); July 22, 2011 Panel Direct

Prefiled at 67:11-15 (entrainment reductions for age-1 equivalents between 86% and 93.2% from regulatory baseline). The In-River Study data, which formed the entire basis for Mr. Nieder's estimate, in fact confirmed our 75.7% estimate based on extensive laboratory studies (taking into account annual intake water flows and sweeping velocity reductions among individual screens in the array). *See* May 30, 2012 Panel Prefiled Direct at 42 (case 4.1c); *see also* Entergy Ex. 180C. As the Biology Team also has testified, the efficacy of the proposed CWWS increases to 82.2% when accounting for entrainment survival and 89.7% when expressed as age-1 equivalents, each of which approaches Mr. Nieder's 96% figure for CCC on an annualized basis. *See* May 30, 2012 Panel Prefiled Direct at 42 (case 4.1a); Entergy Ex. 180C.

In addition, Mr. Nieder's 54% figure does not account for the fact that, on a cumulative basis – *i.e.*, over the course of the remaining life of the facility upon license renewal (until 2033 for Unit 2 and 2035 for Unit 3) and accounting for differences in CWWS and CCC implementation schedules – the reductions in entrainment losses attributable to installation of CWWS would be greater than for either CCC proposal. What is more, even the 54% figure for CWWS used by Mr. Nieder in his February 28, 2014 prefiled testimony is higher than the true efficacy one would achieve with CCC *on an annual basis*, if CCC must be curtailed to meet air quality requirements. Although Mr. Nieder contests whether air quality requirements would limit the operation of CCC at Indian Point, he has not disputed Entergy's estimates of the magnitude of entrainment reductions associated with CCC, assuming air quality requirements do in fact limit its operation.

IV. NYSDEC STAFF STILL PROVIDE NO ANALYSIS OF POTENTIAL IMPACTS OF THE PROPOSED CCC RETROFIT ON STURGEON

Q: Does Mr. Nieder address potential impacts of NYSDEC's proposed CCC retrofit on endangered sturgeon in the Hudson River?

A: No. Mr. Nieder does not address any potential impacts of NYSDEC's proposed CCC retrofit on endangered sturgeon. Potential impacts to sturgeon are mentioned briefly in Mr. Hogan's prefiled testimony. I understand, however, that issues regarding the environmental impacts of NYSDEC's proposed CCC retrofit on endangered species including shortnose and Atlantic sturgeon are supposed to be addressed in later hearings that have yet to be scheduled; I respond to Mr. Hogan's testimony regarding potential impacts on endangered sturgeon at this time with the understanding that I may supplement my testimony in these Proceedings regarding impacts to endangered species later at the appropriate phase of the Proceedings, if necessary.

Q: Can you summarize Mr. Hogan's prefiled testimony regarding potential effects of NYSDEC's proposed CCC retrofit on endangered sturgeon in the Hudson River?

A: Yes. On page 15 of his prefiled testimony, Mr. Hogan states that NYSDEC Staff have "considered impacts to shortnose and Atlantic sturgeon in evaluating which BTA alternatives would accomplish acceptable reduction in entrainment and impingement by the cooling water intake structure" and that "there is a sufficient body of data developed and supplied to the record during the BTA portion of this proceeding, with which to assess the impacts." Hogan Direct at 15:20-24. Mr.

Hogan also states that after considering "appropriate facts and information" NYSDEC staff "made a determination selecting a preferred closed cycle cooling alternative as the BTA." Hogan Direct at 16:1-4.

Q: Does Mr. Hogan's testimony discuss any actual potential impacts of NYSDEC's proposed CCC retrofit on sturgeon?

A: No. As I described above, Mr. Hogan's testimony merely states that NYSDEC staff have considered the evidence in the record and have chosen CCC as BTA for Indian Point; nowhere does Mr. Hogan actually discuss the evidence in the record or any potential impacts, in particular construction impacts, of CCC to sturgeon. As I stated in my prefiled direct testimony, no analysis of the potential impacts of construction activities, including blasting of a "significant area of the IPEC site," or the loading and movement of more than 1,200 barges at the Unit 1 pier, was included in the report *Indian Point Closed-Cycle System Retrofit Evaluation* (Tetra Tech June 2013), and such an analysis also is absent from NYSDEC Staff's testimony. Nor do NYSDEC Staff's witnesses' testimonies address the record evidence that CWWS are more effective at reducing impingement mortality than CCC would be (whereas entrainment of sturgeon is not an issue for either technology). *See, e.g.*, Nieder, *Wholly Disproportionate Test Report*, Feb. 28, 2014, at 14; NMFS, *Biological Opinion for Continued Operations of Indian Point Nuclear Generating Unit Nos. 2 and 3*, Jan. 30, 2013 (Entergy Ex. 213), at 59-61, 64. As such, NYSDEC Staff's analysis and testimony continues to be inadequate to make a State Environmental Quality Review Act ("SEQRA") determination for the CCC retrofit proposed by NYSDEC staff.

Moreover, Mr. Hogan's testimony addresses, if cursorily, only NYSDEC Staff's BTA determination (Hogan Prefiled at 16:28-17:2), and therefore ignores the issue of whether the proposed CCC system meets the requirements of the SEQRA with respect to any aspects other than entrainment and impingement. Therefore NYSDEC Staff still have not provided a complete analysis of potential CCC impacts to endangered sturgeon sufficient to meet SEQRA requirements.

END OF TESTIMONY