CHAPTER 6

NEAR-FIELD TEMPERATURE MODELING

The preceding chapters describe the FFTM applications used to evaluate temperature distributions in the Hudson River resulting from a variety of heat loading conditions (Chapter 5, Table 26). The main objective of the far-field modeling effort was to establish riverwide temperatures under the various heat loading scenarios that could be passed on to a near-field modeling analysis whose purpose was to evaluate compliance with DEC thermal water quality criteria. It is necessary to use the FFTM to determine the riverwide temperatures associated with each loading scenario in order to account for the buildup of heat in the river resulting from sustained power plant operation. The FFTM results for each of the loading scenarios are passed on to the CORMIX model to represent the receiving water conditions into which the plants discharge. For each operating scenario considered in this study, the CORMIX and FFTM results are combined in a separate temperature balance model that determines the dimensions of the critical isotherm. Because the water quality criteria are specified in terms of excess temperature, i.e., higher than the river temperature would be in the absence of the discharge under consideration, the critical isotherm analyses are performed for both ambient and background river temperatures. This approach results in two sets of critical isotherm dimensions: one referenced to ambient, the other to background. Once the dimensions of the critical isotherm have been identified, the model generates estimates of the associated percentage of top-width and cross-sectional area occupied by that isotherm. These values provide a basis for comparison to DEC thermal water quality criteria.

6.1 CORMIX MODEL INPUT AND MODEL LIMITATIONS

The CORMIX model requires input data describing the physical characteristics of the receiving water, the discharge structure, and the heated effluent. Table 28 summarizes the specific data requirements for CORMIX and the data sources used for this study. (All tables and figures follow chapter text.)

6.1.1 **Receiving Water Data**

Several of the receiving water parameters vary both in time and in location in the river. Because CORMIX is a steady-state model, such variations cannot be accommodated.[1] As a result, it was decided to use average conditions as determined from the FFTM results. For example, receiving water density was determined for each tidal stage from the FFTM monthly average temperatures and salinities adjacent to the power plants considered in this study. Similarly, FFTM monthly average receiving water velocities for each tidal stage were assigned to simulate the ambient current. These data were obtained from the statistical analyses performed on all FFTM output (see example, Table 27). In addition to the steady-state limitation of CORMIX, the model can simulate only a simple river geometry. CORMIX allows the user to specify a receiving water depth near the discharge and a channel depth and width. Furthermore, the model places constraints on the range of acceptable channel depths once a discharge depth has been specified. Available documents, including NOAA maps and data collected during previous LMS studies, were reviewed extensively to determine reasonable estimates for these parameters. In most cases the overall modeling effort was not affected adversely by these limitations. However, as discussed in the following section, plume contact with the channel boundaries required some adjustments to the heat balance model.

6.1.2 **Discharge Structure and Effluent Data**

In addition to receiving water parameters, the CORMIX model requires information about the discharge structure and the heated effluent. The configurations of the discharge structures at Roseton, Indian Point, and Bowline Point were obtained from the documentation of previous LMS studies of the three facilities. The physical characteristics of the discharge structures required for CORMIX input are contained in Table 29.

The effluent characteristics used in the CORMIX model are discharge flow rate, effluent density, and effluent excess temperature (ΔT, the difference between intake and discharge temperature). Effluent density was computed from the FFTM salinity and temperature data for a given heat load scenario and the known difference between intake and discharge

[1]The model can handle density stratification in the receiving water and this option was used at the Indian Point location. This topic is discussed in Section 6.2.2.

temperature at a given facility. For example, for the APAC (all plants at capacity) simulation at Indian Point the FFTM temperature at the Indian Point location was increased by the known ΔT for capacity operation and combined with the FFTM salinity value to determine the effluent density for that scenario. The discharge flow rates and ΔT data assigned in the model were obtained from documentation of previous LMS studies and, in some cases, through consultation with utility personnel. These values are contained in Table 30.

6.2 CORMIX VERIFICATION

The CORMIX model was tested using temperature survey data collected at Bowline on 18 August 1975 and at Roseton on 4 August 1976. Data suitable for testing the model at Indian Point were not available. Data collected during the Roseton and Bowline surveys included a sufficient amount of information about the effluent and receiving water conditions to initialize and run CORMIX. The conditions during each of the surveys are summarized in Table 30a.

Comparisons of measured temperatures and those predicted by CORMIX are contained in Figures 60a through 60d. The plots show reasonable agreement between survey and model temperatures. Based on these results CORMIX is considered an adequate tool for evaluating the thermal plumes resulting from discharges at Roseton, Indian Point, and Bowline.

6.3 CORMIX SIMULATIONS AND THE TEMPERATURE BALANCE MODEL

CORMIX simulations for a variety of power plant operation scenarios were performed and processed, together with the appropriate FFTM results, in the temperature balance model. These simulations included modeling the Roseton, Indian Point, and Bowline Point plumes with all plants at capacity (APAC), APAC minus Roseton (Roseton outage), APAC minus Bowline Point (Bowline Point outage), APAC with one unit off at Indian Point (Indian Point outage), and each plant in operation as the only anthropogenic heat source on the river. With the exception of the Indian Point outage, which was simulated for 90 days between 1 June 1981 and 31 August 1981, all scenarios were modeled for June, July, August, and September. The original modeling approach included simulations at four tidal stages: slack flood begins, average flood, slack ebb begins, and average ebb. Results of some of the slack condition simulations were judged to be unrealistic. Consequently, all scenarios were simulated for average flood and average ebb conditions. This issue is discussed further in Section 6.3.3. Output from each simulation was analyzed with the temperature balance model for comparison to the thermal criteria.

6.3.1 **Temperature Balance Model**

The temperature balance model developed to combine the far-field and near-field model results is based on the recognition that the cross-section area average temperature rise, as determined through application of mass, momentum, and energy balances (the FFTM), must be preserved, regardless of the particular near-field temperature distribution pattern produced by the CORMIX model. For a given heat load scenario at a given plant, this model determines the location of the 4°F plume isotherm[2] that produces a cross sectionally averaged temperature equivalent to that predicted by the FFTM. The solution algorithm is based on Equations 13 through 16 (refer to Figure 61).

$$A_p(\Delta T_p + \Delta T_{np}) + A_{np}\Delta T_{np} = A_T \Delta T_T \quad \textbf{(13)}$$

$$\Delta T_p + \Delta T_{np} = 4°F \quad \textbf{(14)}$$

$$A_p + A_{np} = A_T \quad \textbf{(15)}$$

$$A_p(4°F) + (A_T - A_p)(4 - \Delta T_p) = A_T \Delta T_T \quad \textbf{(16)}$$

where

A_p = plume cross-sectional area

A_{np} = non-plume cross-sectional area

A_T = total cross-sectional area

ΔT_p = excess plume temperature above surrounding non-plume excess temperature[3]

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[2]The 4EF isotherm was the relevant criterion isotherm in all cases modeled in this study because at none of the study locations in the river did the monthly average background or ambient temperature exceed 79EF.

[3]The centerline excess plume temperature was used for this value. In most cases model convergence occurred in the heat balance model at a down-current location were CORMIX predicts that the temperature distribution in the plume is uniform (a "top hat" distribution). In these cases characterizing the excess plume temperature as the centerline temperature is accurate. In some

ΔT_{np}	=	excess non-plume temperature above reference temperature (ambient or background due to a given plant's heat buildup and that of other plants)
ΔT_T	=	FFTM excess temperature above reference temperature (ambient or background)

Equation 16 is derived by substituting Equations 14 and 15 into Equation 13. Equation 16 is solved for all values of $(4 - \Delta T_p)$ until the left-hand side of the equation is virtually equal to the right-hand side. At that down-current location the area average of the plume and "non-plume" temperatures is virtually equal to the area-averaged FFTM temperature and the solution is said to converge. The plume dimensions at that down-current location are then used to compute the percentage of top-width and cross-sectional area occupied by the 4 F isotherm. Tables 31 through 39 contain the results of the model applications.

6.3.2. **Results of Temperature Balance Model**

For purposes of comparison with DEC thermal criteria, the information contained in Tables 31-39 was further refined and presented in Tables 39a through 39d. Table V-39a summarizes the near- and far-field model results at Roseton. Far-field results are given as the "far-field model ΔT." These are the cross-sectional area averaged temperature rises associated with the given operating scenario. Instantaneous intra-tidal values were averaged over each of the sixty some-odd floods and ebbs during each summer month, and then averaged for that month. This averaging process is viewed as providing a reasonably accurate picture of the temperature rise that would occur in the river at Roseton for the given full capacity operating condition, and relatively typical river hydrology and meteorology during the month in question.

Near-field results are given in terms of the plume's width and depth at Roseton that are bounded by the 4°F temperature rise above ambient isotherm. These parameters are then used, in conjunction with total river width and cross-sectional area at Roseton, to obtain the percentage width and cross-sectional area that are bounded by the 4 F temperature rise

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cases convergence occurred where CORMIX predicts that the plume has a Gaussian temperature distribution. Further evaluation indicated that the centerline value represents a reasonable estimate of the excess plume temperature.

isotherm.

At Roseton, two-unit operation at full capacity of the Roseton generating station itself resulted in 7% to 11% of the river's surface width and 5% of its cross-section being bounded by the 4°F temperature rise isotherm. The plume so bounded extends between 250 ft to 425 ft from the west shore at Roseton and extends from 29 ft to 19 ft deep, by comparison to a river width at this location of some 3700 ft and an average depth of 41 ft.

Again at Roseton, when the temperature rise contribution of all plants on the river is considered, with each plant operating at capacity and therefore discharging its maximum heat load, the percentage surface width bounded by the 4°F isotherm increases to 9% to 30%, depending on month and tidal phase, while the corresponding range for the cross-sectional area is 5% to 8%. The plume within the 4°F isotherm extends between 350 ft to 1125 ft from the west shore and extends 22 ft to 10 ft below the surface, again by comparison to a river width of 5100 ft and an average depth of 41 ft.

Table 39b summarizes the near- and far-field results at Bowline. Results are presented in the same terms as those defined above for Roseton.

At Bowline, two-unit operation at full capacity of the Bowline generating station itself resulted in 3% of the river's surface width and 3% to 4% of its cross-section being bounded by the 4°F temperature rise isotherm. The plume so bounded extends between 370 ft to 440 ft from the west shore at Bowline and extends about 23 ft below the surface, by comparison to a river width at this location of some 14000 ft and a mean depth of 19 ft.

The fact that the Bowline modeled plume for the case of Bowline only operating is thicker than the mean depth is of no concern. The real plume will be no greater than the river depth at the precise plume location and the width will be proportionately greater. The percentage surface width will also increase proportionately whereas the percentage cross-section will remain the same.

Again at Bowline, when the temperature rise contribution of all plants on the river is considered, with each plant operating at capacity and therefore discharging its maximum heat load, the percentage surface width bounded by the 4°F isotherm increases to 8% to 25%, depending on month and tidal phase, while the corresponding range for the cross-sectional area is 5% to 26%. The plume within the 4°F isotherm extends between 1135 ft to 3635 ft from the west shore and extends 19 ft to 10 ft below the surface, again by comparison to a river width of 14,000 ft and a mean depth of 19 ft.

Table 39c summarizes the near- and far-field model results at Indian Point. The temperature effect on the river in the vicinity of Indian Point is more pronounced than at either Roseton or Bowline. This is because the Indian Point generating station is located between Bowline and Roseton and thus the combined effect of all three plants is greater at this more central location than at the endpoints of the affected reach; i.e., downstream of Bowline and upstream of Roseton. Furthermore, two of the background plants are located just below Indian Point well within a tidal incursion around Indian Point; this fact also exacerbates the temperature effect in the Indian Point region, by comparison to the Bowline and Roseton regions.

For these reasons, several modifications in the near-field analysis were made when applying the near-field model to Indian Point.

In computing percentage surface width and cross-sectional areas at Bowline and Roseton, the river geometry (surface width and cross-sectional area) were assumed to be constant and equal to the values at the point of discharge. These assumptions are quite appropriate because the extent of plume travel up or down river before expanding to the 4 F isotherm is relatively low (less than two miles at Bowline and less than one-half mile at Roseton), the river geometry is relatively constant within these distances, and the temperature effect at both Bowline and Roseton is relatively small in all cases, as can be seen in Tables 39a and 39b.

In the case of Indian Point, however, the plume can extend more than seven miles in flood and more than five miles in ebb. This results in substantial change in river geometry as the plume moves north from Indian Point toward the Bear Mountain Bridge, as well as south into Haverstraw Bay. To calculate percentage surface width and cross-sectional area, the model was modified to adopt this variable geometry. Accordingly, Table 39c includes the location of the plume and the associated river variables.

In most cases of flood, because the section of the river above Indian Point is a narrow gorge, the plume surface width, as generated by the near-field model, exceeded the river's surface width. In these cases, the plume lateral boundary was set at the river width, and the plume depth increased to preserve the model generated plume cross-sectional area. This adjustment is appropriate because once the plume width exceeds the river width, the model only allows the plume to entrain water from underneath. As long as the adjusted plume depth does not reach the river's depth, water is available for such entrainment. These adjusted values for plume width and depth appear in Table 39c for all cases where the percentage river width greater than 4°F is 100%.

Finally, it should be noted that in cases where the 4°F plume bound is not reached until the plume has moved into Haverstraw Bay, substantial zones of the narrow Indian Point gorge will see temperature rises higher than 4°F. In fact, in cases where the far-field ΔT at Indian Point exceeds 4°F; e.g., July and August for all plants operating at capacity, the near-field model will not produce a unique solution, an anomaly in the model described in detail in Appendix VI-3. Accordingly, results were obtained for temperature rise isotherms slightly in excess of the area-averaged far-field model ΔT.

Table 39c indicates that at Indian Point, two-unit operation at full capacity of the Indian Point generating station itself resulted in 54% to 100% of the river's surface width and 14% to 22% of its cross-section being bounded by the 4°F temperature rise isotherm. The plume so bounded extends between 2200 ft to 3300 ft from the east shore in the vicinity of Indian Point and extends from 16 ft to 8 ft, by comparison to a river width in this vicinity that ranges between 2700 ft to 5400 ft and average depths ranging from 57 ft to 31 ft. The wide variation in river width and depth occurs because in flood the plume is restricted to the relatively narrow gorge between Indian Point and Bear Mountain Bridge, while during ebb, the plume extends out into the headwaters of Haverstraw Bay.

Again at Indian Point, when the temperature rise contribution of all plants on the river is considered, with each plant operating at capacity and therefore discharging its maximum heat load, the percentage surface width bounded by the 4°F isotherm ranges between 36% and 100%, depending on month and tidal phase, while the corresponding range for the cross-sectional area is 27% to 83%. The plume within the 4°F isotherm extends between 1900 ft to 2900 ft from the east shore during flood and between 3500 ft and 4700 ft during ebb, by comparison to a range in river widths of 1900 ft to 2900 ft during flood and 7000 ft to 14,000 ft during ebb. The plume extends 59 ft to 16 ft below the surface during flood and 16 ft to 9 ft below the surface during ebb, again by comparison to mean river depths on the order of 50 ft to 70 ft during flood and ranging between 25 ft and 13 ft during ebb.

Temperature distributions at Indian Point were also evaluated under various outage scenarios. Results are shown in Table 39d. With two units off-line at Roseton, the percentage river cross-sectional area bounded by the 4°F isotherm ranges between 27% to 31%. With two units at Bowline off-line, the range is 16% to 30%, roughly the same effect as with Roseton off-line. These results are referenced against the background condition; i.e., all the smaller and older stations are running but are assumed to be part of the background or temperature baseline.

When one unit at Indian Point is taken off line, and all other units (Bowline, Roseton, one unit at Indian Point, and all the older and smaller stations) are run at capacity, the percentage of the river cross-sectional area bounded by the 4°F isotherm ranges between 15% and 31%, by comparison to the 27% to 83% range in this parameter reported above, when all plants are operating at capacity.

6.3.3 Discussion of CORMIX Modeling and the Temperature Balance Model

Several items related to both the CORMIX and the temperature balance models require further discussion. CORMIX simulations of the plume at Indian Point were first executed using a receiving water density that was uniform over depth. In several cases model results showed that the plume mixed completely over the receiving water depth and width at some down- current location. Under these conditions there is no remaining plume surface area through which entrainment of surrounding waters can take place and the CORMIX model predicts no further dilution. When these results were transferred to the temperature balance model, the model did not converge to a solution because at the location where complete mixing occurred the plume area average temperature exceeded that predicted by the FFTM. A review of the CORMIX input for these simulations led to several modeling revisions judged to represent the system under study more accurately. These included (1) increasing the effective channel depth for CORMIX calculations to the maximum allowable value (8.5 m) while preserving the receiving water depth at the discharge location, (2) stratifying the receiving water, and (3) revising the temperature balance solution algorithm to include more refined estimates of the receiving water top width and cross-sectional area at the down-current location where the model solution converges.

The original channel depth assigned in the CORMIX model for the Indian Point location was 7.5 m. As a result, CORMIX simulations for several scenarios showed the plume to be mixed completely over the receiving water depth, an unrealistic result considering the channel depth near Indian Point. Several data sources, including the FFTM river geometry input, show that the channel depth in the vicinity of Indian Point ranges from 13.4 to 20.7 m. Because CORMIX allows a maximum channel depth 30% greater than the assigned depth at the discharge location, more accurate channel depths could not be assigned without artificially increasing the depth at the discharge, an undesirable solution because it would likely result in an artificial increase in the near-field dilution. Consequently, the depth at discharge was maintained at its previously determined value (6.55 m) and the channel depth was increased to the maximum allowable value (8.52 m).

A review of the 1981 Long River Survey data in the vicinity of Indian Point and subsequent density calculations showed that during June, July, and August the receiving water was slightly stratified over depth. Density stratification occurs naturally in this system as a result of (a) warming of near-surface waters and concomitant reduction in density, and (b) tidal inflow of saline waters increasing the density of bottom waters. These phenomena can have the effect of increasing the upward buoyancy flux acting on a thermal plume, preventing plume contact with the channel bottom, and thus helping maintain a portion of the river cross-sectional area that is outside the influence of the plume. Average density gradients were computed for these three months and the CORMIX simulations for Indian Point were rerun with a density-stratified receiving water. In all cases the average receiving water density, as determined from the FFTM statistical output, was maintained.

These model input changes had the general effect of decreasing the plume thickness and increasing its width. Complete mixing over the receiving water depth was no longer predicted by the model and, in most cases, the temperature balance model converged to a solution. For the July and August APAC simulations referenced to ambient at Indian Point, the FFTM area average temperature exceeds 4°F. Consequently, the dimensions of slightly higher isotherms were located (4.7°F for flood and 5.1°F for ebb) with the temperature balance model. In these cases it is assumed that the 4° isotherm would have somewhat larger dimensions than those reported for the higher isotherms.

Because the down-current location where the heat balance model converged was often as much as 4 or 5 miles away from Indian Point, it was decided to revise the river cross-sectional areas and top widths used in the heat balance model to reflect changes in river geometry. For modeling purposes linear equations relating river width and cross-sectional area with longitudinal distance from the Indian Point location were developed for both the flood and ebb conditions. (Recall that the river cross-sectional area is used by the heat balance model in the right-hand side of Equation 16.) As a result, it was necessary to iterate to the final solution. The first estimate of the down-current location of interest was made using the cross-sectional area at the Indian Point location. Cross-sectional area was then recomputed for the estimated down-current location and convergence was rechecked. Convergence was achieved after two or three iteration steps. Once model convergence occurred, the percentage of cross-sectional area and top-width values associated with the critical isotherm were computed based on the river geometry at the convergence location. In some cases, particularly under flood conditions, the model predicted plume widths in excess of the river top width at the 4°F location. When this occurred, a 100% value was entered in the appropriate summary table for the percentage of top width covered by the critical isotherm. However, the computation of the percentage of the cross-sectional area occupied by the critical isotherm was based on the plume width and thickness predicted by CORMIX. Preserving the plume cross-sectional area predicted by CORMIX while limiting the plume width to the channel width value requires that the plume thickness increase. The plume thicknesses reported on Tables 39c and 39d include this adjustment. In these simulations the predicted dilution is slightly overestimated due to the reduced entrainment area resulting from plume contact with the river boundary. Another important effect of revising the river geometry in the heat balance model was to decrease the percentage of the top width occupied by the critical isotherm under ebb conditions. This is explained by the fact that the location of convergence occurred in the upper reaches of Haverstraw Bay, where the river top width increases significantly. Although the percentage of top width associated with the 4°F location is reported in the summary tables, higher isotherms may occupy a larger percentage of the top width at narrower portions of the river upstream of the convergence location.

The final topic requiring further discussion involves the slack tide simulations. Results of the slack tide CORMIX runs at Bowline Point and Roseton showed that the plume would occupy a larger percentage of the cross section and top width under slack conditions than the running tide conditions reported in the summary tables. However, the percentage increases were not substantial and it is highly unlikely that contraventions of the thermal water quality criteria would occur under slack conditions at these locations. At Indian

Point, however, several lines of evidence indicate that it is highly likely that exceedance of the top-width criterion, and possibly the cross-sectional area criterion, would occur under slack conditions. Top-width exceedances occur under all flood scenarios for the Indian Point plume and are close to occurring in several ebb cases, despite the substantial top width of Haverstraw Bay. Accordingly, it is likely that during the transitional phases between flood and ebb (the slack periods) there would be exceedance of the top-width criterion for all scenarios. The percentage of the cross-sectional area occupied by the critical isotherm indicates that cross-sectional area exceedances may occur during slack tides under the APAC scenarios in July and August. Other cross-sectional exceedances may also occur but are less likely because of the non-exceedance condition determined for both running tide simulations.

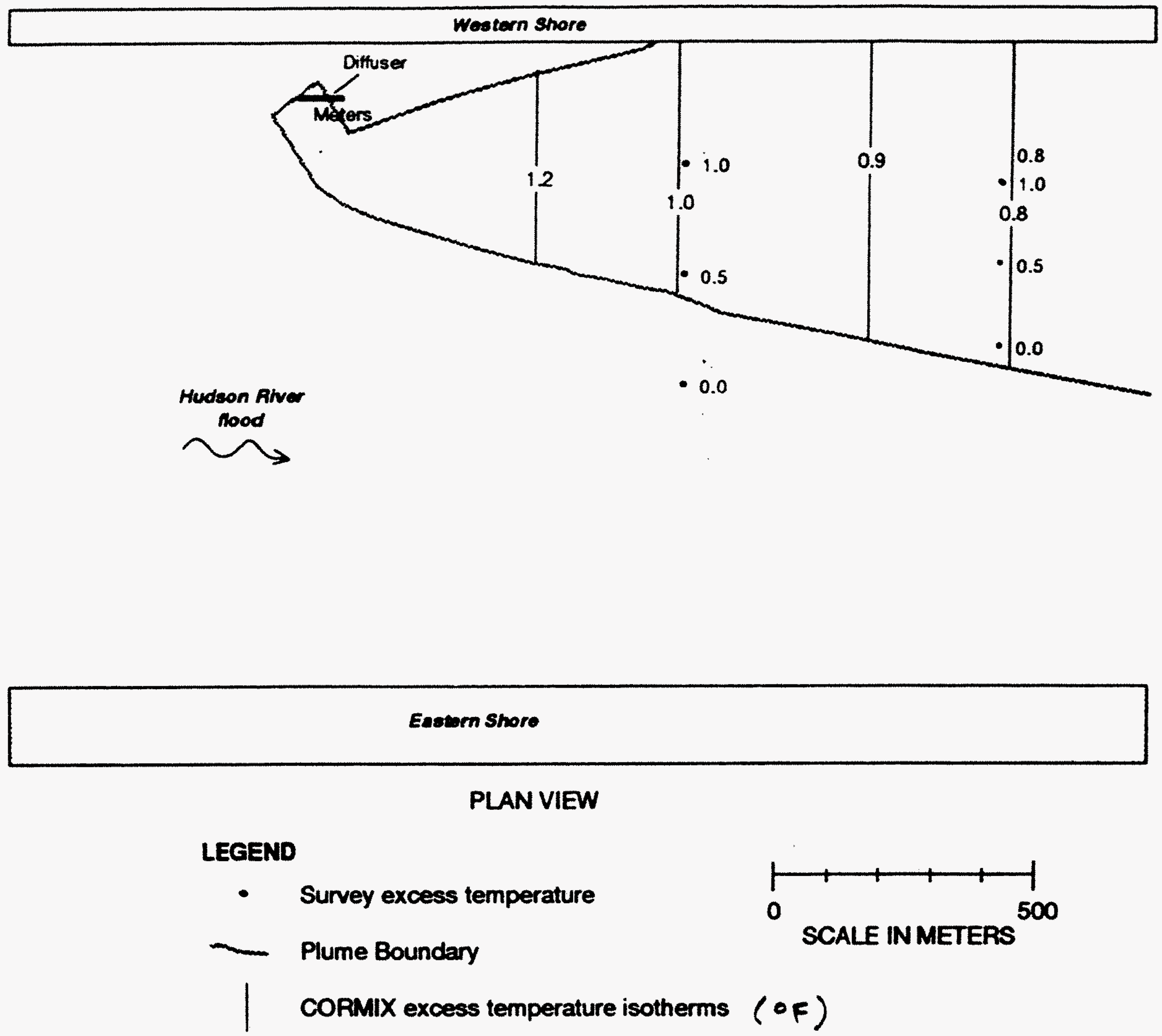


Figure 60a. CORMIX verification, Roseton Generating Station, 4 August 1976, maximum flood.

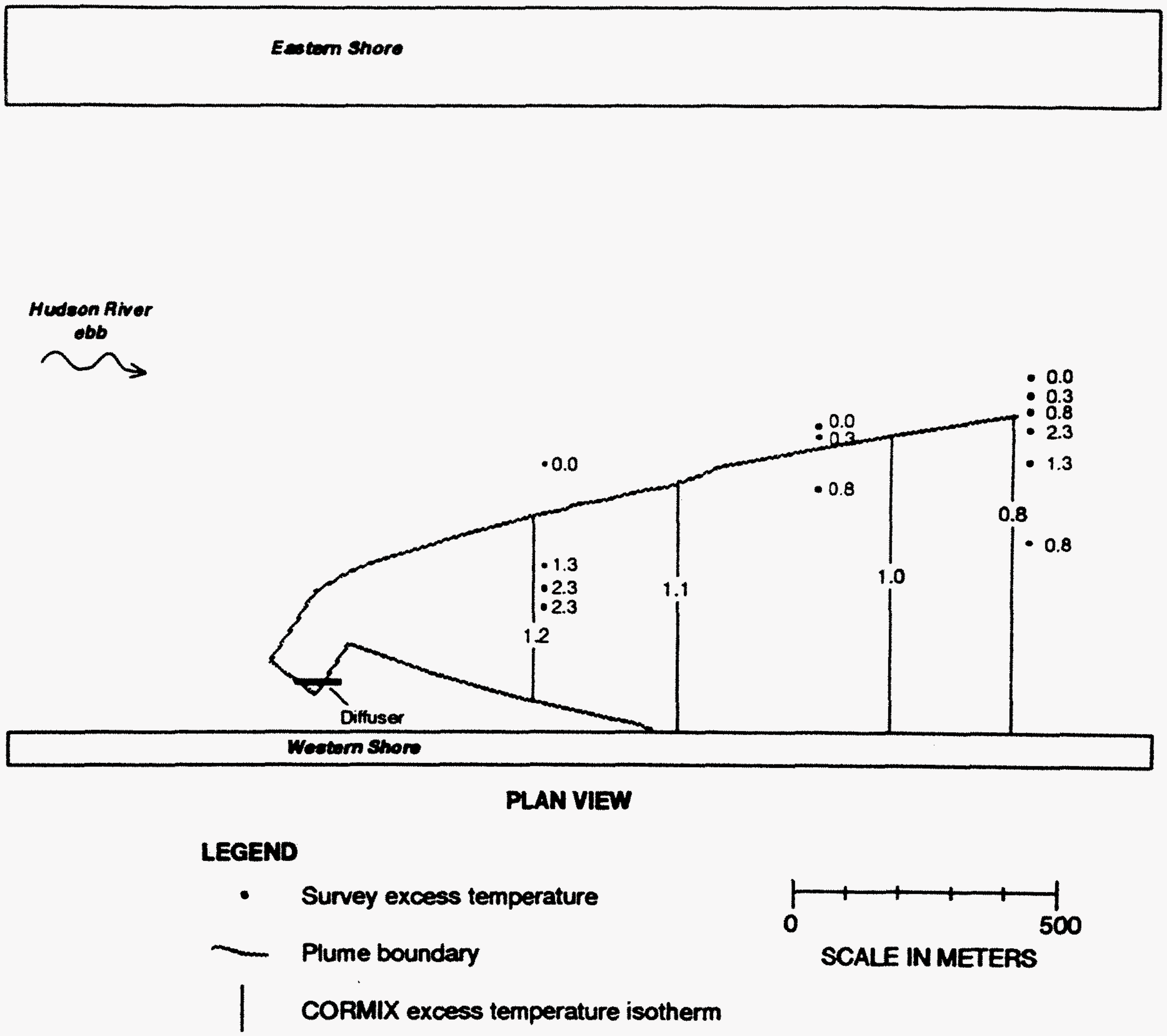


Figure 60b. CORMIX verification, Roseton Generating Station, 4 August 1976, maximum ebb.

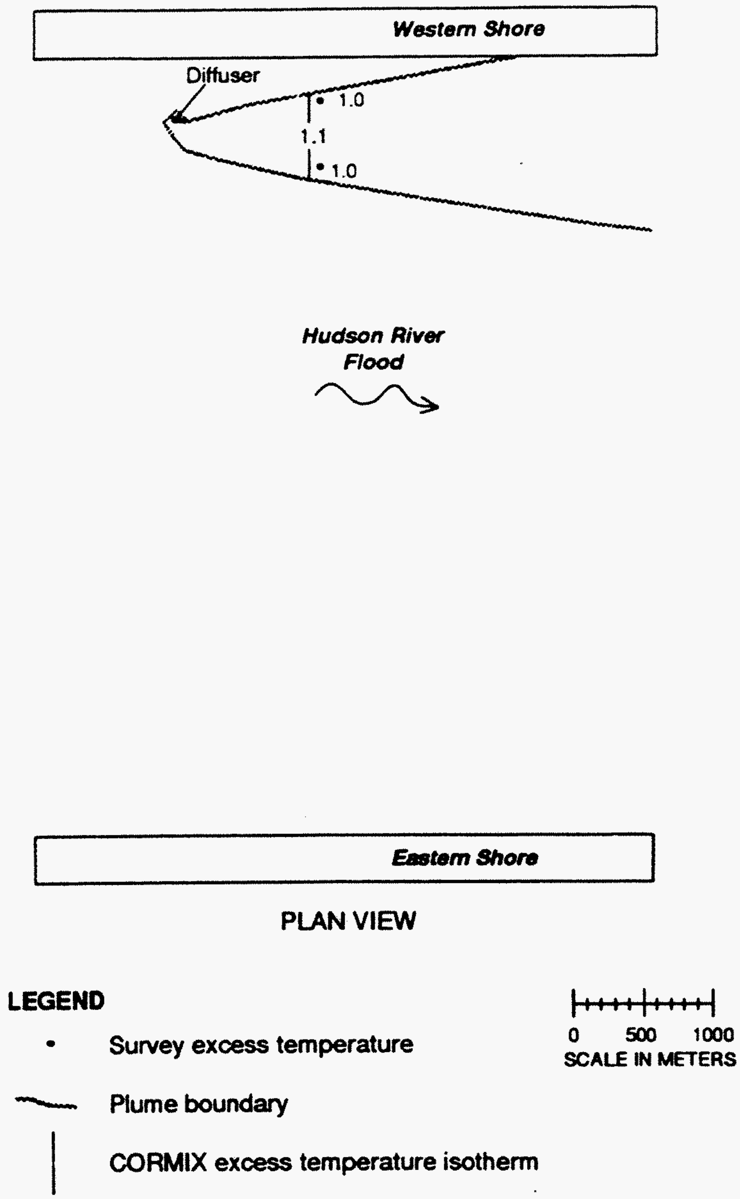


Figure 60c. CORMIX verification, Bowline Point Generating Station, 18 August 1975, maximum flood.

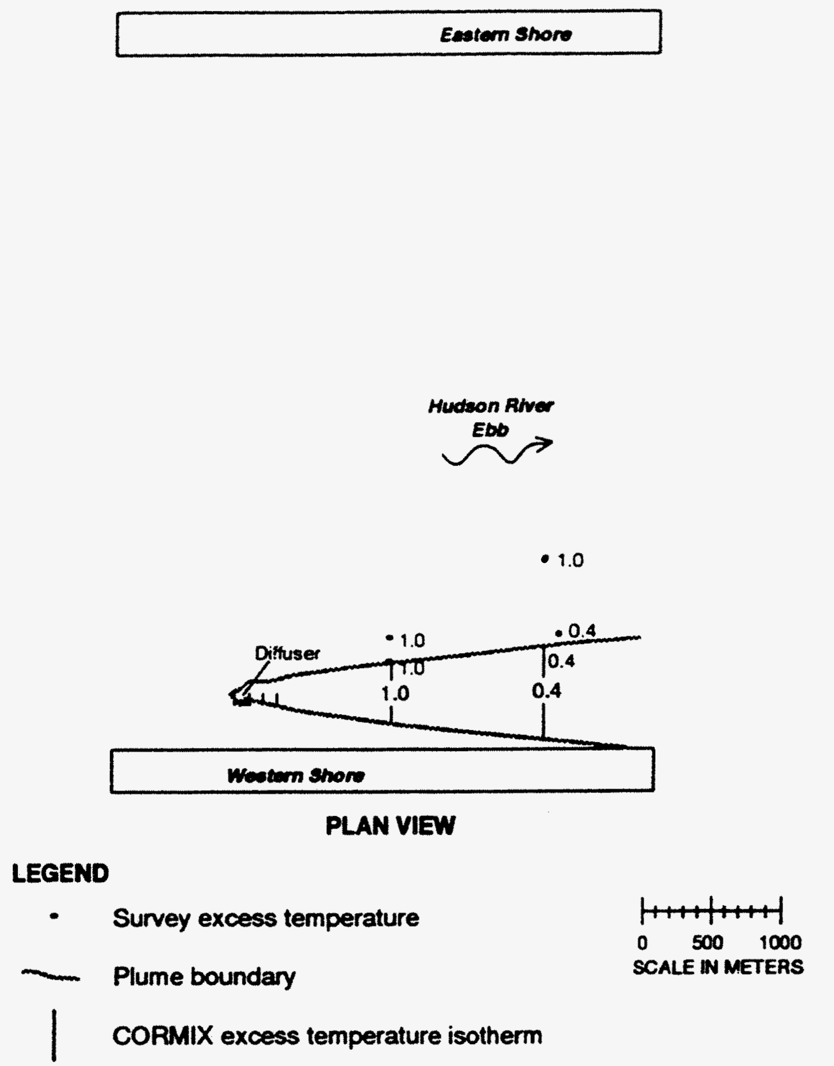
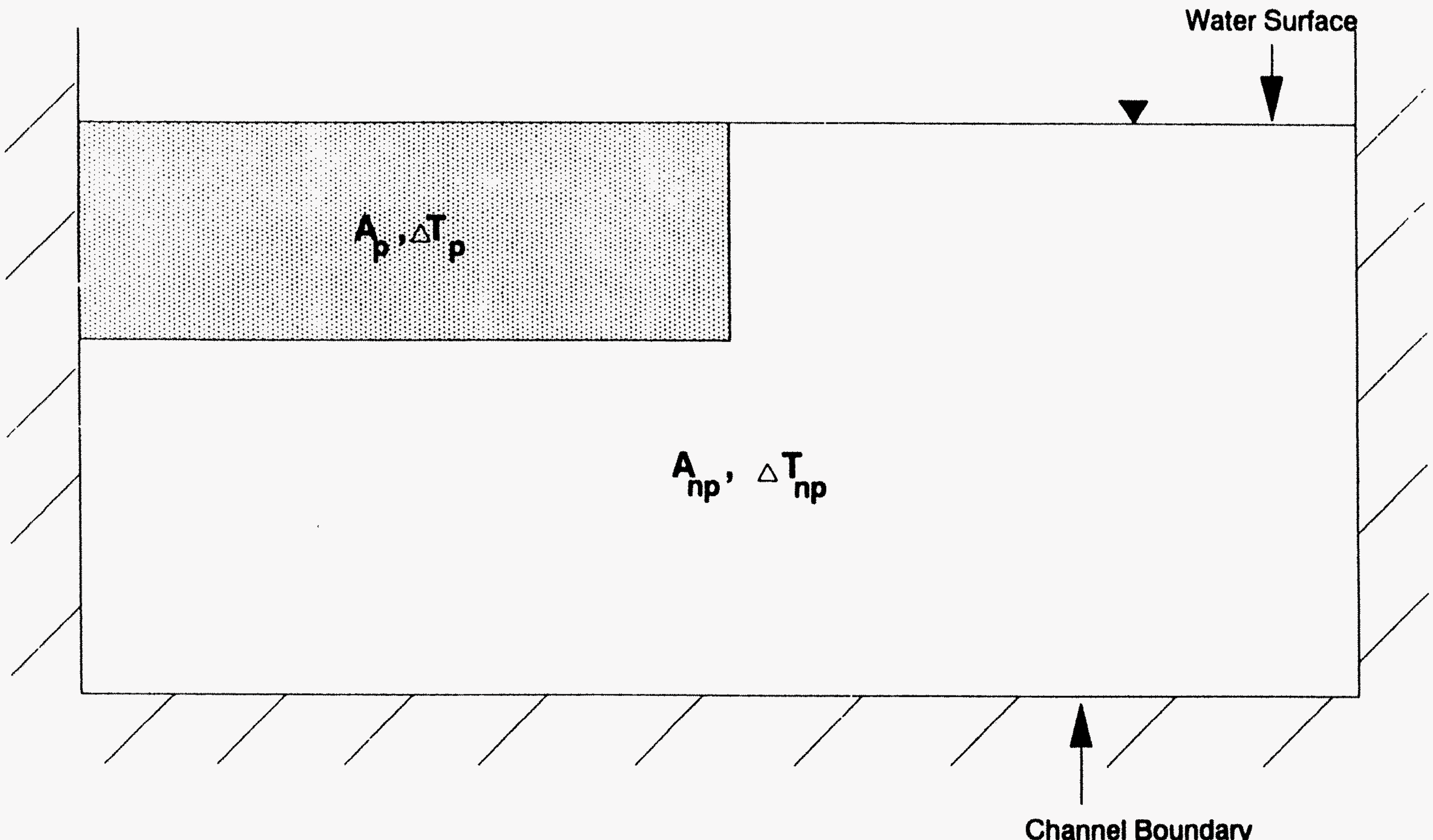


Figure 60d. CORMIX verification, Bowline Point Generating Station, 18 August 1975, maximum ebb.

Figure 61

Generalized Cross-section in the Heat Balance Model



A_p : Plume cross-sectional area

A_{np}: Non-plume cross-sectional area

ΔT_p : Plume excess temperature above FFTM temperature

ΔT_{np}: Non-plume excess temperature above FFTM reference temperature (ambient or background)

TABLE 28

CORMIX INPUT DATA

DATA TYPE	SOURCE		
	ROSETON	INDIAN POINT	BOWLINE
Receiving Water			
Width	NOAA, NOS 12343	NOAA, NOS 12343	NOAA, NOS 12343
Depth	Roseton and Danskammer Point Generating Station Hydrothermal Analysis, LMS 1978	Report on the Evaluation of Thermal Plume Studies of Indian Point Nuclear Generating Station, LMS 1980	Bowline Point Generating Station Hydrothermal Analysis, LMS 1978
Manning's n	Chow, 1964	Chow, 1964	Chow, 1964
Velocity	FFTM	FFTM	FFTM
Density	FFTM	FFTM	FFTM
Discharge Structure			
Diffuser type	Roseton Generating Station Near-Field Effects of Once-Through Cooling System Operation on Hudson River Biota, LMS 1977	Report on the Evaluation of Thermal Plume Studies of Indian Point Nuclear Generating Station, LMS 1980	LMSE 75/0491&169/101
Diffuser location	Roseton and Danskammer Point Generating Station Hydrothermal Analysis, LMS 1978	Report on the Evaluation of Thermal Plume Studies of Indian Point Nuclear Generating Station, LMS 1980	LMSE 75/0491&169/101
Diffuser specification	Roseton and Danskammer Point Generating Station Hydrothermal Analysis, LMS 1978	Report on the Evaluation of Thermal Plume Studies of Indian Point Nuclear Generating Station, LMS 1980	LMSE 75/0491&169/101
Effluent			
Flow rate	Roseton and Danskammer Point Generating Station Hydrothermal Analysis, LMS 1978	Near-Field Effects of Once-Through Cooling System Operation on Hudson River Biota, LMS 1977	Bowline Near-Field Effects of Once-Through Cooling System Operation on Hudson River Biota, July 1977
Excess temperature	Roseton and Danskammer Point Generating Station Hydrothermal Analysis, LMS 1978	Near-Field Effects of Once-Through Cooling System Operation on Hudson River Biota, LMS 1977	Bowline Near-Field Effects of Once-Through Cooling System Operation on Hudson River Biota, July 1977
Density	Computed from FFTM salinity and temperature data and plant excess temperatures	Computed from FFTM salinity and temperature data and plant excess temperature	Computed from FFTM salinity and temperature data and plant excess temperature

TABLE 29

CHARACTERISTICS OF DISCHARGE STRUCTURES

PARAMETER	STATION		
	ROSETON	INDIAN POINT	BOWLINE
Diffuser type	Submerged multiport	Submerged multiport	Submerged multiport
Diffuser length (m)	99.1	70.4	106.6
Distance from diffuser mid-point to closest shoreline (m)	100	0	366
Horizontal angle between diffuser line and current direction (degrees)	90	90	90
Number of ports	14	12	16
Port diameter (m)	0.91	2.66	0.91
Port spacing (m)	7.62	6.40	7.10

TABLE 30

COOLING WATER DISCHARGE DATA

STATION	FLOW (gpm)	ΔT (°F)
Roseton	641,000	17.7
Indian Point	1,680,000	16.3
Bowline	768,000	13.0

TABLE 30a

SURVEY CONDITIONS FOR CORMIX VERIFICATIONS

	ROSETON	BOWLINE
	Flood and ebb	Flood and ebb
Receiving Water		
Velocity (m/s)	0.25	0.25
Density (kg/m^3)	997.2	998.1
Effluent		
Flow (cms)	35.4	19.9
Delta T (°C)	6.1	8.3
Density (kg/m^3)	995.4	995.6

Table 31
All Plants at Capacity Referenced to Ambient

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F ****							
			All Plants (deg F)	Ambient (deg F)	All Plants - Ambient (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Ambient (max. = 67%)	River X-sect *** Area (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Ambient (max. = 50%)
Jun '81	Roseton	Flood	72.19	70.55	1.64	142	107	6.82	2.50	1140	9	14121	5
		Ebb	72.20	70.55	1.65	155	111	6.51	2.47	1140	10	14121	5
	Indian Pt.	Flood	74.21	70.92	3.29	5033	1125	3.96	1.03	888	100	13857	32
		Ebb	74.09	70.85	3.24	4880	1063	4.09	1.03	2150	49	16379	27
	Bowline	Flood	74.09	71.34	2.75	850	466	3.20	1.32	4355	11	25084	6
		Ebb	74.02	71.38	2.64	664	346	3.46	1.42	4355	8	25084	5
Jul '81	Roseton	Flood	79.20	76.91	2.29	545	289	3.42	1.84	1140	25	14121	7
		Ebb	79.23	76.93	2.30	561	288	3.39	1.82	1140	25	14121	7
	Indian Pt.	Flood	81.74	77.18	4.56	7133	1472	6.24	0.50	587	100	12852	71
		Ebb	81.77	77.22	4.55	5561	1252	4.48	0.82	2517	50	16997	33
	Bowline	Flood	81.08	77.34	3.74	3116	1105	5.38	0.34	4355	25	25084	24
		Ebb	80.88	77.33	3.55	2082	757	4.40	0.52	4355	17	25084	13
Aug '81	Roseton	Flood	80.06	77.65	2.41	759	338	3.19	1.64	1140	30	14121	8
		Ebb	80.04	77.63	2.41	663	323	3.21	1.72	1140	28	14121	7
	Indian Pt.	Flood	81.70	77.07	4.63	11990	1510	7.33	0.41	619	100	13384	83
		Ebb	81.67	77.05	4.62	5756	1205	4.84	0.75	2623	46	17175	34
	Bowline	Flood	80.42	76.64	3.78	3310	1107	5.94	0.30	4355	25	25084	26
		Ebb	80.12	76.50	3.62	2324	813	4.85	0.44	4355	19	25084	16
Sep '81	Roseton	Flood	73.74	71.27	2.47	787	344	3.25	1.63	1140	30	14121	8
		Ebb	73.65	71.17	2.48	792	336	3.27	1.61	1140	29	14121	8
	Indian Pt.	Flood	74.22	70.33	3.89	8441	1414	7.53	0.41	628	100	13150	81
		Ebb	74.15	70.26	3.89	8793	1446	7.91	0.39	4000	36	16000	71
	Bowline	Flood	73.06	69.74	3.32	1724	748	3.53	0.77	4355	17	25084	11
		Ebb	72.82	69.58	3.24	1411	568	3.68	0.84	4355	13	25084	8

* Note: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.
** Constant river top widths were assigned for the Roseton and Bowline locations.
*** Constant river cross-sectional areas were assigned for the Roseton and Bowline locations.
**** The plume dimensions for the July and August flood condition at Indian Point correspond to the 4.7 deg. F isotherm; the plume dimensions for the ebb conditions correspond to the 5.1 deg. F isotherm.

Table 32
All Plants at Capacity Referenced to Background

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX2) for Plume Dimension at 4 Degrees F							
			All Plants (deg F)	Background (deg F)	All Plants - Background (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Background (max. = 67%)	River X-sect *** Area (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Background (max. = 50%)
Jun '81	Roseton	Flood	72.19	70.87	1.32	93	77	8.70	2.72	1140	7	14121	5
		Ebb	72.20	70.89	1.31	93	75	8.70	2.72	1140	7	14121	5
	Indian Pt.	Flood	74.21	71.45	2.76	4030	976	3.00	1.57	811	100	14383	20
		Ebb	74.09	71.36	2.73	3964	931	3.14	1.53	1655	56	15548	19
	Bowline	Flood	74.09	71.78	2.31	322	285	4.25	1.79	4355	7	25084	5
		Ebb	74.02	71.81	2.21	261	198	4.64	1.85	4355	5	25084	4
Jul '81	Roseton	Flood	79.20	77.41	1.79	229	156	5.15	2.27	1140	14	14121	6
		Ebb	79.23	77.45	1.78	196	136	5.60	2.34	1140	12	14121	5
	Indian Pt.	Flood	81.74	78.05	3.69	6275	1353	5.24	0.62	710	100	13263	53
		Ebb	81.77	78.07	3.70	6705	1413	5.73	0.57	3134	45	18035	45
	Bowline	Flood	81.08	78.05	3.03	1243	629	3.04	1.06	4355	14	25084	8
		Ebb	80.88	78.01	2.87	934	452	3.22	1.20	4355	10	25084	6
Aug '81	Roseton	Flood	80.06	78.14	1.92	298	185	4.49	2.14	1140	16	14121	6
		Ebb	80.04	78.14	1.90	287	180	4.58	2.16	1140	16	14121	6
	Indian Pt.	Flood	81.70	77.92	3.78	6705	1413	5.73	0.57	648	100	13057	62
		Ebb	81.67	77.88	3.79	6579	1316	5.85	0.57	3067	43	17920	43
	Bowline	Flood	80.42	77.28	3.14	1404	668	3.12	0.94	4355	15	25084	8
		Ebb	80.12	77.10	3.02	1115	506	3.27	1.06	4355	12	25084	7
Sep '81	Roseton	Flood	73.74	71.74	2.00	322	194	4.43	2.12	1140	17	14121	6
		Ebb	73.65	71.66	1.99	349	200	4.28	2.07	1140	18	14121	6
	Indian Pt.	Flood	74.22	70.98	3.24	4559	1055	3.89	1.12	956	100	14084	29
		Ebb	74.15	70.89	3.26	4971	1120	4.05	1.01	2199	51	16461	28
	Bowline	Flood	73.06	70.29	2.77	906	497	3.17	1.29	4355	11	25084	6
		Ebb	72.82	70.12	2.70	672	413	3.34	1.35	4355	9	25084	5

* Note: The letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.

** Constant river top widths were assigned for the Roseton and Bowline locations.

*** Constant river cross-sectional areas were assigned for the Roseton and Bowline locations.

Table 33
All Plants at Capacity Minus Roseton Referenced to Background

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F							
			All Plants but... (deg F)	Background (deg F)	All Plants but... - Background (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]	Plume Width (m) [BH]	Plume Thickness (m) [BV]	Centerline Delta T (F deg) [C]	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Background (max. = 67%)	Typical River *** Area at Down Current Distance	Pct. River X-section >= 4 F deg above Background (max. = 50%)
Jun '81	Indian Pt.	Flood	73.98	71.45	2.53	3436	886	2.90	1.79	928	95	14660	18
		Ebb	73.87	71.36	2.51	3436	886	2.90	1.79	1370	65	15069	17
	Bowline	Flood	73.95	71.78	2.17	208	200	5.07	1.94	4355	5	25084	4
		Ebb	73.90	71.81	2.09	203	172	5.10	1.94	4355	4	25084	3
Jul '81	Indian Pt.	Flood	81.28	78.05	3.23	4704	1125	3.66	1.12	935	100	14015	29
		Ebb	81.31	78.07	3.24	4847	1146	3.79	1.06	2132	54	16349	27
	Bowline	Flood	80.78	78.05	2.73	842	498	3.04	1.34	4355	11	25084	6
		Ebb	80.61	78.01	2.60	620	354	3.36	1.47	4355	8	25084	5
Aug '81	Indian Pt.	Flood	81.20	77.92	3.28	4847	1146	3.79	1.06	915	100	13946	31
		Ebb	81.17	77.88	3.29	4970	1153	3.99	1.00	2198	52	16460	28
	Bowline	Flood	80.09	77.28	2.81	928	506	3.08	1.26	4355	12	25084	6
		Ebb	79.82	77.10	2.72	753	395	3.28	1.35	4355	9	25084	5
Sep '81	Indian Pt.	Flood	73.65	70.98	2.67	3994	985	2.92	1.64	818	100	14399	20
		Ebb	73.58	70.89	2.69	3817	885	3.14	1.57	1576	56	15414	18
	Bowline	Flood	72.64	70.29	2.35	376	292	4.00	1.74	4355	7	25084	5
		Ebb	72.42	70.12	2.30	326	231	4.26	1.78	4355	5	25084	4

Notes: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.

** Constant river top widths were assingned for the Roseton and Bowline locations.

*** Constant river cross-sectional areas were assingned for the Roseton and Bowline locations.

Table 34

All Plants at Capacity Minus One Unit at Indian Point Referenced to Ambient

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F							
			All Plants minus half Indian Point (deg F)	Ambient (deg F)	All Plants minus half Indian Point - Background (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Background (max. = 67%)	River X-sect *** Area (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Background (max. = 50%)
Jun '81	Roseton	Flood	72.17	70.55	1.62	141	107	6.82	2.50	1140	9	14121	5
		Ebb	72.18	70.55	1.63	168	117	6.24	2.43	1140	10	14121	5
	Indian Pt.	Flood	73.15	70.92	2.23	3301	842	2.69	2.02	955	88	14723	15
		Ebb	73.04	70.85	2.19	3092	821	2.71	2.07	1284	64	14991	15
	Bowline	Flood	73.31	71.34	1.97	148	167	5.77	2.05	4355	4	25084	4
		Ebb	73.29	71.38	1.91	88	113	6.90	2.18	4355	3	25084	3
Jul '81	Roseton	Flood	79.17	76.91	2.26	518	277	3.52	1.87	1140	24	14121	7
		Ebb	79.20	76.93	2.27	527	276	3.48	1.85	1140	24	14121	7
	Indian Pt.	Flood	80.37	77.18	3.19	4704	1124	3.66	1.12	935	100	14015	29
		Ebb	80.39	77.22	3.17	4704	1124	3.66	1.12	2055	55	16219	25
	Bowline	Flood	80.06	77.34	2.72	803	413	3.10	1.37	4355	9	25084	5
		Ebb	79.93	77.33	2.60	632	354	3.38	1.46	4355	8	25084	5
Aug '81	Roseton	Flood	80.00	77.65	2.35	606	304	3.30	1.77	1140	27	14121	7
		Ebb	79.98	77.63	2.35	606	304	3.30	1.77	1140	27	14121	7
	Indian Pt.	Flood	80.30	77.07	3.23	4847	1146	3.79	1.06	914	100	13946	31
		Ebb	80.27	77.05	3.22	4847	1146	3.79	1.06	2132	54	16349	27
	Bowline	Flood	79.37	76.64	2.73	632	354	3.38	1.46	4355	8	25084	5
		Ebb	79.13	76.50	2.63	632	354	3.38	1.46	4355	8	25084	5

* Note: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.
** Constant river widths were assigned for the Roseton and Bowline locations.
*** Constant river cross-sectional areas were assigned for the Roseton and Bowline locations.

Table 35

All Plants at Capacity Minus One Unit at Indian Point Referenced to Background

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F							
			All Plants minus half Indian Point (deg F)	Background (deg F)	All Plants minus half Indian Point - Background (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Background (max. = 67%)	River X-sect *** Area (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Background (max. = 50%)
Jun '81	Roseton	Flood	72.17	70.87	1.30	93	77	8.70	2.72	1140	7	14121	5
		Ebb	72.18	70.89	1.29	93	75	8.70	2.72	1140	7	14121	5
	Indian Pt.	Flood	73.15	71.45	1.70	2617	751	2.34	2.61	1091	69	15043	12
		Ebb	73.04	71.36	1.68	2559	732	2.35	2.66	1340	55	15211	11
	Bowline	Flood	73.31	71.78	1.53	88	130	6.90	2.18	4355	3	25084	4
		Ebb	73.29	71.81	1.48	88	113	6.90	2.18	4355	3	25084	3
Jul '81	Roseton	Flood	79.17	77.41	1.76	185	133	5.81	2.36	1140	12	14121	5
		Ebb	79.20	77.45	1.75	184	130	5.79	2.36	1140	11	14121	5
	Indian Pt.	Flood	80.37	78.05	2.32	3275	897	2.55	2.02	960	93	14736	16
		Ebb	80.39	78.07	2.32	3275	897	2.55	2.02	1265	71	14916	15
	Bowline	Flood	80.06	78.05	2.01	143	172	5.77	2.05	4355	4	25084	4
		Ebb	79.93	78.01	1.92	88	116	6.90	2.18	4355	3	25084	3
Aug '81	Roseton	Flood	80.00	78.14	1.86	230	147	5.14	2.25	1140	13	14121	5
		Ebb	79.98	78.14	1.84	219	147	5.28	2.29	1140	13	14121	6
	Indian Pt.	Flood	80.30	77.92	2.38	3418	921	2.64	1.89	932	99	14669	17
		Ebb	80.27	77.88	2.39	3418	921	2.64	1.89	1360	68	15052	16
	Bowline	Flood	79.37	77.28	2.09	148	116	5.70	2.03	4355	3	25084	3
		Ebb	79.13	77.10	2.03	148	116	5.70	2.03	4355	3	25084	3

* Note: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.

** Constant river top widths were assigned for the Roseton and Bowline locations.

*** Constant river cross-sectional areas were assigned for the Roseton and Bowline locations.

Table 36

All Plants at Capacity Minus Bowline Referenced to Background

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F							
			All Plants but... (deg F)	Background (deg F)	All Plants but... - Background (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Background (max. = 67%)	River X-sect *** Area (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Background (max. = 50%)
Jun '81	Roseton	Flood	72.19	70.87	1.32	93	77	8.70	2.72	1140	7	14121	5
		Ebb	72.20	70.89	1.31	93	75	8.70	2.72	1140	7	14121	5
	Indian Pt.	Flood	73.81	71.45	2.36	3299	864	2.79	1.91	956	90	14724	16
		Ebb	73.84	71.36	2.48	3436	886	2.90	1.79	1370	65	15069	17
Jul '81	Roseton	Flood	78.89	77.41	1.48	104	85	8.09	2.65	1140	7	14121	5
		Ebb	78.93	77.45	1.48	104	83	8.08	2.65	1140	7	14121	5
	Indian Pt.	Flood	80.99	78.05	2.94	4117	1023	3.23	1.39	793	100	14342	23
		Ebb	81.02	78.07	2.95	4274	1059	3.29	1.32	1823	58	15829	22
Aug '81	Roseton	Flood	80.06	78.14	1.92	253	164	4.89	2.21	1140	14	14121	6
		Ebb	80.05	78.14	1.91	253	164	4.89	2.21	1140	14	14121	6
	Indian Pt.	Flood	81.15	77.92	3.23	4686	1111	3.73	1.11	938	100	14023	30
		Ebb	81.12	77.88	3.24	4828	1132	3.86	1.05	2122	53	16332	27
Sep '81	Roseton	Flood	73.21	71.74	1.47	105	94	8.10	2.66	1140	8	14121	5
		Ebb	73.13	71.66	1.47	105	94	8.10	2.66	1140	8	14121	5
	Indian Pt.	Flood	73.56	70.98	2.58	3454	888	2.92	1.77	924	96	14652	18
		Ebb	73.50	70.89	2.61	3586	908	3.02	1.67	1451	63	15205	18

* Note: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.

** Constant river widths were assigned for the Roseton and Bowline locations.

*** Constant river cross-sectional areas were assigned for the Roseton and Bowline locations.

Table 37
Ambient Plus Roseton at Capacity

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F							
			Ambient plus Roseton (deg F)	Ambient (deg F)	Ambient plus Roseton - Ambient (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Ambient (max. = 67%)	River X-sect *** Area (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Ambient (max. = 50%)
Jun '81	Roseton	Flood	71.83	70.56	1.28	93	77	8.70	2.72	1140	7	14121	5
		Ebb	71.81	70.55	1.26	93	75	8.70	2.72	1140	7	14121	5
Jul '81	Roseton	Flood	78.60	76.91	1.69	162	120	6.25	2.43	1140	11	14121	5
		Ebb	78.61	76.93	1.68	325	117	6.24	2.43	1140	10	14121	5
Aug '81	Roseton	Flood	79.42	77.65	1.77	184	130	5.79	2.36	1140	11	14121	5
		Ebb	79.38	77.63	1.75	184	130	5.79	2.36	1140	11	14121	5
Sep '81	Roseton	Flood	72.71	71.27	1.44	93	75	8.70	2.72	1140	7	14121	5
		Ebb	72.61	71.17	1.44	93	75	8.70	2.72	1140	7	14121	5

* Note: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.

** Constant river top widths werer assigned for the Roseton and Bowline locations.

*** Constant river cross-sectional areas werer assigned for the Roseton and Bowline locations.

Table 38
Ambient Plus Indian Point at Capacity

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F							
			Ambient plus Indian Point (deg F)	Ambient (deg F)	Ambient plus Indian Point - Ambient (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Ambient (max. = 67%)	River X-sect Area *** (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Ambient (max. = 50%)
Jun '81	Indian Pt.	Flood	73.06	70.92	2.14	3027	820	2.60	2.16	1009	81	14851	14
		Ebb	72.98	70.85	2.13	2959	799	2.61	2.20	1298	62	15046	14
Jul '81	Indian Pt.	Flood	79.99	77.18	2.81	3948	997	3.10	1.49	827	100	14421	21
		Ebb	80.04	77.22	2.82	3948	997	3.10	1.49	1647	61	15533	20
Aug '81	Indian Pt.	Flood	79.92	77.07	2.85	3948	997	3.10	1.49	827	100	14421	21
		Ebb	79.91	77.05	2.86	3329	683	4.74	1.42	1259	54	14893	22
Sep '81	Indian Pt.	Flood	72.47	70.33	2.14	3295	865	2.43	2.25	956	90	14726	14
		Ebb	72.41	70.26	2.15	3226	796	2.60	2.11	1256	63	14878	14

* Note: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.
** Constant river top widths were assigned for the Roseton and Bowline locations.
*** Constant river cross-sectional areas were assigned for the Roseton and Bowline locations.

Table 39
Ambient Plus Bowline at Capacity

Period	Plant	Tidal Phase	Period Averaged Far Field Model Results			Near Field Model Results (CORMIX) for Plume Dimensions at 4 degrees F							
			Ambient plus Bowline (deg F)	Ambient (deg F)	Ambient plus Bowline - Ambient (F deg)	Distance Down Current from Discharge to Maximum Plume Width (m) [X]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width ** (m) at Down Current Distance	Pct. River Width >= 4 F deg above Ambient (max. = 67%)	River X-sect *** Area (m^2) at Down Current Distance	Pct. River X-section >= 4 F deg above Ambient (max. = 50%)
Jun '81	Bowline	Flood	71.95	71.34	0.61	88	130	7	2.18	4355	3	25084	4
		Ebb	72.00	71.38	0.62	88	113	7	2.18	4355	3	25084	3
Jul '81	Bowline	Flood	78.13	77.34	0.79	88	135	7	2.18	4355	3	25084	4
		Ebb	78.11	77.33	0.78	88	116	7	2.18	4355	3	25084	3
Aug '81	Bowline	Flood	77.39	76.64	0.75	88	130	7	2.18	4355	3	25084	4
		Ebb	77.25	76.50	0.75	88	116	7	2.18	4355	3	25084	3
Sep '81	Bowline	Flood	70.33	69.74	0.59	88	135	7	2.18	4355	3	25084	4
		Ebb	70.18	69.58	0.60	88	116	7	2.18	4355	3	25084	3

* NOTE: the letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.

** Constant river top widths were assigned for the Roseton and Bowline locations.

*** Constant river cross-sectional areas were assigned for the Roseton and Bowline locations.

TABLE 39a

MODEL PREDICTIONS FOR MONTHLY AVERAGE SUMMER TEMPERATURE BEHAVIOR AT ROSETON

HEAT LOAD CONDITION	JUNE		JULY		AUGUST		SEPTEMBER	
	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB
Roseton Only								
- Far-Field Model ΔT	1.28	1.26	1.69	1.68	1.77	1.75	1.44	1.44
- Plume Width, ft, >4°F	252	246	394	385	426	426	246	246
- Plume Depth, ft, >4°F	29	29	21	20	19	19	29	29
- Percentage River Width >4°F	7	7	11	10	11	11	7	7
- Percentage River Cross-section >4°F	5	5	5	5	5	5	5	5
Roseton, Indian Point & Bowline								
- Far-Field Model ΔT	1.32	1.31	1.79	1.78	1.92	1.90	2.00	1.99
- Plume Width, ft, >4°F	252	246	512	446	607	590	636	656
- Plume Depth, ft, >4°F	29	29	17	18	15	15	15	14
- Percentage River Width >4°F	7	7	14	12	16	16	17	18
- Percentage River Cross-section >4°F	5	5	6	5	6	6	6	6
All Plants								
- Far-Field Model ΔT	1.64	1.65	2.29	2.30	2.41	2.41	2.47	2.48
- Plume Width, ft, >4°F	350	364	949	944	1110	1059	1128	1102
- Plume Depth, ft, >4°F	22	21	11	11	10	11	11	11
- Percentage River Width >4°F	9	10	25	25	30	28	31	30
- Percentage River Cross-section >4°F	5	5	7	7	8	7	8	8

River Dimensions at Roseton: Surface Width = 3,700 ft Mean Depth = 41 ft Cross-sectional Area = 152,000sf

TABLE 39b

MODEL PREDICTIONS FOR MONTHLY AVERAGE SUMMER TEMPERATURE BEHAVIOR AT BOWLINE

HEAT LOAD CONDITION	JUNE		JULY		AUGUST		SEPTEMBER	
	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB
Bowline Only								
- Far-Field Model ΔT	0.61	0.62	0.79	0.78	0.75	0.75	0.59	0.60
- Plume Width, ft, >4°F	428	370	442	380	428	380	443	381
- Plume Depth, ft, >4°F	23	23	23	23	23	23	23	23
- Percentage River Width >4°F	3	3	3	3	3	3	3	3
- Percentage River Cross-section >4°F	4	3	4	3	4	3	4	3
Roseton, Indian Point & Bowline								
- Far-Field Model ΔT	2.31	2.21	3.03	2.87	3.14	3.02	2.47	2.48
- Plume Width, ft, >4°F	935	648	2065	1484	2191	1662	1630	1355
- Plume Depth, ft, >4°F	14	15	10	11	10	11	10	11
- Percentage River Width >4°F	7	5	14	10	15	12	11	10
- Percentage River Cross-section >4°F	5	4	8	6	8	7	6	6
All Plants								
- Far-Field Model ΔT	2.75	2.64	3.74	3.55	3.78	3.62	3.32	3.24
- Plume Width, ft, >4°F	1465	1135	3626	2484	3634	2669	2453	1863
- Plume Depth, ft, >4°F	10	11	18	14	19	16	12	12
- Percentage River Width >4°F	11	8	25	17	25	19	17	13
- Percentage River Cross-section >4°F	6	5	24	13	26	16	11	8

River Dimensions at Bowline: Surface Width = 14,300 ft Mean Depth = 19 ft Cross-sectional Area = 270,000 sf

TABLE 39c

MODEL PREDICTIONS FOR MONTHLY AVERAGE SUMMER TEMPERATURE BEHAVIOR AT INDIAN POINT

HEAT LOAD CONDITION	JUNE		JULY		AUGUST		SEPTEMBER	
	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB
Indian Point Only								
- Far-Field Model ΔT	2.14	2.13	2.81	2.82	2.85	2.86	2.14	2.15
- Plume Width, ft, >4°F	2689	2622	2713	3271	2713	2240	2837	2611
- Plume Depth, ft, >4°F	9	9	12	10	12	16	8	9
- River Width, ft	3311	4259	2713	5404	2713	4131	3136	4120
- River Mean Depth, ft	48	38	57	31	57	39	51	39
- Percentage River Width >4°F	81	62	100	61	100	54	90	63
- Percentage River Cross-section >4°F	14	14	21	20	21	22	14	14
Roseton, Indian Point & Bowline								
- Far-Field Model ΔT	2.76	2.73	3.69	3.70	3.78	3.79	3.24	3.26
- Plume Width, ft, >4°F	2660	3053	2330	4636	2126	4316	3136	3674
- Plume Depth, ft, >4°F	12	10	33	19	41	19	14	13
- River Width, ft	2661	5430	2330	10,283	2126	8219	3136	7213
- River Mean Depth, ft	58	31	61	19	66	19	48	25
- Percentage River Width >4°F	100	56	100	45	100	43	100	51
- Percentage River Cross-section >4°F	20	19	53	45	62	43	29	28
All Plants								
- Far-Field Model ΔT	3.29	3.24	4.56[a]	4.55[a]	4.63[a]	4.62[a]	3.89	3.89
- Plume Width, ft, >4°F	2914	3488	1926	4106	2030	3952	2060	4743
- Plume Depth, ft, >4°F	16	13	51	15	59	16	56	9
- River Width, ft	2914	7054	1926	8258	2031	8606	2060	13,120
- River Mean Depth, ft	51	25	72	22	71	21	69	13
- Percentage River Width >4°F	100	49	100	50	100	46	100	36
- Percentage River Cross-section >4°F	32	27	71	33	83	34	81	71

[a]For these cases, plume dimensions are bounded by 4.7°F in flood and 5.1°F in ebb. See Appendix VI-3.

TABLE 39d

MODEL PREDICTIONS FOR MONTHLY AVERAGE SUMMER TEMPERATURE BEHAVIOR
AT INDIAN POINT UNDER VARIOUS OUTAGE SCENARIOS

HEAT LOAD CONDITION	JUNE		JULY		AUGUST		SEPTEMBER	
	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB	FLOOD	EBB
Roseton Outage (Indian Point & Bowline Only)								
- Far-Field Model ΔT	2.53	2.51	3.23	3.24	3.28	3.29	2.67	2.69
- Plume Width, ft, >4°F	2906	2906	3068	3760	3002	3783	2684	2904
- Plume Depth, ft, >4°F	10	10	14	12	16	13	12	10
- River Width, ft	3045	4495	3068	6995	3002	7212	2684	5171
- River Mean Depth, ft	52	36	49	25	50	25	58	32
- Percentage River Width >4°F	95	65	100	54	100	52	100	56
- Percentage River Cross-section >4°F	18	17	29	27	31	28	20	18
Bowline Outage (Indian Point & Roseton Only)								
- Far-Field Model ΔT	2.36	2.48	2.94	2.95	3.23	3.24	2.58	2.61
- Plume Width, ft, >4°F	2834	2906	2602	3473	3078	3713	2914	2979
- Plume Depth, ft, >4°F	9	10	14	11	14	13	10	10
- River Width, ft	3137	4495	2602	5981	3078	6962	3032	4761
- River Mean Depth, ft	51	36	59	28	49	25	52	34
- Percentage River Width >4°F	90	65	100	58	100	53	96	63
- Percentage River Cross-section >4°F	16	17	23	22	30	27	18	18
Indian Point Outage (All Plants Save One Unit at Indian Point)								
- Far-Field Model ΔT	2.23	2.19	3.19	3.17	3.23	3.22	---	---
- Plume Width, ft, >4°F	2763	2692	3068	3689	2999	3760	---	---
- Plume Depth, ft, >4°F	9	9	14	12	16	12	---	---
- River Width, ft	3133	4213	3068	6742	2999	6995	---	---
- River Mean Depth, ft	51	38	49	26	50	25	---	---
- Percentage River Width >4°F	88	64	100	55	100	68	---	---
- Percentage River Cross-section >4°F	15	15	29	25	31	16	---	---

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Appendix VI-3-B

Thermal Modeling of Near Slackwater Tide Thermal Plumes

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09 November 1998
File No. 115-178

Dr. William L. Kirk, Department Manager
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Environmental Affairs
Consolidated Edison Company
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Re: Modeling of Thermal Discharges from Roseton, Indian Point and Bowline Point Generating Stations at Near-Slackwater Conditions

Dear Dr. Kirk:

This letter describes computer modeling performed by Lawler, Matusky & Skelly Engineers LLP (LMS) for Consolidated Edison Company of New York, Inc. (ConEd) on behalf of the Hudson River Utilities (HRU). The modeling characterizes the plumes associated with thermal discharges from Roseton, Indian Point 2 & 3, and Bowline Point Generating Stations under extreme hypothetical, "near-slackwater" conditions, as requested by New York State Department of Environmental Conservation (DEC).

The letter first summarizes the modeling, then presents the background and purpose of the modeling, describes the methodology and approach used, and details the results. Figures and tables cited in the text follow the signature page. Other attachments cited in the text follow the figures and tables.

SUMMARY

Near and far field thermal modeling in addition to that presented in Appendix VI-3 of the preliminary ***Draft Environmental Impact Statement for State Pollutant Discharge Elimination System Permits for Bowline Point, Indian Point 2 & 3 and Roseton Steam Electric Generating Stations*** (DEIS), dated June 1993, was conducted at the specific request of DEC to examine hypothetical conditions represented by the lowest 10^{th} percentile flood currents and mean low water depths in the vicinity of each station, and concurrent operation of all generating stations at maximum permitted capacity. To differentiate these conditions from the maximum ebb and maximum flood conditions considered in the DEIS, they are called "near-slackwater" conditions. The near-slackwater analysis uses the same modeling methods described in DEIS Appendix VI-3, including the MIT Far Field Thermal Model (FFTM), the CORMIX plume model and the Thermal Balance Model. The results for the near-slackwater conditions are similar to those presented in DEIS Appendix VI-3 for maximum flood conditions. The estimated 4 F° excess temperature isotherms associated with the Roseton and Bowline cooling water discharges encompass substantially less than two-thirds of the surface width of the Hudson River and less than 50 percent of the cross-sectional area. The forecast 4 F° isotherm for the Indian Point cooling water discharge encompasses the entire surface width of the River, but less than 50 percent of the cross-sectional area.

BACKGROUND AND PURPOSE

The modeling reported in this letter responds to a question raised by DEC regarding the thermal modeling presented in DEIS Appendix VI-3. The specific elements of the additional modeling required to address the question are outlined in a 30 April 1996 FAX from Mr. Ed Radle (DEC) to Dr. William L. Kirk (ConEd). Following a 14 August 1996 telephone discussion of the FAX, Mr. Charles Beckers (LMS) outlined final details of the analysis in a 29 August 1996 letter to Mr. Aslam Mirza (DEC).

The objective of the near-slackwater modeling is an understanding of the behavior of the three thermal plumes under the same hypothetical conditions analyzed in the DEIS, except that the current velocities in the Hudson River would correspond to a condition as close to slack water as can be studied with the CORMIX plume model. The assumed hypothetical conditions considered in the DEIS are:

- Actual June, July, August and September 1981 hydrological, oceanographic, and meteorological conditions, which represent a period of very low inflow and high ambient temperature
- Maximum permitted thermal loads for all generating stations and other heat sources discharging to the Hudson River
- Maximum ebb and flood currents
- Mean low tide depths

In the present study, the lowest 10th percentile flood currents replace the maximum ebb and flood currents in the study scenario. The lowest 10th percentile currents are close to the lowest velocities at which the CORMIX plume model can be expected to produce usable results, because of model limitations, and the results reported in the DEIS suggest that flood currents produce larger plumes than ebb currents.

METHODS AND APPROACH

As detailed in DEIS Appendix VI-3, LMS employed three models to evaluate the Roseton, Indian Point, and Bowline thermal plumes:

- The Cornell Mixing Zone Model (CORMIX) to estimate conditions in the near field
- The Massachusetts Institute of Technology (MIT) Dynamic Network Model (also called the Far Field Thermal Model or FFTM) to estimate conditions in the far field
- A Temperature Balance Model developed by LMS to combine the results from CORMIX and the FFTM, and to evaluate conditions in the transition from near to far field

As described in DEIS Appendix VI-3, the terms near field and far field are used in these studies to mean:

- The near field (or plume) - the region in the immediate vicinity of each discharge where cooling water occupies a clearly distinguishable, three-dimensional temperature regime in the river and has not yet fully mixed with the river
- The far field - the region farther from the discharges where the plumes are no longer distinguishable from the river, but the influence of the discharge is still present

For purposes of these studies, the spatial extent of each thermal plume is defined by the 4 F° excess temperature contour associated with the cooling water discharge, and is determined by comparing the temperatures forecast by the models with all plants operating at capacity (the "All Plants At Capacity" or APAC condition) with the temperatures forecast when the three plants under study are not discharging (the "Background" or BKGD condition). The overall procedure is applied independently for each generating station during each month of the four-month 1981 period for which the model is calibrated.

The present study requires replacement of the maximum ebb and flood currents with the lowest 10th percentile flood current velocities in the vicinity of the three generating stations under study. In addition, the modeling requires estimates of the water temperatures and salinities corresponding to the occurrence of the lowest 10th percentile velocities. Salinity and temperature vary with a number of factors in the river, including tidal velocities, headwaters flows, meteorological conditions, and, for temperature, generating station operations. River velocity, salinity and temperature influence the dilution and spreading processes affecting the thermal discharge plumes.

There are no direct time series observations of Hudson river currents, water temperatures or salinities during the 1981 study period of sufficient length to allow direct determination of these statistics. Instead, LMS estimated the lowest 10th percentile current speeds by statistically analyzing the current speeds computed by the FFTM for the 1981 period. At the same time, LMS determined the mean water temperatures and salinities corresponding to the time of occurrence of the 10th percentile currents using the values forecast by the FFTM.

The results presented in this letter were produced using the DEIS version of the FFTM, the CORMIX2 module of CORMIX Version 3.2 (September 1996), and a modified version of the Temperature Balance Model. The CORMIX2 module is the part of CORMIX that models multi port diffusers. The modifications to the Temperature Balance Model were necessary to accommodate the centerline orientation of the thermal plumes at the 10th percentile velocities. Detailed discussions of CORMIX, the FFTM, and the Temperature Balance Model may be found in DEIS Appendix VI-3.

RESULTS

Determination of Tenth Percentile Conditions

Tables 1, 2 and 3 present the results of the Tenth Percentile Analysis for Roseton, Indian Point and Bowline, respectively. The column labeled "BKGD" refers to the FFTM model of conditions in the river with all plants, except the three under study, operating at capacity (as described in DEIS Appendix VI-3). The column labeled "APAC" refers to the FFTM model of conditions in the river with all plants, including the three under study, operating at capacity (also as described in DEIS Appendix VI-3). In the FFTM, velocity and salinity are not a function of the plant operations.

CORMIX Analysis

Tables 4, 5 and 6 summarize the inputs used in the CORMIX model for each month studied at Roseton, Indian Point and Bowline, respectively.

With two exceptions, the input values are the same as those used in the CORMIX modeling described in Appendix VI-3 of the DEIS, so that the two sets of results can be combined to form an overall picture of the plume behavior over a tidal cycle. The first exception is that the current speeds, receiving water densities and discharge densities were changed to reflect the hypothetical Tenth Percentile Conditions. The second exception stems from LMS' review of the input values used in the DEIS for accuracy. As a result of that review, the value for the Indian Point port height was revised to more accurately reflect the configuration of that diffuser. LMS reviewed the CORMIX runs presented in the DEIS and found that the change in port elevation has no effect on the conclusions drawn in Appendix VI-3 regarding the extent of the Indian Point thermal plume. The change to the Indian Point port height value is made strictly in the name of rigor. All other values carried over from the DEIS were found to be accurate. Figures 1, 2 and 3 show the relevant dimensions and the overall configuration of each diffuser.

CORMIX allows the user to specify a wind speed and a surface heat exchange coefficient. LMS set both to zero in the near-slackwater modeling; this approach is both consistent with the approach used in the DEIS and conservative, i.e., it maximizes the heat in the plume at any point.

Figures 4 through 63 present the results of the various CORMIX analyses for the three generating stations, as represented in the graphical output produced by the CORMIX model.[1] The following table shows which figures correspond to each of the conditions modeled.

Conditions Represented by Each Figure

	Roseton	Indian Point	Bowline Point
June	4, 5, 6, 7 & 8	24, 25, 26, 27 & 28	44, 45, 46, 47 & 48
July	9, 10, 11, 12 & 13	29, 30, 31, 32 & 33	49, 50, 51, 52 & 53
August	14, 15, 16, 17 & 18	34, 35, 36, 37 & 38	54, 55, 56, 57 & 58
September	19, 20, 21, 22 & 23	39, 40, 41, 42 & 43	59, 60, 61, 62 & 63

In each set of five figures:

1 Figures 44 through 63 (the Bowline results) differ in spatial extent from the Roseton and Indian Point results due to a limitation of the CORMIX graphics.

- the first shows the plan view of the plume, with the vertical axis the cross-river direction (meters), the horizontal axis the along-current direction (meters), the arrows indicating the direction of river current, the solid lines indicating the plume boundaries and the broken line the plume centerline

- the second shows the side view of the plume as seen from the eastern shoreline, with the vertical axis indicating depth (elevation above the bottom, meters), the horizontal axis the alongshore distance (meters, positive in the direction of flow), the arrows indicating the direction of river current, the solid line indicating the plume boundary and the broken line the plume centerline

- the third shows the side view normal to the plume centerline, with the vertical axis indicating depth (elevation in meters above the bottom at the point of discharge)[2], the horizontal axis the distance along the plume centerline (meters)[3], the solid line the plume boundary and the broken line the plume centerline

- the fourth shows the centerline excess temperature as a function of distance down current, with the vertical axis excess temperature in Celsius degrees and the horizontal axis distance down current along the shoreline (meters)

- the fifth shows the centerline excess temperature as a function of distance along the plume centerline, with the vertical axis excess temperature in Celsius degrees and the horizontal axis distance along the plume centerline (meters)

Note that the boundaries of the plumes shown in these figures are the dynamic boundaries as defined by CORMIX, not a specific isotherm. CORMIX plots the plume boundaries based on the cross-sectional distribution forecast to exist at a given distance along the plume centerline. In sections of the plume displaying a gaussian cross-sectional distribution, the plotted boundary indicates the locus of points corresponding to a fixed percentage of the centerline excess temperature. Since the centerline excess temperature varies with distance along the centerline, the excess temperature at the plotted boundary of a gaussian section also varies with distance from the discharge. In sections displaying a uniform ("tophat") distribution, CORMIX plots the boundary as the locus of points

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2 Because the bottom at the point of discharge is typically shallower than elsewhere in the river, the deeper areas are shown as negative values on the vertical axis.

3 In the plume centerline view, the horizontal axis represents distance in an approximately east-west direction as the plume travels across the river from the point of discharge until it reaches the opposite shore. Thereafter, the horizontal axis represents distance along the shoreline (approximately south to north).

corresponding to the transition from the cross-sectionally uniform interior excess temperature to the surrounding ambient. Thus, in tophat sections, the boundary coincides with the location of all the excess temperature isotherms needed to portray that precipitous change.

Also note that, in the plan views, the boundary labeled "bank/shore left" is the western shore and the one labeled "bank/shore right" is the eastern shore. All longitudinal profiles are drawn looking from the eastern shore toward the western shore.

In reviewing Figures 4 through 63, the reader should keep in mind that CORMIX estimates the plume that would exist under steady-state conditions. In the present case, that means these figures show the plume that would occur if the flow were always flooding at the 10th percentile velocity. These conditions actually occur for only a brief period following slack water, so none of the plumes would ever have an opportunity to develop fully to the form shown in these figures. In particular, none of the plume centerlines would be expected to reach the opposite shorelines, as the plan view figures might lead the reader to believe.

For reference, the 12 CORMIX prediction files and session reports are Attachments A through L.

Temperature Balance Modeling

Table 7 presents the results of the Temperature Balance Model for all 12 cases studied. Table 7 is similar to Table 32 in DEIS Appendix VI-3, except that the column labeled "Distance Down Current . . . " in DEIS Table 32 is replaced by a column labeled "Distance Cross River . . . " This change and the corresponding changes to the computations are necessary to represent the near-slackwater plumes correctly. Unlike the maximum ebb and flood plumes, which tend to parallel the shoreline, the near-slackwater plumes shown in Figures 4 through 63 tend to project across the River.

The two columns of greatest interest in Table 7 are labeled: "Pct. River Width >= 4 F deg above Background" and "Pct. River X-section >= 4 F deg above Background". As shown, the estimated 10th percentile flood conditions are very similar to those predicted to occur for the maximum flood conditions in DEIS Table 32.

DISCUSSION

When interpreting the foregoing results, four factors should be kept in mind:

- the plant operating conditions modeled represent extreme hypothetical conditions

- all generating stations on the Hudson River are operating continuously at maximum permitted capacity for a long period of time; for all practical purposes this condition never occurs

♦ the tidal conditions modeled do not actually occur in nature

- in the region of the Hudson River modeled, mean low water coincides more closely with maximum ebb than it does with the 10th percentile flood condition[4]

♦ CORMIX is a steady state model

- while the flow conditions modeled would actually occur for a very brief period immediately following slack-before-flood, CORMIX assumes they have been continuous over a long period of time; as a result, the CORMIX results overstate the cross-river extent of the plume centerline

♦ the river flow conditions modeled also represent extreme conditions in the river

- as discussed in the DEIS Appendix VI-3 (see Figures 49a through 49d), the modeled river flows are clearly atypical

Consequently, the estimated spatial extents of the plumes presented in this letter can be thought of as nearly absolute upper bounds to the actual plumes that would occur under more realistic operating and natural conditions.

CONCLUSION

In conclusion, the results presented in this letter for the 10th percentile, near-slackwater conditions are similar to those presented in DEIS Appendix VI-3 for maximum flood conditions. The estimated 4 F° isotherms associated with the Roseton and Bowline cooling water discharges occupy substantially less than two-thirds of the surface width of the river and less than 50 percent of the cross-sectional area. The forecast 4 F° isotherm for the Indian Point cooling water discharge occupies the entire surface width of the river, but less than 50 percent of the cross-sectional area.

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[4] Schureman, P., Tides and Currents in Hudson River, U.S. Coast & Geodetic Survey Special Publication 180, 1934, Figures 14 through 26.

If you have any questions regarding the study reported in this letter, please call either Mr. Charles Beckers or me at 914-735-8300.

Sincerely,

John P. Lawler, Ph.D., P.E.
Partner

Tables and Figures
Attachments

Table 1
10th Percentile Analysis Results for Roseton Generating Station

Month	Velocity (fps)	Salinity (mg/l)	Temperature (°F)	
			BKGD	APAC
June	0.32	248.23	70.73	72.04
July	0.33	748.71	77.74	79.57
August	0.32	672.67	78.27	80.14
September	0.30	2153.23	72.61	74.75

Table 2
10th Percentile Analysis Results for Indian Point Generating Station

Month	Velocity (fps)	Salinity (mg/l)	Temperature (°F)	
			BKGD	APAC
June	0.29	3251.73	71.15	73.85
July	0.30	4133.77	77.38	80.94
August	0.29	3879.49	77.79	81.52
September	0.28	7462.33	71.98	75.28

Table 3
10th Percentile Analysis Results for Bowline Point Generating Station

Month	Velocity (fps)	Salinity (mg/l)	Temperature (°F)	
			BKGD	APAC
June	0.24	4218.37	70.89	73.09
July	0.23	5393.39	77.15	80.11
August	0.23	5892.53	76.58	79.46
September	0.22	8582.54	70.92	73.76

Table 4
Summary of CORMIX Model Inputs for Roseton Generating Station

Parameter	Period	Value	Source
General Depth of Receiving Water [m (ft)]	All	11.50 (37.7)	DEIS Appendix VI-3
Receiving Water Depth at Discharge Location [m (ft)]	All	8.70 (28.5)	DEIS Appendix VI-3
Current Speed [m/s (fps)]	June	0.098 (0.32)	Tenth percentile analysis shown in Table 1
	July	0.101 (0.33)	
	August	0.098 (0.32)	
	September	0.091 (0.30)	
Manning's n	All	0.03	Literature value typical of these conditions
Bounded Width [m (ft)]	All	1140 (3740)	DEIS Appendix VI-3
Receiving Density [kg/m^3 (lbs./ft^3)]	June	997.97 (62.18)	Computed using the Tumlirz equation[1] with the salinity and temperature shown in Table 1
	July	997.33 (62.14)	
	August	997.19 (62.13)	
	September	999.05 (62.25)	
Diffuser Length [m (ft)]	All	99.1 (325)	DEIS Appendix VI-3
Distance from shore [m (ft)]	All	100 (328)	DEIS Appendix VI-3
Number of Ports	All	14	DEIS Appendix VI-3
Port diameter [m (ft)] and contraction ratio	All	0.91 (3.0) 1.00	DEIS Appendix VI-3
Port Height [m (ft)]	All	2.7 (9)	DEIS Appendix VI-3

1 Fofonoff, N.P. (1962), Physical properties of sea-water, in *The Sea, Volume One* , M.N. Hill, ed., Interscience Publishers, New York, 1962, 864 pp.

Parameter	Period	Value	Source
Alignment of Diffuser Axis relative to Flow [°]	All	0	DEIS Appendix VI-3
Alignment of Ports relative to Diffuser Axis [°]	All	90	DEIS Appendix VI-3
Vertical Angle [° positive up]	All	0	DEIS Appendix VI-3
Cooling Water Flow [m^3/s (MGD)]	All	40.44 (920)	DEIS Appendix VI-3
Discharge Excess Temperature [C° (F°)]	All	10.0 (18.0)	DEIS Appendix VI-3
Discharge Density [kg/m^3 (lbs/ft^3)]	June	995.24 (62.01)	Computed using the Tumlirz equation[2] with the salinity shown in Table 1 and the temperature equal to the sum of the temperature shown in Table 1 plus the excess temperature
	July	994.16 (61.94)	
	August	993.99 (61.93)	
	September	996.15 (62.07)	

2 Fofonoff, N.P. (1962), Physical properties of sea-water, in *The Sea, Volume One*, M.N. Hill, ed., Interscience Publishers, New York, 1962, 864 pp.

Table 5
Summary of CORMIX Model Inputs for Indian Point Generating Station

Parameter	Period	Value	Source
General Depth of Receiving Water [m (ft)]	All	8.5 (27.9)	DEIS Appendix VI-3
Receiving Water Depth at Discharge Location [m (ft)]	All	6.55 (21.5)	DEIS Appendix VI-3
Current Speed [m/s (fps)]	June	0.088 (0.29)	Tenth percentile analysis shown in Table 2
	July	0.091 (0.30)	
	August	0.088 (0.29)	
	September	0.085 (0.28)	
Manning's n	All	0.03	Literature value typical of these conditions
Bounded Width [m (ft)]	All	1510 (4950)	DEIS Appendix VI-3
Receiving Density [kg/m^3 (lbs/ft^3)] (where two densities are shown, water column was modeled as linearly stratified)	June	999.2 (62.26) 1000.8 (62.36)	Computed using the Tumlirz equation[1] with the salinity and temperature shown in Table 2
	July	999.46 (62.27) 999.84 (62.30)	
	August	999.22 (62.26) 999.52 (62.28)	
	September	1002.96 (62.49)	
Diffuser Length [m (ft)]	All	70.4 (231)	DEIS Appendix VI-3
Distance from shore [m (ft)]	All	0 (0)	DEIS Appendix VI-3
Number of Ports	All	12	DEIS Appendix VI-3
Port diameter [m (ft)] and contraction ratio	All	2.66 (8.73) 0.8	Diameter of an equivalent circular port with the same cross-sectional area, as in DEIS Appendix VI-3; contraction ratio corrects for flow differences between circular and rectangular opening

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1 Fofonoff, N.P. (1962), Physical properties of sea-water, in *The Sea, Volume One*, M.N. Hill, ed., Interscience Publishers, New York, 1962, 864 pp.

Parameter	Period	Value	Source
Port Height [m (ft)]	All	2.15 (7.05)	Adjusted from value in DEIS Appendix VI-3 to more accurately reflect the diffuser configuration (limited by CORMIX constraints)
Alignment of Diffuser Axis relative to Flow [°]	All	0	DEIS Appendix VI-3
Alignment of Ports relative to Diffuser Axis [°]	All	90	DEIS Appendix VI-3
Vertical Angle [° positive up]	All	0	DEIS Appendix VI-3
Cooling Water Flow [m^3/s (MGD)]	All	106 (2420)	DEIS Appendix VI-3
Discharge Excess Temperature [C° (F°)]	All	9.06 (16.3)	DEIS Appendix VI-3
Discharge Density [kg/m^3 (lbs/ft^3)]	June	997.6 (62.16)	Computed using the Tumlirz equation[2] with the salinity shown in Table 2 and the temperature equal to the sum of the temperature shown in Table 2 plus the excess temperature
	July	996.88 (62.11)	
	August	996.58 (62.09)	
	September	1000.46 (62.33)	

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2 Fofonoff, N.P. (1962), Physical properties of sea-water, in *The Sea, Volume One*, M.N. Hill, ed., Interscience Publishers, New York, 1962, 864 pp.

Table 6
Summary of CORMIX Model Inputs for Bowline Point Generating Station

Parameter	Period	Value	Source
General Depth of Receiving Water [m (ft)]	All	5.5 (18.0)	DEIS Appendix VI-3
Receiving Water Depth at Discharge Location [m (ft)]	All	6.9 (22.6)	DEIS Appendix VI-3
Current Speed [m/s (fps)]	June	0.073 (0.24)	Tenth percentile analysis shown in Table 1
	July	0.070 (0.23)	
	August	0.070 (0.23)	
	September	0.067 (0.22)	
Manning's n	All	0.03	Literature value typical of these conditions
Bounded Width [m (ft)]	All	4355 (14,280)	DEIS Appendix VI-3
Receiving Density [kg/m^3]	June	1000.82 (62.36)	Computed using the Tumlirz equation[1] with the salinity and temperature shown in Table 1
	July	1000.72 (62.35)	
	August	1001.19 (62.40)	
	September	1004.01 (62.56)	
Diffuser Length [m (ft)]	All	106.6 (350)	DEIS Appendix VI-3
Distance from shore [m (ft)]	All	366 (1200)	DEIS Appendix VI-3
Number of Ports	All	16	DEIS Appendix VI-3
Port diameter [m (ft)] and contraction ratio	All	0.91 (3.0) 1.00	DEIS Appendix VI-3
Port Height [m (ft)]	All	1.83 (6)	DEIS Appendix VI-3
Alignment of Diffuser Axis relative to Flow [°]	All	0	DEIS Appendix VI-3
Alignment of Ports relative to Diffuser Axis [°]	All	90	DEIS Appendix VI-3
Vertical Angle [° positive up]	All	5	DEIS Appendix VI-3

1 Fofonoff, N.P. (1962), Physical properties of sea-water, in *The Sea, Volume One*, M.N. Hill, ed., Interscience Publishers, New York, 1962, 864 pp.

Parameter	Period	Value	Source
Cooling Water Flow [m^3/s (MGD)]	All	48.45 (1105)	DEIS Appendix VI-3
Discharge Excess Temperature [C (F)]	All	7.22 (13)	DEIS Appendix VI-3
Discharge Density [kg/m^3 (lbs/ft^3)]	June	998.88 (62.24)	Computed using the Tumlirz equation[2] with the salinity shown in Table 1 and the temperature equal to the sum of the temperature shown in Table 1 plus the excess temperature
	July	998.50 (62.21)	
	August	998.99 (62.24)	
	September	1002.03 (62.43)	

2 Fofonoff, N.P. (1962), Physical properties of sea-water, in *The Sea, Volume One* , M.N. Hill, ed., Interscience Publishers, New York, 1962, 864 pp.

Table 7
Temperature Balance Model Results

Period	Plant	Tidal Phase	Far Field Model Results for 10% Flood Conditions					Near Field Model (CORMIX2) Results for Plume Dimensions at 4 Degrees F							
			All Plants (deg F)	Background (deg F)	Delta T Criterion (F deg)	Interpreted Reading (F deg)	Delta T = All Plants minus Background (F deg)	Distance Cross River from Shoreline to 4 F deg Isotherm (m) [Y]*	Plume Width (m) [BH]*	Plume Thickness (m) [BV]*	Centerline Delta T (F deg) [C]*	River Width (m)**	Pct. River Width >= 4 F deg above Background	River X-sect Area (m^2)**	Pct. River X-section >= 4 F deg above Background
Jun '81	Roseton	10% Flood	72.04	70.73	4.00	4.00	1.31	208.91	99.32	5.00	2.93	1241	17%	13456.0	5%
	Indian Pt.	10% Flood	73.85	71.15	4.00	4.00	2.70	1607.17	989.22	1.79	3.56	1610	100%	15626.0	24%
	Bowline	10% Flood	73.09	70.89	4.00	4.00	2.20	506.77	71.72	6.90	1.91	3077	16%	17976.0	5%
Jul '81	Roseton	10% Flood	79.57	77.74	4.00	4.00	1.83	427.46	237.00	3.35	2.25	1241	34%	13456.0	11%
	Indian Pt.	10% Flood	80.94	77.38	4.00	4.00	3.56	1615.01	1026.86	1.71	3.55	1610	100%	15626.0	24%
	Bowline	10% Flood	80.11	77.15	4.00	4.00	2.96	1345.17	502.26	3.02	1.05	3077	44%	17976.0	22%
Aug '81	Roseton	10% Flood	80.14	78.27	4.00	4.00	1.87	446.33	249.28	3.30	2.21	1241	36%	13456.0	12%
	Indian Pt.	10% Flood	81.52	77.79	4.00	4.00	3.73	1607.17	1026.42	1.72	3.56	1610	100%	15626.0	24%
	Bowline	10% Flood	79.46	76.58	4.00	4.00	2.88	1171.25	411.54	3.19	1.13	3077	38%	17976.0	19%
Sep '81	Roseton	10% Flood	74.75	72.61	4.00	4.00	2.14	637.16	356.14	3.06	1.91	1241	51%	13456.0	16%
	Indian Pt.	10% Flood	75.28	71.98	4.00	4.00	3.30	1593.63	992.62	1.79	3.56	1610	99%	15626.0	24%
	Bowline	10% Flood	73.76	70.92	4.00	4.00	2.84	997.33	319.42	3.46	1.24	3077	32%	17976.0	19%

Notes:

* The letters in the square brackets [ ] indicate the corresponding CORMIX model variable name.

** River widths and cross-sectional areas based on FFTM input data, for consistency between CORMIX and FFTM parts of the table.