BEFORE THE STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL REGULATION

In Re:	)	
	)	
Arvah B. Hopkins, Unit No. 2	)	PA-74-03
City of Tallahassee's	)	
Petition for Modification.	)	
	)	

ORDER MODIFYING CONDITIONS OF CERTIFICATION

This matter having come before me as the Secretary of the Department of Environmental Regulation upon Petition presented by the City of Tallahassee seeking modifications of the conditions of certification imposed on Arvah B. Hopkins Unit No. 2. After full consideration of the matter and review of the agreement between the City and the Department, and being otherwise fully advised herein, it is:

ORDERED:

That the conditions of certification for Arvah B. Hopkins Unit No. 2 are hereby modified in accordance with Exhibit I, attached.

DONE AND ENTERED this 30TH day of MAY, 1979.

Jacob D. Varn
JACOB D. VARN
Secretary

Department of Environmental
Regulation
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Copies furnished to all parties

BEFORE THE STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL REGULATION

In Re: Arvah B. Hopkins, Unit No. 2, City of Tallahassee's Petition for Modification.	Case No. PA-74-03

JOINT PETITION FOR MODIFICATION OF CONDITIONS OF CERTIFICATION

Come now the City of Tallahassee and the State of Florida Department of Environmental Regulation, by and through their undersigned representatives, pursuant to Section 403.516, Florida Statutes and special Condition 6 of the Conditions of Certification for Arvah B. Hopkins Unit No. 2, and jointly present this petition seeking modification of the Conditions of Certification for Arvah B. Hopkins Unit No. 2 in accordance with the attached Conditions of Certification.

In support of said Petition, the parties would show the following:

1. The City has requested certain modifications to its Conditions of Certification dealing with sampling, monitoring, reporting, and specifications for control equipment, or related time schedules.
2. These modifications have been reviewed by the Department.
3. The City and the Department agree that the modifications shown on Exhibit 1 attached hereto are necessary to attain the objectives of Chapter 403, Florida Statutes.

DATED this 30th day of May, 1979.

[signature]
For the City of Tallahassee

Shari Smallwood
For the State of Florida Department of Environmental Regulation

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

MEMORANDUM B-681

TO: Mr. Hamilton S. Oven, Jr.

FROM: Tim S. Stuart TSS

DATE: June 3, 1976

SUBJECT: Comprehensive - Power Plant Siting - Arvah B. Hopkins, modification of conditions of certification

Based on the calculations of Mr. Y.-M. Lee (copy attached), it would appear that the subject plant can meet DER thermal standards by utilizing a shaded ditch or pond with 1.3 acres of surface area. Therefore, we do not recommend that a zone of mixing be established, but rather that a suitable cooling area be used. Because of the vagaries of the data and calculations, it would probably be best to use a surface area of about 2.5 acres.

TSS:ltcc

Attachment

JUN 8 1976

PERMIT

H6-6/75

See p5 for modifications

Exhibit 1

A. B. HOPKINS POWER PLANT
THERMAL STUDY (II)

According to our previous study (referred to as study (I), attached), we will use the temperature data at the critical condition (February 10, 1976) to calibrate the model, and then use the model to determine the surface area of the ditch needed to cool the heated water in order to satisfy the State temperature limitations. At this critical condition, the temperature at the effluent outlet (referred to as point 0), mid-distance of the ditch (point 1), POD (point 2) and Three Pole Creek (point A) are listed in the following table:

0 Effluent Outlet (^oF)	1 Mid-distance (^oF)	2 POD (^oF)	A Three Pole Creek (^oF)
79	75	71	56

Other relevant geometrical and flow data are:

W = Average width of the ditch	=	12.5	ft,
L = Total length of the ditch	=	1200.	ft,
t_r = Average retention time	=	145.	min,
Q = Flow	=	2.228	cfs.

Let

$T_o = 79, \quad x_o = 0.0,$

$T_1 = 75, \quad x_1 = 600.\,,$

$T_2 = 71, \quad x_2 = 1200.\,,$

$T_A = 56.$

Due to the accuracy of the measurement (accurate to only an integer), the temperature drops exactly the same amount (4^oF) from point 0 to point 1 and from point 1 to 2. This renders the exponentially decaying theory invalid.

To make the situation realistic and the problem solvable, we reassign

$T_1 = 74.55$

Rearranging equation (3) in Study (I), we have

$$\frac{T - T_E}{T_0 - T_E} = e^{-\alpha x} \quad , \tag{1}$$

$$\ln \frac{T - T_E}{T_0 - T_E} = -\alpha x \quad . \tag{2}$$

If we let $(T,x) = (T_2,x_2)$, (T_1,x_1) respectively, we have

$$\ln \frac{T_2 - T_E}{T_0 - T_E} = -\alpha x_2 \quad , \tag{3}$$

$$\ln \frac{T_1 - T_E}{T_0 - T_E} = -\alpha x_1 \quad . \tag{4}$$

Dividing (3) by (4), we have

$$\frac{\ln \dfrac{T_2 - T_E}{T_0 - T_E}}{\ln \dfrac{T_1 - T_E}{T_0 - T_E}} = \frac{x_2}{x_1} = 2 \quad ,$$

$$\ln \frac{T_2 - T_E}{T_1 - T_E} = 2 \ln \frac{T_1 - T_E}{T_0 - T_E} \quad ,$$

$$\ln \frac{T_2 - T_E}{T_0 - T_E} = \ln \left\{ \frac{T_1 - T_E}{T_0 - T_E} \right\}^2$$

$$\frac{T_2 - T_E}{T_0 - T_E} = \left\{\frac{T_1 - T_E}{T_0 - T_E}\right\}^2 \quad ,$$

$$(T_2 - T_E)(T_0 - T_E) = (T_1 - T_E)^2 \quad ,$$

$$T_2T_0 - (T_0 + T_2)T_E + T_E^2 = T_1^2 - 2T_1T_E + T_E^2$$

$$(T_0 + T_2 - 2T_1)T_E = T_2T_0 - T_1^2 \quad ,$$

$$T_E = \frac{T_2T_0 - T_1^2}{T_0 + T_2 - 2T_1} \quad . \tag{5}$$

Substituting $T_0 = 79$, $T_1 = 74.55$, $T_2 = 71$ into (5), we have

$$T_E = \frac{71 \times 79 - (74.55)^2}{79 + 71 - 2\ 74.55} = 56.997 \doteqdot 57.0$$

Substituting into (3), we have

$$\alpha = -\frac{1}{x_2} \ln \frac{T_2 - T_E}{T_0 - T_E}$$

$$= -\frac{1}{1200} \ln \frac{71 - 57}{79 - 57}$$

$$= 3.767 \times 10^{-4} \quad .$$

$$K = \alpha \rho C_p HU$$

$$= \alpha \rho C_p \frac{Q}{W}$$

$$= 3.767 \times 10^{-4} \times 62.4 \times 1.0 \times \frac{2.228}{12.5} \times 24 \times 3600$$

$$= 361.93$$

Substituting α, T_E and T_0 into equation (2), we have

$$\ln \frac{T - 57}{79 - 57} = -3.767\ 10^{-4} \cdot x \qquad (6)$$

For a given T, we can find x by equation (6). Let $T = T_A + 5 = 56 + 5 = 61$, we have

$$x_s = -\frac{10^4}{3.767} \ln \frac{61 - 57}{79 - 57}$$

$$= 4525.5 \quad (ft)$$

$$A_s = x_s \times W$$

$$= 4525.5 \times 12.5$$

$$= 56568.75 \quad (ft^2)$$

$$= 1.2988 \quad (acres)$$

$$\doteq 1.3 \quad (acres)$$

Therefore, the following requirements are proposed:

(1) Keep the capacity (total of Units 1 and 2) less than 2.228 cfs (= 1000. GPM).

(2) Keep using cold side blow down on cooling tower.

(3) Increase the length of the existing ditch to 4526 ft of similar width and depth, or build a new ditch (or cooling pond ?) with surface area of 56570. ft^2 (= 1.3 acres)

(4) Properly shade the ditch during warmer period.

A. B. HOPKINS POWER PLANT

THERMAL STUDY(I)

1. Theory:

On the basis of the reports listed below, we have concluded that the stream temperature prediction models of Gameson et. al., Velz & Gannon, Duttweiler and Edinger & Geyer can be considered identical.

(A) Frank L. Parker & Peter A. Krenkel (December, 1969), "Thermal Pollution: Status of the Art, Chapter IV: Prediction of Heat Dissipation";

(B) James A. Montgomery (August, 1970), "Analysis and Control of Thermal Pollution, Page IV 6-1, the Energy Budget Approach to Water Temperature Prediction, Example Problem";

(C) Derek K. Brady et. al. "Analyses of Heat Transfer at Cooling Lakes", Commercial Power Generation, Chemical Engineering Progresses Symposium Series, Vol. 67, No. 119

The model uses energy budget approach and assumes the temperature decays downstream in an exponential manner. In differential form, the model can be written as:

$$\frac{dT}{dx} = -\frac{K}{\rho C_p H U}(T-T_E) \qquad (1)$$

Where:

$$\left.\begin{array}{lll}
T\ (^{o}F) & : & \text{Temperature} \\
T_E\ (^{o}F) & : & \text{Equilibrium Temperature} \\
\rho\ (= 62.4\ \text{lb ft}^{-3}) & : & \text{Water Density} \\
C_p\ (= 1.0\ \text{BTU lb}^{-1}\ {}^{o}F^{-1}) & : & \text{Specific Heat of Water} \\
H\ (\text{ft}) & : & \text{Mean Stream Depth} \\
U\ (\text{ft day}^{-1}) & : & \text{Mean Stream Velocity} \\
x\ (\text{ft}) & : & \text{Down Stream Distance} \\
K\ (\text{BTU ft}^{-2}\ \text{day}^{-1}\ {}^{o}F^{-1}) & : & \text{Energy Exchange Coefficient}
\end{array}\right\} \qquad (2)$$

In integral form, the model is:

$$T = (T_o - T_E)\, e^{-\alpha x} + T_E \tag{3}$$

Where:

$$\left.\begin{aligned} T_o &= \text{Temperature at } x=0 \\ \alpha &= \frac{K}{\rho C_p H U} \end{aligned}\right\} \tag{4}$$

Among the variables and coefficients in (2) and (4), ρ , C_p are constants, H and U can be measured or calculated if the flow (cfs) in the stream is given. x is the independent down-stream distance which can be chosen arbitrarily, T is what will be predicted. T_o must be given as the boundary condition. Therefore, we have K and T_E left to be determined theoretically or experimentally. From reference (B), K and T_E can be determined through a table and a sequence of formulas. These formulas include evaporation, water vapor pressure, wind speed, radiation, etc, as parameters. For reference, we include the table and the formulas in the appendix. We feel that it is difficult to obtain the correct values for these parameters and most of the formulas are empirical. Therefore, we would suggest to use the direct experimental method to determine K and T_E, i.e using the actual data to find K and T_E (calibrate the model).

2. The monthly temperature limitations on heated water discharging into Fresh Waters in northern Florida (summarized from 17-3.05):

   (A) Heated water with a temperature at the POD more than 5^{o} F higher than the ambient (natural) temperature of any stream shall not be discharged into such stream.

   (B) No heated water with a temperature above 90^{o} F shall be discharged into any fresh waters regardless of the ambient temperature of the RBW.

3. Two legal agreements or decisions:

   DER staff decided that the point of discharge (POD) is at State Road 260 and agreed that the temperature at Three Pole Creek should be used as the ambient temperature.

4. The temperature data collected and supplied by Mr. David McKee of Tallahassee A. B. Hopkins Power Plant cover the period from December 1975 to March 1976. The data were collected under two conditions: (A) unit 1 only with hot side blow down on cooling water; (B) simulation of unit 1 and 2 by increasing the capacity of unit 1 with cold side blow down on cooling tower. The number of samples and sampling frequency are irregular.

TABLE 1

Date	Time	Temperature at Effluent Outlet	Temperature drop from EO to POD	Temperature at POD	Temperature Difference Between POD and TP Cr.	Temperature at Three-Pole Creek
1/15/76	5:30 PM	80	8	72	9	63
1/16/76	5:00 PM	78	14	64	3	61
1/22/76	8:00 AM	70	5	65	11	54
1/22/76	12:30 PM	68	2	66	7	59
1/28/76	12:00 PM	75	9	66	8	58
1/28/76	5:00 PM	74	7	67	9	58
1/29/76	8:00 AM	75	12	63	11	52
1/29/76	2:00 PM	78	6	72	10	62
1/29/76	5:15 PM	75	7	68	9	59
2/2/76	8:00 AM	68	6	62	10	52
2/2/76	12:40 PM	72.5	6.5	66	7	59
2/2/76	5:00 PM	73	6	67	8	59
2/3/76	8:00 AM	71	7.5	63.5	9.5	54
2/3/76	1:00 PM	73	1	72	8	64
2/3/76	4:30 PM	73	3	70	6	64
2/10/76	9:00 AM	79	8	71	15	56
2/10/76	4:30 PM	72	2	70	7	63
2/11/76	8:00 AM	70	5	65	9	56
2/11/76	8:45 AM	70	4	66	9	57
2/19/76	8:00 AM	78	10	68	4	64
2/20/76	8:00 AM	72	5	67	5	62
2/20/76	3:00 PM	79	5	74	4	70
2/26/76	9:00 AM	72	4	68	7	61
2/26/76	1:00 PM	75	0	75	7	68
2/27/76	9:00 AM	75	11	64	5	59
3/3/76	10:00 AM	77	2	75	9	66
3/4/76	8:00 AM	77	8	69	5	64
3/10/76	11:00 AM	68	-2	70	5	65
3/10/76	2:30 PM	70	-2	72	6	66
3/11/76	12:45 PM	70	-4	74	6	68
3/17/76	8:30 AM	77	12	65	9	56
3/18/76	8:00 AM	74	9	65	9	56
3/18/76	2:30 PM	75	1	74	6	68
3/25/76	8:30 AM	72	0	72	11	61
3/29/76	9:30 AM	80	2	78	10	68
3/29/76	1:15 PM	79	-3	82	10	72

All the data for condition (B) at the effluent outlet, POD, and Three Pole Creek are as shown in Table 1. For the use of the analysis which follows we have also calculated the temperature drop from effluent outlet to POD and the temperature difference between POD and Three Pole Creek and included them in the table.

For condition (B), the following data were also supplied by Mr. McKee.

Average width of the ditch	= 12.5 ft
Total length of the ditch	= 1200 ft
Total surface area	= 15000 ft^2
Average retention time	= 145 minutes
Flow	= 2.228 cfs

5. Analysis

The maximum temperature drop from effluent outlet to POD is 14^{o} F. (A temperature rise from effluent outlet to POD was noticed during March). The minimum temperature difference between POD and Three Pole Creek is 3^{o} F. The maximum temperature difference between these two points is 15^{o} F. This occurred at 9:00 AM February 10, 1976. We will consider this as the critical (worst) condition, and use the data to calibrate the model.

6. Proposed solutions:

1) Keep using cold side blow down all the time to decrease the effluent outlet temperature;

2) Construct a longer meandering ditch and use the full length during cooler seasons and use only a part of it covered with shade during warm periods. The total surface area of the ditch can be determined by the calibrated model.

Appendix

Calculation of T_E & K

(Revised)

Table 1

$$T_E \xrightarrow{\text{Table 1}} \beta \xrightarrow{K = \left[15.7 + (0.26+\beta)\,bw\right]} K \xrightarrow{M = \left[H_R - 1801 + bw\,(e_a - C + 0.26T_a)\right]/K} M \xrightarrow{T_E = \frac{-\frac{K}{0.051} + \sqrt{\left(\frac{K}{0.051}\right)^2 - \frac{4M}{0.051}}}{2}} T_E$$

Assume T_E first

Check with the T_E Assumed

Table 1.

T_E (°F)	β (mm Hg °F^{-1})	C (mm Hg)
50 to 60	0.405	-11.22
60 to 70	0.555	-20.15
70 to 80	0.744	-33.30
80 to 90	0.990	-53.33

b : experimental evaporation (≈15)

w : wind speed (mph)

H_R : Net Radiation Input (BTU ft^{-2} hr^{-1})

T_a : Air Temp. (°F)

e_a : Water Vapor Pressure of Ambient Air (mm Hg)