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SCE&G®
A SCANA COMPANY

February 8, 2011
NND-11-0045

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555-0001

ATTN: Document Control Desk

Subject: Virgil C. Summer Nuclear Station (VCSNS) Units 2 and 3 Combined License Application (COLA) - Docket Numbers 52-027 and 52-028 – Response to NRC Clarification Request Concerning Request for Additional Information (RAI) SW-11

Reference:
1. Letter from Ronald B. Clary to Document Control Desk, Submittal of Revision 2 to Part 3 (Environmental Report) of the Combined License Application for the V. C. Summer Nuclear Station Units 2 and 3, dated July 2, 2010.
2. Email Clarification Request from Patricia Vokoun regarding RAI SW-11, dated February 1, 2011.

By letter dated March 27, 2008, South Carolina Electric & Gas Company (SCE&G) submitted a combined license application (COLA) for V.C. Summer Nuclear Station (VCSNS) Units 2 and 3, to be located at the existing VCSNS site in Fairfield County, South Carolina. Subsequently the Environmental Report (ER), Part 3 of the application, was revised and submitted to the NRC (reference 1).

This letter is in response to an Email Clarification Request regarding RAI SW-11 (Reference 2). The request is to provide updated information related to the CORMIX model for VCSNS Units 2 and 3. The enclosure to this letter provides selected pages of the CORMIX calculation performed by SHAW Nuclear. Please note these selected pages are not considered proprietary.

Please address any questions to Mr. Alfred M. Paglia, Manager, Nuclear Licensing, New Nuclear Deployment, P. O. Box 88, Jenkinsville, S.C. 29065; by telephone at 803-345-4191; or by email at apaglia@scana.com.

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I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 8th day of February, 2011.

Sincerely,

Ronald B. Clary
Vice President
New Nuclear Deployment

ARR/RBC/ar

Enclosure: Response to Email Clarification Request from Patricia Vokoun regarding RAI SW-11, dated February 1, 2011.

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Response to Email Clarification Request from Patricia Vokoun regarding Request for Additional Information (RAI) SW-11, dated February 1, 2011

Clarification Request: Provide updated model results for the proposed Summer Units 2 and 3 discharge that include:

• A statement indicating the review status of the information requested with the State of South Carolina for permitting purposes

• A discussion of temperature of blowdown discharge

• Tables of CORMIX input data for variety of discharge temperatures for both summer and winter scenarios

• CORMIX results for steady state temperature model

• CORMIX results for unsteady flow temperature model

• A description of the dilution of the whole effluent toxicity (WET) concentration

• Data for WET dilution modeling for steady and unsteady state conditions and Chronic and Acute mixing conditions.

Response: SCE&G submitted a Preliminary Engineering Report and NPDES Permit Application for the Unit 2 and 3 Waste Water System to South Carolina Department of Health and Environmental Control (SCDHEC) on November 18, 2010 (Letter NND-10-0385). This application is currently under review by SCDHEC. Included in the NPDES Permit Application is the SHAW Nuclear CORMIX calculation.

The overall conclusions from the CORMIX calculation (pages 5 - 7) and other selected pages are provided to address the specific data requested as follows:

• A discussion of temperature of blowdown discharge (page 10)

• Tables of CORMIX input data for variety of discharge temperatures for both summer and winter scenarios (pages 14 – 19)

• CORMIX results for steady state temperature model (page 34)

• CORMIX results for unsteady flow temperature model (pages 35 – 39)

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• A description of the dilution of the whole effluent toxicity (WET) concentration (page 40)

• Data for WET dilution modeling for steady and unsteady state conditions and Chronic and Acute mixing conditions (pages 41 – 49)

1.0 CONCLUSION

The combined cooling water blowdown and waste water retention basin (WWRB) discharge from the VC Summer Station Units 2 and 3 is proposed to be mixed with waters of the Parr Reservoir located on the Broad River using a multi-port diffuser. The effects of the mixing of the proposed discharge from Units 2 and 3 with the receiving waters of the Parr Reservoir were simulated using the computer model CORMIX version 6.0 (MixZon, 2009a), which is a software on Shaw Nuclear's Approved Computer Program List.

South Carolina Department of Health and Environmental Control (SCDHEC) water quality regulations specify the following requirements, among others, that are applicable to the mixing of discharge from Units 2 and 3 with the waters of Parr Reservoir on the Broad River:

- The water temperature of all freshwaters which are free flowing shall not be increased more than 5°F (2.8°C) above natural temperature conditions and shall not exceed a maximum of 90°F (32.2°C) as a result of the discharge of heated liquids unless a different site-specific temperature standard has been established, a mixing zone has been established, or a Section 316(a) determination under the Federal Clean Water Act has been completed (SCDHEC, 2008).
- A demonstration, using CORMIX or other approved methodologies, is required to establish permit conditions for chronic mixing consistent with a mixing zone boundary of one-half the width of the stream and a downstream length of twice the stream width (SCDHEC, 2005 and 2009).
- A demonstration, using CORMIX or other approved methodologies, is required to establish permit conditions for acute mixing consistent with a mixing zone boundary of one-tenth the width of the stream and a downstream length of one-third the stream width (SCDHEC, 2005 and 2009).

Model simulations were performed to determine the following:

- The dimensions of the mixing zone(s) that will meet SCDHEC regulatory requirements
- The effluent dilution factors consistent with the SCDHEC regulatory requirements for Whole Effluent Toxicity (WET)

The inputs for the CORMIX model were derived from site specific data, drawings, calculations and assumptions about site conditions. Model runs were performed for a series of steady and unsteady ambient river flow conditions. As required by SCDHEC, the proposed discharge was simulated under steady state modeling conditions to mix with the long term low flow in the Broad River defined by the 7-day 10 year low flow (7Q10, USGS 2007a). The USGS calculated 7Q10 flow in Broad River [853 cubic feet per second (cfs)] was apportioned to the two channels in accordance with the ratio of their cross-sectional areas. It was assumed that under steady state conditions an

apportioned 485 cfs of water will flow past the diffuser located in the east channel of the Broad River during the 7Q10 low flow period and will be available to mix with the diffuser discharge.

Modeling was also performed to evaluate the mixing zone and temperature impacts within the Parr Reservoir for scenarios when the discharge from Units 2 and 3 remains constant over time but the ambient flow field (river flow rates, velocity and flow directions) vary over time due to the operation of the Fairfield Pumped Storage Hydro Peaking Plant. Tidal simulations within CORMIX were not possible due to the non-uniform tidal cycle represented by the FFPS operation. This was confirmed during discussions with the model code developer, Mr. Robert Donekar, who indicated that the tidal module in CORMIX was not applicable to the VC Summer discharge where the ambient flow rates could change multiple times in a day unlike twice a day for tidal situations. Mr. Donekar also confirmed that due to small dimensions of the mixing zone downstream length, the re-entrainment of the temperature during flow reversals caused by FFPS operations is not likely to be significant. The diurnal operations of the FFPS were evaluated and nine additional scenarios were selected to represent the range of flow conditions within the Parr Reservoir. Each scenario was modeled as a steady state condition using the critical river flow condition defined by the 7Q10 value, along with additional water withdrawals and returns related to Fairfield Pumped Storage hydro-power generation cycle causing changes in the river flow rate, velocity and direction (SCE&G, 2010a).

For each of the ten flow condition, the following four design cases were evaluated:

- Unit 2 and 3 discharge at 90.1°F temperature occurring during August-September when the river flow is low and river water temperatures (81.2°F) are highest
- Unit 2 and 3 discharge at 90.1°F temperature occurring during February when the river water temperatures (45.9°F) are at their lowest
- Unit 2 and 3 discharge at 95.0°F temperature occurring during August-September when the river flow is low and river water temperatures (81.2°F) are highest
- Unit 2 and 3 discharge at 95.0°F temperature occurring during February when the river water temperatures (45.9°F) are at their lowest

The two diffuser discharge temperatures (90. 1°F and 95.0°F) used in the above listed design cases represent the cooling tower blowdown nominal and maximum temperatures (Shaw Nuclear Services Inc., 2010a). The nominal temperature represents the maximum continuous temperature for maintaining 100% peak power efficiencies and the maximum temperature represents a transient condition potentially observed during cooling tower maintenance/outages or ambient temperature levels exceeding design conditions.

A series of 40 model runs were made using CORMIX corresponding to the mixing of 90.1°F and 95.0°F discharge, in winter and summer, with steady and unsteady flow conditions in the Parr Reservoir of Broad River.

For the assessment of the thermal impacts of discharge, only the chronic effects were required by SCDHEC to be evaluated; therefore the model predictions were not screened against the SCDHEC criteria for acute effects. Model calculation results indicate that for all flow conditions, the SCDHEC criteria for chronic thermal mixing are met. The largest predicted mixing zone extends to a distance of up to 51 feet downstream and 186 feet cross-stream. A mixing zone of these dimensions satisfies the SCDHEC criteria for chronic mixing.

For the WET assessment, chronic dilution factors at the downstream and cross-stream edges of the mixing zone were calculated; for the acute dilution factor only the downstream length of the mixing zone was considered. The acute mixing zone width boundary criteria were not considered because the diffuser length exceeds the steady state acute mixing zone width boundary condition. Model calculation results for the most stringent scenario for WET mixing (out of the 40 scenarios using a combination of steady and unsteady flow conditions, chronic and acute toxic effects) indicate that at a minimum the WET concentrations will be diluted 2.5 times prior to reaching the boundaries of the WET mixing zone.

2.0 PURPOSE

This calculation was performed to assess the water quality impacts of the proposed mixed cooling water blowdown and WWRB combined discharge from the VC Summer Station Units 2 and 3 using a multi-port diffuser in the Parr Reservoir located on the Broad River. The results of the calculations will help support and provide input into the National Pollutant Discharge Elimination System (NPDES) Operating Permit application for the VC Summer Nuclear Station Units 2 and 3. The data analysis and computer modeling was performed per the February 23, 2010 CORMIX Computer Modeling Revised Scope of Work and Budget (SCE&G, 2010c).

When the Units 2 and 3 are operational, raw water will be drawn from the Monticello Reservoir for use as makeup cooling water in the Station mechanical draft cooling towers. After use in the Station processes, the cooling water blowdown and the WWRB discharge water will be returned to the Parr Reservoir of the Broad River. The return water discharge is expected to be elevated in temperature and certain chemical constituents.

The mixing of the proposed discharge from Units 2 and 3 with the receiving waters of the Parr Reservoir of the Broad River was simulated. Model simulations were performed in order to determine the following:

- The dimensions of the mixing zone(s) that will meet SCDHEC regulatory requirements
- The effluent dilution factors consistent with the SCDHEC regulatory requirements for WET analyses

USGS, 2007d, National Water Information System, USGS 02160990 Parr Shoals Reservoir at Parr, S.C., Daily Data: http://waterdata.usgs.gov/sc/nwis/inventory/?site_no=02160990&

USGS, 2007e, South Carolina Water Science Center, Letter from Toby D. Feaster to Steve Summer regarding 7Q10 at Alston, S.C., dated March 6, 2007.

4.0 CALCULATION INPUTS

The inputs for the CORMIX model were derived from site specific data, drawings, calculations and assumptions about site conditions in the references listed in Section 3.0. Model runs were performed for ten ambient river flow conditions to determine the mixing zone dimensions and estimate dilution within the mixing zone in accordance with the SCDHEC regulatory requirements for thermal discharge and WET criteria. These inputs for various model scenarios are discussed and tabulated in the following sections.

4.1. Temperature Distribution Modeling Inputs

CORMIX modeling was performed to evaluate the mixing zone and downstream temperature impacts within the Parr Reservoir under ten flow conditions which were selected to represent the range of operation with and without the FFPS. For each set of flow conditions, the following four design cases were evaluated:

- Unit 2 and 3 discharge at 90.1°F temperature occurring during August-September when the river flow is low and river water temperatures (81.2°F) are highest
- Unit 2 and 3 discharge at 90.1°F temperature occurring during February when the river water temperatures (45.9°F) are at their lowest
- Unit 2 and 3 discharge at 95.0°F temperature occurring during August-September when the river flow is low and river water temperatures (81.2°F) are highest
- Unit 2 and 3 discharge at 95.0°F temperature occurring during February when the river water temperatures (45.9°F) are at their lowest

The two diffuser discharge temperatures (90. 1°F and 95.0°F) used in the above listed design cases represent the cooling tower blowdown nominal and maximum temperatures (Shaw Nuclear Services Inc., 2010a).

Table 4-1
CORMIX Input Data for 90.1°F Discharge Mixing With Broad River Steady State Flow in Summer

Parameter	Value	Unit	Source
Ambient Parameters			
Normal minimum pool elevation, Parr Reservoir	255.3045	ft NAVD'88	Equivalent to the normal minimum pool elevation of 256 ft NGVD'29 assumed in the NRC-ER analysis (Reference: FPC, 1974).
Cross-section type	bounded		The ambient water body that will receive the V.C. Summer discharge is the east channel of the Broad River, where the diffuser carrying the cooling water blow down and waste water retention basin discharge from V.C. Summer Units 2 and 3 is proposed to be located. The eastern channel is a bounded cross-section, approximately 620 ft wide at the discharge point when the Broad River flow corresponds to the normal minimum pool El. 255.3 ft. See Figure 2 - Proposed Discharge Location and Channel Widths.
7Q10 low flow, Broad River	853	cfs	The USGS computed 7Q10 low flow at Station 02161000, Broad River at Alston, located downstream from the site, is 853 cubic ft per second (cfs). This value was reported in a USGS memorandum dated March 6, 2007 to SCE&G (Reference: USGS, 2007e) and is acceptable to SCDHEC.
Flow rate past diffuser (7Q10 low flow, east channel of Broad River), QA	485	cfs	The east channel cross-sectional area is 4233 ft^2. This value was obtained by using the normal minimum pool elevation of 255.3045 ft NAVD'88 as water surface elevation in cell C5 of XSECT.XLS, supplied with the Bechtel 2007 Calculation Package (Tetra Tech, 2007), and updated by Shaw and reading the resultant cross-sectional area in Cell C11. The west channel cross-sectional area was estimated by extending the cross-section from the near shore discharge location (1898124E, 888580N) past the island to the west channel in "Area 3 Proposed Discharge Location Parr Reservoir/Broad River South Carolina" on page 32 of *Final Report, Hydrographic Survey, SCE&G COL Project, Lake Monticello and Parr Reservoir, OSI Report #06ES097*, 25242-103-V14-CM01-00001-001.PDF (OSI, 2007); the west channel cross-sectional area was estimated at 3210 ft^2 (Tetra Tech, 2010b). The USGS 7Q10 flow in Broad River was apportioned to the two channels in accordance with the ratio of their cross-sectional areas. The east channel 7Q10 flow was then calculated as 853 * 4233/(4233+3210) = 485 cfs.

Parameter	Value	Unit	Source
Discharge Channel Width, BS	425	ft	The average width of the east channel at the discharge point at 7Q10 low flow. This is not the entire bank-to-bank width of the east channel, but is the width of the rectangular cross-section at the proposed discharge location that binds the flow at the discharge location and down gradient. See Figure 1 - Reservoir Cross-Sections at Proposed Discharge Location, with the rectangular cross-section marked on the figure.
Channel appearance	Uniform		Appearance of the bounded channel in downstream direction
Average channel depth, HA	10.3	ft	See Figure 1: Reservoir Cross-Sections at Proposed Discharge Location, with the CORMIX rectangular cross-section marked. The normal minimum pool elevation is EL. 255.3 ft, and the average channel bottom depth elevation is 245 ft.
Channel depth at discharge, HD	13.3	ft	See Figure 1 - Reservoir Cross-Sections at Proposed Discharge Location. Channel bottom at the discharge point is EL. 242 ft, which is 13.3 ft below the normal minimum pool elevation of 255.3 ft
Manning's n	0.03		In order to specify the river channel bottom friction, a value of 0.03 was selected as the Manning's coefficient "n", in accordance with the range of values tabulated in the CORMIX users guide (Reference: Doneker et al., 2007)and information provided by Tetra Tech on March 2, 2010 in response to RFI VS-RFI-ENV-001 dated February 26, 2010 (Tetra Tech, 2010b). The selected value represents clean and straight natural river channels.
Wind velocity, UW	3	m/s	Wind speed at 10 meter level, reflecting conditions equivalent to breeze or a very light wind. Reference: Tetra Tech, 2010a. Wind conditions are unimportant for near-field mixing, but may affect plume behavior in the far-field.

Parameter	Value	Unit	Source
Ambient Water Temperature, Ta	81.21	°F	Average Parr Reservoir Temperature during the low flow months of August and September (Water Years 1996 through 2004, CARLISLE-PARR TEMPS 1096-0905 during low flow months.xlsx, Tetra Tech, 2007). A long term flow record was synthesized for the Parr Reservoir based on the 68 year record period at Carlisle (Water Years 1938-2005; RIVER FLOWs.xls, sheet PARR 7Q sorted). The 6th, 7th and the 8th lowest 7-day-low-flow (7Q1) values observed during the 68 years period were 814.87 cfs on 9/24/1954; 834.41 cfs on 9/24/1956; and 909.60 cfs on 8/27/1988 (RIVER FLOW.xls; sheet PARR7Q sorted for flow data and sheet Par = f(Carlisle) for calendar dates) . The Alston station based 7Q10 value based on the USGS is 853 cfs. It appears that the 7Q10 low flow is likely to occur during the months of August and September, during which the average Parr Reservoir temperature is 81.21° F.
Effluent Characterization Parameters			
Pollutant Type	Conservative		Conservative pollutant type does not undergo chemical or biological transformation due to decay or growth processes.
Discharge Temperature (Excess), C0	8.89	°F	The difference between 90.1° F discharge temperature (Reference: Shaw Nuclear Services, Inc., 2010a) and the average Parr Reservoir temperature during low flow conditions (81.21° F).
Effluent Flow Rate, Q0	9383	GPM	Combined annual average discharge flow rate from both units to Parr Reservoir (Reference: Shaw Nuclear Services, Inc., 2010b).
Diffuser Discharge Geometry Data			
Nearest Bank Location	Left		The river bank nearest to the diffuser line is located on the left when facing downstream in the direction of the ambient current.
Diffuser Type	Multiport		Simulated using CORMIX2 Multiport module
Diffuser Length, LD	69.67	ft	The diffuser line is the straight line extending from one diffuser endpoint (first nozzle/port) to the other endpoint (last nozzle/port). Each port is separated by a distance of 3 ft 8 inches. There are 20 ports total, with a distance of 69 ft 8 inches in between them (Reference: Shaw Nuclear Services, Inc., 2010d, Drawing VSG-0000-SK-MY52).
Distance to 1st endpoint, YB1	29.33	ft	Distance from the near shore /bank (defined by low water point of El. 255.3 ft) to the first diffuser nozzle/port (Reference: Shaw Nuclear Services, Inc., 2010e, Drawing VSG-WWS-SH-001).
Distance to 2nd endpoint, YB2	99	ft	Distance from the near shore /bank (defined by low water point of El. 255.3 ft) to the last diffuser nozzle/port (Reference: Shaw Nuclear Services, Inc., 2010e, Drawing VSG-WWS-SH-001).

Parameter	Value	Unit	Source
Height Of Port Centers, H0	3	ft	The height of the discharge port centers (EL. 245.0 ft) is 3 ft above the bottom of the existing channel (EL. 242 ft). The diffuser pipe invert is at El. 235.0 ft (Reference: Shaw Nuclear Services, Inc., 2010c, and verified using Shaw Nuclear Services, Inc., 2010e, Drawing VSG-WWS-SH-001).
Port Diameter, D0	0.67	ft	The average diameter of all ports/nozzles in the diffuser is 8 inches (Reference: Shaw Nuclear Services, Inc., 2010d, Drawing VSG-0000-SK-MY52).
Contraction Coefficient, CC	1		Typical values range from 1.0 for a well-rounded port/nozzle down to 0.6 for a sharp-edged port or orifice. If not specified or unknown, a value of 1.0 is recommended to be used by the User Guide to CORMIX (Doneker, et. al, 2007).
Total number of Openings	20		Total number of diffuser nozzles/ports (Reference: Shaw Nuclear Services, Inc., 2010e, Drawing VSG-WWS-SH-001).
Alignment Angle, GAMMA	90	degree	GAMMA is the angle between diffuser line and ambient current, measured counterclockwise from the ambient current direction (x-axis). GAMMA is 90 for an alignment where the diffuser line is perpendicular to the ambient current (Reference: Shaw Nuclear Services, Inc., 2010e, Drawing VSG-WWS-SH-001).
Vertical Angle, THETA	45	degree	The vertical angle (THETA) of the nozzle/port discharge centerline is 45 degrees above the horizontal plane, i.e., pointing upwards at an angle of 45 degrees (Reference: Shaw Nuclear Services, Inc., 2010d, Drawing VSG-0000-SK-MY52).
Port Orientation	Alternating		Every other nozzle/port points in an opposing direction (Reference: Shaw Nuclear Services, Inc., 2010d, Drawing VSG-0000-SK-MY52).
Direction of nozzles on each side of the diffuser	Same		Nozzles are not fanned out; they either face upstream or downstream (Reference: Shaw Nuclear Services, Inc., 2010d, Drawing VSG-0000-SK-MY52).
Mixing Zone/Toxic Dilution Zone/Area of Interest Parameters			
Toxic discharge	No		NA for temperature evaluation
Concentration for Water Quality Standard (Excess)	5	°F	SCDHEC regulatory requirement for mixing zone
Region of Interest	4250	ft	Maximum distance downstream of diffuser used for evaluating the results; CORMIX requires this to be at least 10 times the channel width

Table 4-2 provides a tabulation of CORMIX input values and their sources for the steady state scenario where 90.1°F discharge occurs during February when the river water temperatures (45.9°F) are at their lowest. Except for the ambient water temperature and the discharge excess temperature, the inputs for this scenario remain unchanged from Table 4-1. This CORMIX model run was named Run01b.

Table 4-2
CORMIX Input Data for 90.1°F Discharge Mixing With Broad River Steady State Flow in Winter

Parameter	Value	Unit	Source
Ambient Parameters – same as Run01, Table 4-1 except for the following			
Ambient Water Temperature, Ta	45.9	°F	Lowest Monthly Parr Reservoir Temperature, observed during the month of February. Reference: Tetra Tech, 2010a.
Effluent Characterization Parameters– same as Run01, Table 4-1 except for the following			
Discharge Temperature (Excess), C0	44.2	°F	The difference between 90.1° F discharge (Reference: Shaw Nuclear Services, Inc., 2010a) and the lowest monthly Parr Reservoir temperature measured during February (45.9° F), when the Parr Reservoir temperatures are the lowest (Reference: Tetra Tech, 2010a).
Diffuser Design Geometry Data– same as Run01, Table 4-1			
Mixing Zone/Toxic Dilution Zone/Area of Interest Parameters – same as Run01, Table 4-1			

Table 4-3 provides a tabulation of CORMIX input values and their sources for the steady state scenario where 95.0°F discharge occurs during August-September when the river flow is low and river water temperatures (81.2°F) are high. Except for the discharge excess temperature, the inputs for this scenario remain unchanged from Table 4-1. This CORMIX model run was named Run02.

Table 4-3
CORMIX Input Data for 95.0°F Discharge Mixing With Broad River Steady State Flow in Summer

Parameter	Value	Unit	Source
Ambient Parameters – same as Run01, Table 4-1			
Effluent Characterization Parameters– same as Run01, Table 4-1 except for the following			
Discharge Temperature (Excess), C0	13.79	°F	The temperature difference between 95.0° F discharge (Reference: Shaw Nuclear Services, Inc., 2010a) and the Parr Reservoir temperature during low flow conditions (81.21° F).
Diffuser Design Geometry Data– same as Run01, Table 4-1			
Mixing Zone/Toxic Dilution Zone/Area of Interest Parameters – same as Run01, Table 4-1			

Table 4-4 provides a tabulation of CORMIX input values and their sources for the steady state scenario where 95.0°F discharge occurs during February when the river temperatures (45.9°F) are lowest. Except for the ambient water temperature and the discharge excess temperature, the inputs for this scenario remain unchanged from Table 4-1. This CORMIX model run was named Run02b.

Table 4-4
CORMIX Input Data for 95.0°F Discharge Mixing With Broad River in Steady State Flow Winter

Parameter	Value	Unit	Source
Ambient Parameters – same as Run01, Table 4-1 except for the following			
Ambient Water Temperature, Ta	45.9	°F	Lowest Monthly Parr Reservoir Temperature, observed during the month of February. Reference: Tetra Tech, 2010a.
Effluent Characterization Parameters– same as Run01, Table 4-1 except for the following			
Discharge Temperature (Excess), C0	49.1	°F	The temperature difference between the 95° F discharge (Reference: Shaw Nuclear Services, Inc., 2010a) and the lowest monthly Parr Reservoir temperature measured during February (45.9° F), when the Parr Reservoir temperatures are the lowest (Reference: Tetra Tech, 2010a).
Diffuser Design Geometry Data– same as Run01, Table 4-1			
Mixing Zone/Toxic Dilution Zone/Area of Interest Parameters – same as Run01, Table 4-1			

4.1.2 Unsteady Flow

Modeling was performed to evaluate the mixing zone and temperature impacts within the Parr Reservoir during operation of the FFPS. Unsteady conditions exist when the discharge from Units 2 and 3 remains constant over time but the ambient flow field (river flow rates, velocity and flow directions) vary over time. The unsteady state flow conditions correspond to the critical river flow condition defined by the 7Q10 value, with additional water withdrawals and returns related to power generation cycle causing changes in the river flow rate, velocity and direction.

As described previously, the steady state flow in the east channel of the Broad River past the diffuser during the river flow condition defined by the 7Q10 value is assumed to be 485 cfs. This represents 56.87% of the 853 cfs low flow 7Q10 in Broad River recorded at the USGS station at Alston, SC, where the percentages of the flow going through the east and the west channels of the Broad River are based on the respective ratios of east and west channel cross-sections at minimum pool elevation calculated in section 4.1.1.

This 7Q10 flow is increased by the additional flow released when the Fairfield Pumped Storage (FFPS) Hydro-Peaking Plant is in generating mode. There are eight units at Fairfield Pumped Storage. During generating mode, up to eight units can operate at the FFPS, with each operating unit releasing 5,450 cfs from the Monticello Reservoir to the Parr Reservoir. Of this, an

Table 9-1
CORMIX Results for Steady State Temperature Model

Design Case	Discharge Temp., °F	River Temp., °F	River Flow	Discharge Channel Width, ft	Mixing Zone Dimensions					
					Maximum down-stream extent (length) ft	Cross-stream extent (width), ft	Excess Temp. at the down-stream edge of mixing zone, °F	Temp. at the down-stream edge of mixing zone, °F	Ratio of mixing zone width to discharge channel width	Ratio of mixing zone length to discharge channel width
Run01: 90.1°F discharge in summer	90.1	81.2	Steady State, 7Q10,	425	< 51.0	< 136.2	1.2	82.4	0.32	0.12
Run01b: 90.1°F discharge in winter		45.9			< 28.1	< 136.2	4.7	50.6	0.32	0.07
Run02: 95.0°F discharge in summer	95.0	81.2	Steady State, 7Q10	425	< 40.2	< 136.2	1.7	82.9	0.32	0.09
Run02b: 95.0°F discharge in winter		45.9			< 32.6	< 77.4	< 5.0	< 50.9	0.18	0.08

Table 9-2
CORMIX Results for Unsteady Flow Temperature Model

FFPS Status	Effluent Discharge and River Temperature Scenario	River Temp., °F	Discharge Channel Width, ft	Direction of Flow	Mixing Zone dimensions: Maximum down-stream extent (length) ft	Cross-stream extent (width), ft	Excess Temp. at the down-stream edge of mixing zone, °F	Temp. at the down-stream edge of mixing zone, °F	Ratio of mixing zone width to discharge channel width	Ratio of mixing zone length to discharge channel width
Morning transition period between end of pump back and start of generation	Run01: 90.1°F discharge in summer	81.2	425	Down River	< 51.0	< 136.2	1.2	82.4	0.32	0.12
	Run01b: 90.1°F discharge in winter	45.9			< 28.1	< 136.2	4.7	50.6	0.32	0.07
	Run02: 95.0°F discharge in summer	81.2	425		< 40.2	< 136.2	1.7	82.9	0.32	0.09
	Run02b: 95.0°F discharge in winter	45.9			< 32.6	< 77.4	< 5.0	< 50.9	0.18	0.08
End of 1st hour of generation, 3 units operating	Run03ii: 90.1°F discharge in summer	81.2	658	Down River	< 1.4	< 69.7	0.9	82.1	0.11	0.002
	Run03bii: 90.1°F discharge in winter	45.9			< 1.4	< 69.7	4.5	50.4	0.11	0.002
	Run04ii: 95.0°F discharge in summer	81.2	658		< 1.4	< 69.7	1.4	82.6	0.11	0.002
	Run04bii: 95.0°F discharge in winter	45.9			1.4	< 69.7	5.0	50.9	0.11	0.002

FFPS Status	Effluent Discharge and River Temperature Scenario	River Temp., °F	Discharge Channel Width, ft	Direction of Flow	Mixing Zone dimensions					
					Maximum down-stream extent (length) ft	Cross-stream extent (width), ft	Excess Temp. at the down-stream edge of mixing zone, °F	Temp. at the down-stream edge of mixing zone, °F	Ratio of mixing zone width to discharge channel width	Ratio of mixing zone length to discharge channel width
Peak Generation, all 8 units operating	Run03iii: 90.1°F discharge in summer	81.2	802	Down River	< 2.0	< 69.7	0.5	81.7	0.09	0.002
	Run03biii: 90.1°F discharge in winter	45.9			< 2.0	< 69.7	2.4	48.3	0.09	0.002
	Run04iii: 95.0°F discharge in summer	81.2	802		< 2.0	< 69.7	0.8	82.0	0.09	0.002
	Run04biii: 95.0°F discharge in winter	45.9			< 2.0	< 69.7	2.7	48.6	0.09	0.002
End of generation, 1 unit operating	Run03iv: 90.1°F discharge in summer	81.2	802	Down River	< 51.0	< 186.2	0.5	81.7	0.23	0.064
	Run03biv: 90.1°F discharge in winter	45.9			< 28.1	< 186.2	2.0	47.9	0.23	0.035
	Run04iv: 95.0°F discharge in summer	81.2	802		< 40.2	< 186.2	0.7	81.9	0.23	0.050
	Run04biv: 95.0°F discharge in winter	45.9			< 25.8	< 186.2	2.2	48.1	0.23	0.032

FFPS Status	Effluent Discharge and River Temperature Scenario	River Temp., °F	Discharge Channel Width, ft	Direction of Flow	Mixing Zone dimensions: Maximum down-stream extent (length) ft	Cross-stream extent (width), ft	Excess Temp. at the down-stream edge of mixing zone, °F	Temp. at the down-stream edge of mixing zone, °F	Ratio of mixing zone width to discharge channel width	Ratio of mixing zone length to discharge channel width
Evening transition period between end of generation and start of pump back	Run03v: 90.1°F discharge in summer	81.2	802	Down River	< 51.0	< 186.2	0.9	82.1	0.23	0.064
	Run03bv: 90.1°F discharge in winter	45.9			20.2	76.0	< 5.0	< 50.9	0.09	0.025
	Run04v: 95.0°F discharge in summer	81.2	802		< 6.3	< 74.3	4.9	86.2	0.09	0.008
					For Run04v, the model predicts a mixing zone width of 2.43 feet, which is the width of the temperature plume for an individual nozzle. Along the length of the diffuser, 20 such plumes are generated out of the 20 diffuser ports, with some separation in between individual plumes. The composite thermal plume will cover the area occupied by each of these plumes and any gaps in between. The minimum width of the composite thermal plume and therefore the mixing zone is expected to be equal to the diffuser length of 69.67 feet, while the maximum width of the mixing zone is based on CORMIX prediction of 74.34 feet for the cross-width of the mixing zone after the merging of individual jet/plumes.					
	Run04bv: 95.0°F discharge in winter	45.9			< 22.4	< 76.4	4.9	50.8	0.10	0.028
End of 1st hour of pump back, 4 units operating	Run03vi: 90.1°F discharge in summer	81.2	802	Up River	< 2.3	< 69.7	1.0	82.3	0.09	0.003
	Run03bvi: 90.1°F discharge in winter	45.9			< 4.6	< 69.8	3.7	49.6	0.09	0.006
	Run04vi: 95.0°F discharge in summer	81.2	802		< 2.3	< 69.7	1.6	82.8	0.09	0.003
	Run04bvi: 95.0°F discharge in winter	45.9			< 4.6	< 69.8	4.1	50.0	0.09	0.006

FFPS Status	Effluent Discharge and River Temperature Scenario	River Temp., °F	Discharge Channel Width, ft	Direction of Flow	Mixing Zone dimensions					
					Maximum down-stream extent (length) ft	Cross-stream extent (width), ft	Excess Temp. at the down-stream edge of mixing zone, °F	Temp. at the down-stream edge of mixing zone, °F	Ratio of mixing zone width to discharge channel width	Ratio of mixing zone length to discharge channel width
Peak Pump Back, all 8 units operating	Run03vii: 90.1°F discharge in summer	81.2	425	Up River	< 1.4	< 69.7	0.3	81.5	0.16	0.003
	Run03bvii: 90.1°F discharge in winter	45.9			< 1.4	< 69.7	1.3	47.2	0.16	0.003
	Run04vii: 95.0°F discharge in summer	81.2	425		< 1.4	< 69.7	0.4	81.6	0.16	0.003
	Run04bvii: 95.0°F discharge in winter	45.9			< 1.4	< 69.7	1.5	47.4	0.16	0.003
End of pump back, 4 units operating	Run03viii: 90.1°F discharge in summer	81.2	425	Up River	< 1.3	< 69.7	0.5	81.7	0.16	0.003
	Run03bviii: 90.1°F discharge in winter	45.9			< 1.3	< 69.7	2.6	48.5	0.16	0.003
	Run04viii: 95.0°F discharge in summer	81.2	425		< 1.3	< 69.7	0.8	82.0	0.16	0.003
	Run04bviii: 95.0°F discharge in winter	45.9			< 1.3	< 69.7	2.9	48.8	0.16	0.003

FFPS Status	Effluent Discharge and River Temperature Scenario	River Temp., °F	Discharge Channel Width, ft	Direction of Flow	Mixing Zone dimensions: Maximum down-stream extent (length) ft	Cross-stream extent (width), ft	Excess Temp. at the down-stream edge of mixing zone, °F	Temp. at the down-stream edge of mixing zone, °F	Ratio of mixing zone width to discharge channel width	Ratio of mixing zone length to discharge channel width
Low water slack	Run03ix: 90.1°F discharge in summer	81.2	425	Down River	< 51.0	< 136.2	1.7	82.9	0.32	0.120
	Run03bix: 90.1°F discharge in winter	45.9			CORMIX predicts 2.5 times dilution of the effluent in the near field of the diffuser at zero distance downstream, resulting in reduction of the temperature differential between effluent and the river water from 44.2°F to 17.8°F. At zero distance downstream from the diffuser, the river temperature is predicted to be 63.7°F. The model stops and is unable to predict further dilution at distances downstream.					
	Run04ix: 95.0°F discharge in summer	81.2	425		< 40.2	< 136.2	2.2	83.4	0.32	0.095
					CORMIX predicts 6.32 times dilution in a limited region (downstream extent = 40.2 ft) surrounding the discharge location. This dilution is sufficient to reduce the temperature differential between the effluent and the river water from 13.8°F to 2.2°F, so that at 40.2 feet downstream of the diffuser, the river temperature is expected to be 83.4°F, meeting the regulatory requirements for the mixing zone.					
	Run04bix: 95.0°F discharge in winter	45.9			CORMIX predicts 2.5 times dilution of the effluent in the near field of the diffuser at zero distance downstream, resulting in reduction of the temperature differential between effluent and the river water from 49.1°F to 19.3°F. At zero distance downstream from the diffuser, the river temperature is predicted to be 65.2°F. The model stops and is unable to predict further dilution at distances downstream.					
High Water Slack	Run03x: 90.1°F discharge in summer	81.2	802	Down River	< 51.0	< 186.2	0.9	82.2	0.23	0.064
	Run03bx: 90.1°F discharge in winter	45.9			0.0 (see note 1)	74.5	< 5.0	50.9	0.09	NA (see note 1)
	Run04x: 95.0°F discharge in summer	81.2	802		0.0 (see note 1)	< 74.3	4.9	86.1	0.09	NA (see note 1)
	Run04bx: 95.0°F discharge in winter	45.9			CORMIX predicts 9.6 times dilution of the effluent in the near field of the diffuser at zero distance downstream, resulting in reduction of the temperature differential between effluent and the river water from 49.1°F to 5.1°F. Therefore at zero distance downstream from the diffuser, the river temperature is predicted to be 51.0°F. The model stops and is unable to predict further dilution at distances downstream.					

Notes:

1. For runs 03bx and 04x, CORMIX output indicates that the discharge is mixed within immediate vicinity of the diffuser nozzles resulting in meeting the SCDHEC criteria without downstream migration

9.2. WET Dilution Modeling

Tables 9-3 and 9-4 present the results of steady state WET analysis for chronic and acute mixing conditions (4 scenarios each), while Tables 9-5 and 9-6 presents the results of the unsteady state temperature analysis (40 scenarios).

The following SCDHEC criteria were used to screen the results:

1. A demonstration, using CORMIX or other approved methodologies, is required to establish permit conditions for chronic mixing consistent with a mixing zone boundary of one-half the width of the stream and a downstream length of twice the stream width.

2. A demonstration, using CORMIX or other approved methodologies, is required to establish permit conditions for acute mixing consistent with a mixing zone boundary of downstream length of one third the stream width.

For the acute effects, only the downstream length of the mixing zone was evaluated. The mixing zone width boundary criteria were not considered because the diffuser length exceeds the steady state acute mixing zone width boundary condition.

Model calculation results indicate that for the steady state chronic mixing scenarios, the maximum allowable (most stringent) dilution factor that will result in meeting the SCDHEC chronic criteria for WET is 7.3 (Table 9-3). For the steady state acute mixing scenarios, the maximum allowable (most stringent) dilution factor that will result in meeting the SCDHEC chronic criteria for WET is 9.9 (Table 9-3).

A review of the model calculation results for the unsteady state chronic and acute mixing scenarios (Tables 9-5 and 9-6) indicate that the maximum allowable (most stringent) dilution factor that will result in meeting the SCDHEC criteria for WET is 2.5 for both the chronic and acute conditions.

Therefore, overall the most stringent scenario for WET mixing (steady and unsteady flow conditions, chronic and toxic effects) indicates that at a minimum the WET concentrations will be diluted 2.5 times prior to reaching the boundaries of the WET mixing zone. The maximum dimensions of this mixing zone are 141.7 feet long (equal to one-third of the stream width at low flow; based on SCDHEC requirement for acute mixing) and 212.5 feet wide (equal to one-half of the stream width at low flow; based on SCDHEC requirement for chronic mixing).

Table 9-3
Dilution Factors for Whole Effluent Toxicity, Steady State, Chronic Mixing Conditions

Design case	Discharge Channel Width, ft	Chronic mixing zone length, ft	Dilution Factor at downstream edge of mixing zone	Chronic Mixing Zone Width, ft	Dilution Factor at cross-stream edge of mixing zone	Maximum Allowable Dilution Factor
Run01: 90.1°F discharge in summer	425	850	11.5	212.5	> 7.3	7.3
Run01b: 90.1°F discharge in winter		850	15.6	212.5	> 9.4	9.4
Run02: 95.0°F discharge in summer	425	850	12.6	212.5	> 8.0	8.0
Run02b: 95.0°F discharge in winter		850	20.8	212.5	> 10.5	10.5

Note: Estimate of cross-stream width is based on dilution in a limited region surrounding the discharge location where vertical instability occurs.

Table 9-4
Dilution Factors for Whole Effluent Toxicity, Steady State, Acute Mixing Conditions

Design case	Discharge Channel Width, ft	Acute mixing zone length, ft	Dilution Factor at downstream edge of mixing zone
Run01: 90.1°F discharge in summer	425	141.7	9.9
Run01b: 90.1°F discharge in winter		141.7	13.0
Run02: 95.0°F discharge in summer	425	141.7	11.4
Run02b: 95.0°F discharge in winter		141.7	12.1

Table 9-5
Dilution Factors for Whole Effluent Toxicity, Unsteady State, Chronic Mixing Conditions

FFPS Status	Effluent Discharge and River Temperature Scenario	Discharge Channel Width, ft	Direction of Flow	Chronic mixing zone length, ft	Dilution Factor at down-stream edge of mixing zone	Chronic Mixing Zone Width, ft	Dilution Factor at cross-stream edge of mixing zone	Maximum Allowable Dilution Factor	Comments
Morning transition period between end of pump back and start of generation	Run03i: 90.1°F discharge in summer	425	Down River	850	11.5	212.5	> 7.3	7.3	Estimate of cross-stream width is based on dilution in a limited region surrounding the discharge location where vertical instability occurs
	Run03bi: 90.1°F discharge in winter			850	15.6	212.5	> 9.4	9.4	Estimate of cross-stream width is based on dilution in a limited region surrounding the discharge location where vertical instability occurs
	Run04i: 95.0°F discharge in summer	425		850	12.6	212.5	> 8.0	8.0	Estimate of cross-stream width is based on dilution in a limited region surrounding the discharge location where vertical instability occurs
	Run04bi: 95.0°F discharge in winter			850	20.8	212.5	> 10.5	10.5	Estimate of cross-stream width is based on dilution in a limited region surrounding the discharge location where vertical instability occurs
End of 1st hour of generation3 units operating	Run03ii: 90.1°F discharge in summer	658	Down River	1316	86.2	329	> 124.6	86.2	
	Run03bii: 90.1°F discharge in winter			1316	149.8	329	> 164.7	149.8	
	Run04ii: 95.0°F discharge in summer	658		1316	115.7	329	> 130.6	115.7	

	Run04bii: 95.0°F discharge in winter			1316	164.4		> 175.2	164.4	
FFPS Status	**Effluent Discharge and River Temperature Scenario**	**Discharge Channel Width, ft**	**Direction of Flow**	**Chronic mixing zone length, ft**	**Dilution Factor at down-stream edge of mixing zone**	**Chronic Mixing Zone Width, ft**	**Dilution Factor at cross-stream edge of mixing zone**	**Maximum Allowable Dilution Factor**	**Comments**
Peak Generation, all 8 units operating	Run03iii: 90.1°F discharge in summer	802	Down River	1604	191.1	401	> 266.0	191.1	
	Run03biii: 90.1°F discharge in winter			1604	226.1	401	> 272.8	226.1	
	Run04iii: 95.0°F discharge in summer	802		1604	191.3	401	> 266.0	191.3	
	Run04biii: 95.0°F discharge in winter			1604	235.2	401	> 279.4	235.2	
End of generation, 1 unit operating	Run03iv: 90.1°F discharge in summer	802	Down River	1604	37.0	401	30.0	30.0	
	Run03biv: 90.1°F discharge in winter			1604	41.2	401	33.5	33.5	
	Run04iv: 95.0°F discharge in summer	802		1604	38.8	401	30.6	30.6	
	Run04biv: 95.0°F discharge in winter			1604	42.2	401	34.5	34.5	

FFPS Status	Effluent Discharge and River Temperature Scenario	Discharge Channel Width, ft	Direction of Flow	Chronic mixing zone length, ft	Dilution Factor at down-stream edge of mixing zone	Chronic Mixing Zone Width, ft	Dilution Factor at cross-stream edge of mixing zone	Maximum Allowable Dilution Factor	Comments
Evening transition period between end of generation and start of pump back	Run03v: 90.1°F discharge in summer	802	Down River	1604	> 9.7	401	> 9.7	9.7	CORMIX predicts 9.7 times dilution near the diffuser (51 ft. downstream, maximum width 186 ft). The model is unable to make reliable predictions further downstream.
	Run03bv: 90.1°F discharge in winter			1604	> 14.1	401	> 14.1	14.1	CORMIX predicts 14.1 times dilution near the diffuser (44 ft. downstream, maximum width 80 ft). The model is unable to make reliable predictions further downstream.
	Run04v: 95.0°F discharge in summer	802		1604	> 13.7	401	> 13.7	13.7	CORMIX predicts 13.7 times dilution near the diffuser (60 ft. downstream, maximum width 84 ft). The model is unable to make reliable predictions further downstream.
	Run04bv: 95.0°F discharge in winter			1604	> 14.2	401	> 14.2	14.2	CORMIX predicts 14.2 times dilution near the diffuser (40 ft. downstream, maximum width 79 ft). The model is unable to make reliable predictions downstream.
End of 1st hour of pump back, 4 units operating	Run03vi: 90.1°F discharge in summer	802	Up River	1604	120.3	401	> 274.9	120.3	
	Run03bvi: 90.1°F discharge in winter			1604	104.9	401	137.2	104.9	
	Run04vi: 95.0°F discharge in summer	802		1604	111.7	401	238.2	111.7	
	Run04bvi: 95.0°F discharge in winter			1604	104.1	401	125.5	104.1	

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CALCULATION IDENTIFICATION NUMBER				PAGE: 45
J.O. OR W.O NUMBER	DISCIPLINE CODE	CALCULATION NUMBER	REVISION NUMBER	
1321770201	C	VSG-WWS-M3C-014	00	

FFPS Status	Effluent Discharge and River Temperature Scenario	Discharge Channel Width, ft	Direction of Flow	Chronic mixing zone length, ft	Dilution Factor at down-stream edge of mixing zone	Chronic Mixing Zone Width, ft	Dilution Factor at cross-stream edge of mixing zone	Maximum Allowable Dilution Factor	Comments
Peak Pump Back, all 8 units operating	Run03vii: 90.1°F discharge in summer	425	Up River	850	283.1	212.5	> 451.8	283.1	
	Run03bvii: 90.1°F discharge in winter			850	283.2	212.5	> 466.2	283.2	
	Run04vii: 95.0°F discharge in summer	425		850	283.2	212.5	> 451.8	283.2	
	Run04bvii: 95.0°F discharge in winter			850	283.3	212.5	> 451.8	283.3	
End of pump back, 4 units operating	Run03viii: 90.1°F discharge in summer	425	Up River	850	140.3	212.5	> 223.8	140.3	
	Run03bviii: 90.1°F discharge in winter			850	140.3	212.5	> 230.7	140.3	
	Run04viii: 95.0°F discharge in summer	425		850	140.3	212.5	> 223.8	140.3	
	Run04bviii: 95.0°F discharge in winter			850	140.4	212.5	> 223.8	140.4	

FFPS Status	Effluent Discharge and River Temperature Scenario	Discharge Channel Width, ft	Direction of Flow	Chronic mixing zone length, ft	Dilution Factor at down-stream edge of mixing zone	Chronic Mixing Zone Width, ft	Dilution Factor at cross-stream edge of mixing zone	Maximum Allowable Dilution Factor	Comments
Low water slack	Run03ix: 90.1°F discharge in summer	425	Down River	850	> 5.4	212.5	> 5.4	5.4	CORMIX predicts 5.4 times dilution near the diffuser (51 ft. downstream, maximum width 136 ft). After this the model stops and is unable to make reliable predictions.
	Run03bix: 90.1°F discharge in winter			850	> 2.5	212.5	> 2.5	2.5	CORMIX predicts 2.5 times dilution near the diffuser (0 ft. downstream, maximum width 70 ft, based on the diffuser length). After this the model stops and is unable to make reliable predictions.
	Run04ix: 95.0°F discharge in summer	425		850	> 6.3	212.5	> 6.3	6.3	CORMIX predicts 6.3 times dilution near the diffuser (40 ft. downstream, maximum width 136 ft). After this the model stops and is unable to make reliable predictions.
	Run04bix: 95.0°F discharge in winter			850	> 2.5	212.5	> 2.5	2.5	CORMIX predicts 2.5 times dilution near the diffuser (0 ft. downstream, maximum width 70 ft). After this the model stops and is unable to make reliable predictions.
High Water Slack	Run03x: 90.1°F discharge in summer	802	Down River	1604	> 9.4	401	> 9.4	9.4	CORMIX predicts 9.4 times dilution near the diffuser (51 ft. downstream, maximum width 186 ft). After this the model stops and is unable to make reliable predictions.
	Run03bx: 90.1°F discharge in winter			1604	> 9.2	401	> 9.2	9.2	CORMIX predicts 9.2 times dilution near the diffuser (0 ft. downstream, maximum width 75 ft). After this the model stops and is unable to make reliable predictions.
	Run04x: 95.0°F discharge in summer	802		1604	> 7.6	401	> 7.6	7.6	CORMIX predicts 7.6 times dilution near the diffuser (0 ft. downstream, maximum width 75 ft). After this the model stops and is unable to make reliable predictions
	Run04bx: 95.0°F discharge in winter			1604	> 9.6	401	> 9.6	9.6	CORMIX predicts 9.6 times dilution near the diffuser (0 ft. downstream, maximum width 75 ft). After this the model stops and is unable to make reliable predictions.

Table 9-6
Dilution Factors for Whole Effluent Toxicity, Unsteady State, Acute Mixing Conditions

FFPS Status	Effluent Discharge and River Temperature Scenario	Discharge Channel Width, ft	Direction of Flow	Acute mixing zone length, ft	Dilution Factor at downstream edge of mixing zone	Comments
Morning transition period between end of pump back and start of generation	Run03i: 90.1°F discharge in summer	425	Down River	141.7	9.9	
	Run03bi: 90.1°F discharge in winter			141.7	13.0	
	Run04i: 95.0°F discharge in summer	425		141.7	11.4	
	Run04bi: 95.0°F discharge in winter			141.7	12.1	
End of 1st hour of generation, 3 units operating	Run03ii: 90.1°F discharge in summer	658	Down River	219.3	66.2	
	Run03bii: 90.1°F discharge in winter			219.3	73.6	
	Run04ii: 95.0°F discharge in summer	658		219.3	76.0	
	Run04bii: 95.0°F discharge in winter			219.3	73.5	
Peak generation, all 8 units operating	Run03iii 90.1°F discharge in summer	802	Down River	267.3	133.0	
	Run03biii: 90.1°F discharge in winter			267.3	147.7	
	Run04iii: 95.0°F discharge in summer	802		267.3	133.2	
	Run04biii: 95.0°F discharge in winter			267.3	146.1	
End of generation, 1 unit operating	Run03iv 90.1°F discharge in summer	802	Down River	267.3	25.3	
	Run03biv: 90.1°F discharge in winter			267.3	31.4	
	Run04iv: 95.0°F discharge in summer	802		267.3	26.9	
	Run04biv: 95.0°F discharge in winter			267.3	32.8	

FFPS Status	Effluent Discharge and River Temperature Scenario	Discharge Channel Width, ft	Direction of Flow	Acute mixing zone length, ft	Dilution Factor at downstream edge of mixing zone	Comments
Evening transition period between end of generation and start of pump back	Run03v: 90.1°F discharge in summer	802	Down River	267.3	> 9.7	CORMIX predicts 9.7 times dilution in the near field of the diffuser (51 ft. downstream). The model is unable to make reliable predictions for locations further downstream.
	Run03bv: 90.1°F discharge in winter			267.3	> 14.1	CORMIX predicts 14.1 times dilution in the near field of the diffuser (44 ft. downstream). The model is unable to make reliable predictions for locations further downstream.
	Run04v: 95.0°F discharge in summer	802		267.3	> 13.7	CORMIX predicts 13.7 times dilution in the near field of the diffuser (60 ft. downstream). The model is unable to make reliable predictions for locations further downstream.
	Run04bv: 95.0°F discharge in winter			267.3	> 14.2	CORMIX predicts 14.2 times dilution in the near field of the diffuser (40 ft. downstream). The model is unable to make reliable predictions for locations further downstream.
End of 1st hour of pump back, 4 units operating	Run03vi: 90.1°F discharge in summer	802	Up River	267.3	62.0	
	Run03bvi: 90.1°F discharge in winter			267.3	65.0	
	Run04vi: 95.0°F discharge in summer	802		267.3	63.2	
	Run04bvi: 95.0°F discharge in winter			267.3	65.5	
Peak Pump Back, all 8 units operating	Run03vii: 90.1°F discharge in summer	425	Up River	141.7	233.0	
	Run03bvii: 90.1°F discharge in winter			141.7	233.1	
	Run04vii: 95.0°F discharge in summer	425		141.7	233.0	
	Run04bvii: 95.0°F discharge in winter			141.7	233.1	
End of pump back, 4 units operating	Run03viii: 90.1°F discharge in summer	425	Up River	141.7	116.4	
	Run03bviii: 90.1°F discharge in winter			141.7	116.6	
	Run04viii: 95.0°F discharge in summer	425		141.7	116.5	
	Run04bviii: 95.0°F discharge in winter			141.7	116.6	

FFPS Status	Effluent Discharge and River Temperature Scenario	Discharge Channel Width, ft	Direction of Flow	Acute mixing zone length, ft	Dilution Factor at downstream edge of mixing zone	Comments
Low water slack	Run03ix: 90.1°F discharge in summer	425	Down River	141.7	> 5.4	CORMIX predicts 5.4 times dilution in the near field of the diffuser (51 ft. downstream). After this the model stops and is unable to make reliable predictions.
	Run03bix: 90.1°F discharge in winter			141.7	> 2.5	CORMIX predicts 2.5 times dilution in the near field of the diffuser (0 ft. downstream). After this the model stops and is unable to make reliable predictions.
	Run04ix: 95.0°F discharge in summer	425		141.7	> 6.3	CORMIX predicts 6.3 times dilution in the near field of the diffuser (40 ft. downstream). After this the model stops and is unable to make reliable predictions.
	Run04bix: 95.0°F discharge in winter			141.7	> 2.5	CORMIX predicts 2.5 times dilution in the near field of the diffuser (0 ft. downstream). After this the model stops and is unable to make reliable predictions.
High Water Slack	Run03x: 90.1°F discharge in summer	802	Down River	267.3	> 9.4	CORMIX predicts 9.4 times dilution in the near field of the diffuser (51 ft. downstream). After this the model stops and is unable to make reliable predictions.
	Run03bx: 90.1°F discharge in winter			267.3	> 9.2	CORMIX predicts 9.2 times dilution in the near field of the diffuser (0 ft. downstream). After this the model stops and is unable to make reliable predictions.
	Run04x: 95.0°F discharge in summer	802		267.3	> 7.6	CORMIX predicts 7.6 times dilution in the near field of the diffuser (0 ft. downstream). After this the model stops and is unable to make reliable predictions.
	Run04bx: 95.0°F discharge in winter			267.3	> 9.6	CORMIX predicts 9.6 times dilution in the near field of the diffuser (0 ft. downstream). After this the model stops and is unable to make reliable predictions.

10.0 ATTACHMENTS