THERMAL POLLUTION STUDY
INTERIM REPORT

Upper Ohio River Basin
October 1967 - December 1969

Work Document No. 41

This document has been prepared to record a specific water pollution control activity carried out to date in the Ohio River Basin. The information contained herein will serve as a ready reference to aid in the planning and development program in the Basin.

Questions or comments relative to this material should be directed to:

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Federal Water Quality Administration
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I. INTRODUCTION

Purpose

The purpose of this document is to present the results of an interim study of thermal pollution in the Upper Ohio River Basin. The study was designed to develop procedures for aiding in the determination of major heat loads in the Basin.

Thermal pollution represents one of the growing threats to maintenance of good quality water. This usually occurs below major industries such as steel mills and stream-electric generating plants. Other industries such as chemical, petroleum refining, etc., contribute thermal loads of lesser magnitude in most cases. Problems are associated with the size and flow of the stream, proximity to other industries, and intended use of the stream.

The stream-electric power industry is by far the largest thermal polluter in the Basin. Each kilowatt hour of electricity produces about 4,877 BTU of heat to the cooling water. Many of the progressive electric power corporations are providing necessary cooling facilities to control their thermal loads. In most cases, these cooling units are operated as a closed system providing benefits to both the owner and the public.

Acknowledgments

During this interim study, little formal contact was made with any of the power companies since most of the work pertained to actual field conditions on a random basis. Most area electric power plants operate near rated capacity.

River discharge information was obtained from the U. S. Army Corps of Engineers and the U. S. Geological Survey.

II. SUMMARY

Findings

1. Excessive (>5° F average increase) thermal loads were found in the following areas:

   a. Beaver Basin

      1) Mahoning River, Ohio Edison Company, Niles Plant (250 MW), Niles, Ohio - largest observed average river temperature increase of 12.8° F

      2) Beaver River, Pennsylvania Power Company, New Castle Plant (293 MW), New Castle, Pennsylvania - largest observed average river temperature increase of 10.0° F.

   b. Monongahela Basin

      1) Monongahela River, M. P. 29.5, West Penn Power Company, Mitchell Plant (449 MW) - largest observed average river temperature increase of 11.3° F.

      2) Monongahela River, M. P. 25.2, Duquesne Light Company, Elrama Plant (425 MW) - largest observed average river temperature increase of 7.2° F.

   c. Muskingum Basin

      1) Muskingum River, M. P. 118, Columbus and Southern Ohio Electric Power Company, Connesville Plant (433 MW) - largest observed average river temperature increase of 8.3° F.

      2) Muskingum River, M. P. 68.3, Ohio Power Company, Philo Plant (500 MW) - largest observed average river temperature increase of 5.1° F.

3) Muskingum River, M. P. 28.15, Ohio Power Company, Beverly Plant, lower unit (876 MW) - largest observed average river temperature increase of 6.8° F.

2. No single average river temperature increases greater than 5° F were found for any power generating plants along the Ohio River, however, some difficulties are present at the following locations:

   a. Ohio River, M. P. 15.2, Duquesne Light Company, Phillips Plant (315 MW) - single temperature measurement found greater than 89° F.

   b. Ohio River, M. P. 53.9, Ohio Edison Company, Sammis Plant (1,960 MW) - single temperature measurements found greater than 89° F, some hot spots as high as 96.4° F. Future proposed expansion will increase average temperatures over 7° F.

   c. Ohio River, M. P. 76.5, Ohio Power Company, Cardinal and Tidd Plants (1,452 MW) - single spot temperature increases greater than 12° F.

Recommendations

1. Cooling facilities are recommended to be installed immediately at the following locations:

   a. Mahoning River, Ohio Edison Company, Niles Plant

   b. Beaver River, Pennsylvania Power Company, New Castle Plant

   c. Monongahela River, M. P. 29.5, West Penn Power Company Mitchell Plant

   d. Monongahela River, M. P. 25.2, Duquesne Light Company, Elrama Plant

e. Muskingum River, M. P. 118, Columbus and Southern Ohio Electric Power Company, Connesville Plant

f. Muskingum River, M. P. 68.3, Ohio Power Company, Philo Plant

g. Muskingum River, M. P. 28.15, Ohio Power Company, Beverly Plant

2. No future expansion of any of the above power plants should be permitted without the installation of cooling facilities.

3. Any future expansion of the power plants listed below over the capacity indicated should not be permitted without the installation of cooling towers.

a. Ohio River, M. P. 35, Duquesne Light Company, Beaver Valley Power Plant. (100 MW)

b. Ohio River, M. P. 53.9, Ohio Edison Company, Sammis Plant (1,960 MW)

c. Ohio River, M. P. 76.5, Ohio Power Company, Cardinal Plant (1,230 MW)

d. Ohio River, M. P. 102.5, Ohio Edison Company, Burger Plant (544 MW)

e. Ohio River, M. P. 111.1, Ohio Power Company, Kammer Plant (675 MW)

f. Ohio River, M. P. 161.5, Monongahela Power Company, Willow Island Plant (215 MW)

g. Ohio River, M. P. 241.6, Appalachian Power Company, Phillip Sporn Plant (1,060 MW)

h. Ohio River, M. P. 260.1, Ohio Valley Electric Company, Kyger Creek Plant. (1,086 MW)

III. STUDY AREA

General Information

The electric power generation needs have been doubling in capacity every ten years during the past, few, decades. Predictions indicate that this trend will more than prevail for the next few decades.

Fossil fuel power stations are the most common source of electricity in the United States. Hydroelectric power is generated in some parts of the country with new hydro installations being built in many areas, but this will only represent a small part of the total capacity. Nuclear power stations will become more common along with their greater cooling water needs.

The Upper Ohio River Basin has a large coal reserve making this type of fuel very attractive for steam-electric generation. Many large power stations are being built as mine mouth generating plants. A great future exists for the electric power industry. At the present time there are about 105 electric power stations in the Upper Ohio River Basin with a total design capacity of about 20,200 megawatts. In one hour the combined capacity of these plants can produce a heat load to the river of 330 billion BTU's or enough energy to heat about four million residential homes. About five major plants with a design capacity of 10,600 megawatts are under construction at the present time in the Upper Ohio River Basin. Only one of these future plants with a design capacity of 1000 megawatts does not have provision for cooling facilities.

About 20% of the electric plants in the Upper Ohio Basin were selected for field studies. Most of these study units produced more than 200 megawatts of power each. Field studies were set up for several tributaries and the Ohio River to provide a good cross section of companies, minor basins and

section of companies, minor basins and thermal conditions. This report covers the study period of October 1967 - December 1969. A summary of these plants appears in Table 1.

Table 1

THERMAL POLLUTION STUDIES

Upper Ohio River Basin

	Mile Point	Company	Capacity (Megawatts)
I.	Allegheny River Basin		
	17.5	West Penn Power Company, Springdale Plant	416.1
	16.0	Duquesne Light Company, Colfax Plant	262.5
II.	Beaver River Basin		
	Niles, Ohio (Mahoning River)	Ohio Edison Company	250.0
	New Castle, Pa. (Shenango River)	Pennsylvania Power Company	293.0
III.	Kanawha River Basin		
	78.5	Appalachian Power Company, Kanawha River Plant	426.0
IV.	Monongahela River Basin		
	29.5	West Penn Power Company, Mitchell Plant	448.7
	25.2	Duquesne Light Company, Elrama Plant	425.0
V.	Muskingum River Basin		
	Conesville, Ohio	Columbus & Southern Ohio Electric Company, Conesville Plant	433.0
	Philo, Ohio	Ohio Power Company, Philo Plant	500.0

Mile Point	Company	Capacity (Megawatts)
Beverly, Ohio	Ohio Power Company Muskingum Plant (Additional 615 mw has cooling facilities)	876.0
VI. Ohio River		
2.1	Duquesne Light Company, Reed Plant	180.0
15.2	Duquesne Light Company, Phillips Plant	315.0
35.0	Duquesne Light Company, Beaver Valley Plant	100.0
53.9	Ohio Edison Company, Sammis Plant	1960.0
76.4	Ohio Power Company, Tidd Plant	222.0
76.5	Ohio Power Company, Cardinal Plant (The Tidd and Cardinal plants were combined for the study.)	1230.0
102.5	Ohio Edison Company, Burger Plant	544.0
111.1	Ohio Power Company, Kammer Plant	675.0
161.5	Monongahela Power Company, Willow Island Plant	215.0
241.6	Appalachian Power Company, Sporn Plant	1060.0
260.1	Ohio Valley Electric, Kyger Creek	1086.0
VII. Scioto River Basin		
Columbus, Ohio	Columbus & Southern Ohio Electric Company, Picway Plant	230.0

IV. THERMAL POLLUTION STUDIES

Methodology

Each study section was measured by a temperature sensing instrument containing a calibrated thermistor on an electrical cable. All measurements were made from an anchored boat, so that depth data could be obtained from the same point. Temperatures were measured across the river at several places to provide good cross sectional data at several depths.

To adequately assess the thermal loads in each area, a reference station was established upstream of the power plant. Conditions causing "short circuiting" of heated water moving upstream from point of discharge to point of intake were also observed. Short circuiting is somewhat dependent upon the type of discharge structure used. Downstream stations were chosen to show the effects of the thermal loads at various distances.

Although three dimensional conditions exist in the mixing zone (longitude, latitude, and depth), this study considered each station as a cross sectional volume of river representing a specified quantity of heat. The mixing zone is merely defined as the reach of river where heated water causes the river temperature to increase over ambient. Recovery is considered at the point where the temperature starts to decrease to ambient temperature. The average temperature and ranges were reviewed for hot spots, excessive variations and conditions which could affect aquatic life. A comparison was also made with established procedures for calculation of theoretical conditions based on rated capacities of the individual power station per FWQA Manual, "Industrial Waste Guide on Thermal Pollution", September 1968. No attempt was made during this interim study to relate the rated capacity to the actual operating capacity during the actual study period.

Thermal Loads

A review of the thermal conditions for all power stations investigated by the Upper Ohio Basin Office appears in Table 2.

Table 2

Thermal Load Conditions

Company	M. P. River	Capacity MW	Date	Flow cfs	A °F	B °F	C °F	D °F	E Miles	F
Duquesne Light Company Colfax Station	16.0 Allegheny	262.5	7-10-68	8700	0.7	2.6	78.8	83.4	2	No
West Penn Power Company Springdale Plant	17.5 Allegheny	416.1	7-10-68	8700	1.0	1.0	78.4	83.4	2	No
Ohio Edison Company Niles, Ohio	Mahoning	250.0	9-11-68	376	14.4	12.8	71.2	85.7	2	Yes
Pennsylvania Power Company New Castle, Pennsylvania	Beaver	293.0	9-10-69	860	7.6	10.0	74.1	89.6	1	No
Appalachian Power Company	78.5 Kanawha	426.0	10-10-68	2500	3.7	2.3	63.5	71.4	2	No
Duquesne Light Company Elrama Plant	25.2 Monongahela	425.0	7-16-68	1100	8.4	5.9	90.5	102.2	>2	No
Duquesne Light Company Elrama Plant	25.2 Monongahela	425.0	9-11-68	2620	3.5	7.2	80.6	91.8	>2	No
West Penn Power Company Mitchell Plant	29.5 Monongahela	449.0	7-15-68	1270	7.8	11.3	83.4	98.6	>2	No
West Penn Power Company Mitchell Plant	29.5 Monongahela	449.0	9-11-68	2620	3.7	5.8	74.8	81.5	>2	No

A = Theoretical average water temperature increase in mixing zone.
B = Actual average temperature increase measured in mixing zone.
C = Lowest single temperature measured in mixing zone.
D = Highest single temperature measured in mixing zone.
E = Length of mixing zone before recovery.
F = Evidence of short circuiting.

Table 2 (Continued)

Company	M. P. River	Capacity MW	Date	Flow cfs	A °F	B °F	C °F	D °F	E Miles	F
Columbus & Southern Ohio Electric Company Conesville, Ohio	Muskingum	433	9-25-69	2,430	3.9	8.3	62.6	82.4	1	No
Ohio Power Company Philo, Ohio	Muskingum	500	9-23-69	1,900	5.7	5.1	68.7	75.2	1	No
Ohio Power Company Beverly, Ohio	Muskingum	876	9-23-69	1,900	10.0	6.8	69.8	79.5	>1	Yes
Duquesne Light Company Reed Plant	2.1 Ohio	180	7-21-68	8,880	0.5	2.1	83.4	87.8	1	No
Duquesne Light Company Phillips Plant	15.2 Ohio	315	7-17-68	8,880	0.7	1.1	85.2	89.6	2	No
Duquesne Light Company Phillips Plant	15.2 Ohio	315	7-18-69	11,000	0.6	1.2	82.4	89.6	2	No
Ohio Edison Company Sammis Plant	53.9 Ohio	1960	9-13-68	12,000	3.6	3.8	73.7	87.8	<.2	Yes
Ohio Edison Company Sammis Plant	53.9 Ohio	1960	12-20-68	44,500	1.0	2.1	33.8	46.2	<.2	Yes
Ohio Edison Company Sammis Plant	53.9 Ohio	1960	7-2-69	11,000	3.9	1.6	82.4	96.4	<.2	Yes
Ohio Power Company Tidd & Cardinal Plants	76.5 Ohio	1452	10-3-68	6,000	4.2	3.5	75.2	86.0	>2	Yes
Ohio Power Company Tidd & Cardinal Plants	76.5 Ohio	1452	9-30-69	6,500	4.8	4.6	72.3	86.0	>2	Yes
Ohio Edison Company Burger Plant	102.5 Ohio	544	10-4-68	15,000	0.8	2.0	69.8	78.8	2	No

Table 2 (Continued)

Company	M. P. River	Capacity MW	Date	Flow cfs	A °F	B °F	C °F	D °F	E Miles	F
Ohio Edison Company Burger Plant	102.5 Ohio	544	10-1-69	6,900	1.7	3.0	71.6	80.6	?	No
Ohio Power Company Kammer Plant	111.1 Ohio	675	10-11-68	10,000	1.5	1.1	69.8	74.3	1	No
Monongahela Power Company Willow Island Plant	161.5 Ohio	215	10-4-69	10,100	0.5	1.2	82.8	86.0	<1	No
Appalachian Power Company Phillip Sporn Plant	241.6 Ohio	1060	10-10-68	11,800	2.0	2.5	67.1	77.9	<1	No
Appalachian Power Company Phillip Sporn Plant	241.6 Ohio	1060	6-26-69	31,500	0.8	1.3	78.8	86.0	<1	No
Appalachian Power Company Phillip Sporn Plant	241.6 Ohio	1060	8-8-69	22,000	1.1	2.2	80.6	87.8	<2	No
Ohio Valley Electric Kyger Creek	260.1 Ohio	1086	10-9-68	12,400	1.9	3.3	68.0	75.2	<2	No

APPENDIX

Field Data and Theoretical Conditions

Thermal Pollution Studies

ALLEGHENY River, M. P. 17.5

WEST PENN, SPRINGDALE Power Plant

JULY 10, 1968

A. Assume: 416 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3{,}413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(4.16×10^5 KW) = 2.03×10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

Q = (8.7×10^3)(6.24×10)(3.6×10^3) = 1.95×10^9 lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{2.03 \times 10^9}{1.95 \times 10^9} = 1.0 \ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 79.7 \ ^\circ F - 78.7 \ ^\circ F = 1.0 \ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 7-10-68 Location Allegheny River - M. P. 17.5
Flow 8700 cfs Plant Name Springdale - West Penn Power Company
Air Temperature - Begin 87.7 °F Finish 87.7 °F Work Done By Lorentz, Jones, Moser

REFERENCE WATER TEMPERATURE 78.6 °F M. P. 17.7

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank
225' — 775'

ABOVE OUTFALL (M. P. 17.7)

Sur.	79.2	Sur.		Sur.	78.8	Sur.		Sur.	78.8
8'	78.8	8'		8'	78.4	8'		8'	78.4
18' ~~20'~~	78.6	20'		14' ~~XXX~~	78.4	20'		20'	
30'		30'		30'		30'		30'	

AVERAGE TEMPERATURE 79.7 °F

BELOW OUTFALL (M. P. 17.5)

Sur.	83.4	Sur.	82.4	Sur.	79.4	Sur.	78.8	Sur.	79.7
4'	82.8	4'	81.5	4'	78.8	4'	78.8	4'	79.2
8'	81.2	8'	81.5	8'	78.6	8'	78.8	8'	79.0
12'	80.8	12'	80.2	12'	78.4	12'	78.6	12'	78.8
15'	80.4	16'	79.4	16'	78.4	16'	78.6	16'	
20'		19' ~~20X~~		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVERAGE TEMPERATURE 79.[illegible] °F

ZONE OF MIXING (M. P. 17.0)

Sur.	80.6	Sur.	81.0	Sur.	81.0	Sur.	80.0	Sur.	82.2
4'	80.6	4'	79.5	4'	79.4	4'	79.2	4'	80.6
8'	80.2	8'	79.4	8'	79.0	8'	78.8	8'	80.6
12'		12'	79.0	12'	78.8	12'	78.8	12'	78.8
16'		16'		16'	78.8	16'	78.6	16'	78.6
20'		20'		18' ~~20X~~	78.6	19' ~~20X~~	78.4	20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVERAGE TEMPERATURE [illegible] °F

DOWNSTREAM PT. NO INCREASE (M. P. 16.5)

Sur.	81.0	Sur.	81.0	Sur.	81.2	Sur.	81.4	Sur.	82.4
4' ~~8'~~	80.6	4' ~~8X~~	80.8	4' ~~8X~~	81.0	4' ~~8X~~	80.6	4' ~~8X~~	81.5
8' ~~XXX~~	80.2	8' ~~20X~~	80.6	8' ~~20X~~	80.4	8' ~~20X~~	80.6	8' ~~20X~~	80.2
12' ~~XXX~~	78.8	12' ~~30X~~	79.9	12' ~~30X~~	79.0	12' ~~30X~~	79.4	12' ~~20X~~	79.0
16'	78.8	16'	79.7	16'	78.8	16'	78.8	16'	79.0
		20'	79.2	20'	78.8	20'	78.8	20'	78.8
		24'	78.9	24'	78.6	24'	78.6	24'	78.[illegible]
				28'	78.6	28'	78.6	28'	[illegible]

Thermal Pollution Studies

ALLEGHENY River, M. P. 1.0

DUQUESNE LIGHT Co. CHESWICK Power Plant

JULY 10, 1968

A. Assume: 263 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3{,}413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(2.63×10^5 KW) = 1.29×10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

Q = (8.7×10^3)(6.24×10)(3.6×10^3) = 1.95×10^9 lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{1.29 \times 10^9}{1.95 \times 10^9} = 0.7\ °F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 82.4\ °F - 79.8\ °F = 2.6\ °F$$

THERMAL POLLUTION STUDIES

Date 7-10-68 Location Alleghany River M. P. 16.0
Flow 5700 cfs Plant Name Colfax - Duquesne Light Company
Air Temperature - Begin 87.8 °F Finish 88.0 °F Work Done By Lorentz, Jones, Moser

REFERENCE WATER TEMPERATURE 80.6 °F M. P. 15.8

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

200' 600'

ABOVE OUTFALL (M. P. 15.9)

Sur.	81.5	81.5	82.0	80.8	80.6
4'	81.5	80.6	80.2	80.6	80.6
8'	80.8	78.8	78.8	79.2	80.2
12'	80.6	78.8	78.8	78.8	78.8
16'	80.0	78.8	78.8	78.8	78.8
20'		78.8		78.8	78.8

AVERAGE TEMP [illegible]

BELOW OUTFALL (M. P. 15.7)

Sur.	82.6	82.4	82.2	81.5	81.5
4'	81.9	82.4	81.5	80.6	80.6
8'	80.8	82.4	80.6	78.8	80.6
12'	80.6	80.6	79.4	78.8	78.8
16'	79.0	79.0	78.8	78.8	78.8
20'		78.8	78.8	78.8	78.8
24'					
28'					
32'					

AVERAGE TEMP 80.3 °F

ZONE OF MIXING (M. P. 15.0)

Sur.	83.4	82.8	82.0	82.0	81.5
4'	82.4	81.5	81.5	80.8	81.5
8'		80.6	79.2	78.8	78.8
12'		79.2	78.8	78.8	78.8
16'			78.8		78.8
20'			78.8		
24'					
28'					
32'					

AVERAGE TEMP 80.4 °F

DOWNSTREAM PT. NO INCREASE (M. P. 14.2) @ Highway Bridge Below Dam

Sur.	82.6	82.6	I	82.6	80.8
8'	82.2	82.2	S	82.2	80.6
20'			L		
30'			A		
			N		Below Lock
			D		Chamber

Thermal Pollution Studies

MAHONING (BEAVER) River, M. P. 52

OHIO EDISON CO. NILES Power Plant

SEPTEMBER 11, 1969

A. Assume: 250 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35} = 9,750$ BTU/KWH heat rate

$(0.85 \times 9,750)-3,413 = 4,877$ BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(2.5 \times 10^5 \text{ KW}) = 1.22 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr}) = \text{lbs/Hr}$

$Q = (3.76 \times 10^2)(6.24 \times 10)(3.6 \times 10^3) = 8.45 \times 10^7$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb } ^\circ\text{F})}$

$$\Delta T_r = \frac{1.22 \times 10^9}{8.45 \times 10^7} = 14.4\ ^\circ\text{F}$$

E. Actual Field

Temperature Rise: $\Delta T_r = (\text{Avg. Cross-Sect. T, } ^\circ\text{F})-(\text{Background T, } ^\circ\text{F})$

$$\Delta T_r = 84.1\ ^\circ\text{F} - 71.3\ ^\circ\text{F} = 12.8\ ^\circ\text{F}$$

THERMAL POLLUTION STUDIES

Date 9-11-69 Location Mahoning River @ Niles (M. P. 52*)
Flow 376 cfs Plant Name Niles - Ohio Edison Company
Air Temperature - Begin- 77 °F Finish 82 °F Work Done By Lorentz & Moser
Relative Humidity 46 % Beginning Time 1200

Left Bank	Apx. Distances Between Sampling Points Middle	Right Bank

Beginning Reference Water Temperature (M.P. 52.3)

Left		Middle		Right	
Sur.	71.6	Sur.	PIER	Sur.	71.2
Mid.	71.2	Mid.		Mid.	71.2
Bot.	71.2	Bot.		Bot.	71.2
Depth	8'	Depth		Depth	8'

ABOVE OUTFALL (M.P. 52.0) At Intake

Sur.	73.4	Sur.	73.4	Sur.	73.4	Sur.	74.8	Sur.	77.0
6'	71.6	6'	71.6	6'	72.6	6'	72.6	3'	75.2
20'		20'		20'		20'		6'	72.6
30'		30'		30'		30'		30'	

EVIDENCE OF THERMAL SHORT CIRCUIT? Yes

DESCRIPTION OF FINDINGS - MAGNITUDE AND TYPE About 1° F total average rise at intake. Plant on left bank, looking upstream. Discharge channel faces D.S. from plant. Hot water crosses stream and flows upstream along right bank, then crosses on surface to intake.

MAXIMUM OUTFALL TEMPERATURE 84.6 TIME 1245

SIZE OF MAXIMUM TEMPERATURE ZONE: 50' D.S. of outfall, along right bank

BELOW OUTFALL (M.P. 51.8)

Sur.	84.6	Sur.	82.4	Sur.	82.0	Sur.	81.0	Sur.	81.7
4'	85.7	4'	82.4	4'	81.4	4'	81.0	4'	81.4
7'	85.4	8'	81.0	8'	81.0	8'	81.0	8'	81.5
12'		12'		12'		12'		12'	
16'		16'		16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

*By Survey R.M.I.

Thermal Pollution Studies

Beaver River, M. P. 20.1

Pennsylvania Power Co., New Castle Power Plant

September 10, 1969

A. Assume: 293 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(2.93×10^5 KW) = 1.46×10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (8.60 \times 10^2)(6.24 \times 10)(3.6 \times 10^3) = 1.93 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{1.46 \times 10^9}{1.93 \times 10^8} = 7.6 \, ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 84.9 \, ^\circ F - 74.9 \, ^\circ F = 10.0 \, ^\circ F$$

THERMAL POLLUTION STUDIES

Date 9-10-69 Location Beaver River Below New Castle (M. P. 20.1*)
Flow 560 cfs Plant Name New Castle Plant - Penn Power Company
Air Temperature - Begin- 67 °F Finish 80 °F Work Done By Lorentz & Moser
Relative Humidity 74 % Beginning Time 1100

Left Bank	Apx. Distances Between Sampling Points Middle	Right Bank

Beginning Reference Water Temperature (M.P. 20.55) Junction with Oxbow

	Left	Middle	Right
Sur.	75.2	74.8	74.4
Mid.	75.2	75.2	
Bot.	75.2	75.2	74.1
Depth	9'	12'	4'

ABOVE OUTFALL (M.P. 20.05) At small diversion dam

	1	2	3	4	5
Sur.	Dam	Dam	75.2	75.2	75.2
	8'	8'	5' 75.2	5' 75.2	4' 75.2
20'					
30'					

EVIDENCE OF THERMAL SHORT CIRCUIT? No
DESCRIPTION OF FINDINGS - MAGNITUDE AND TYPE

MAXIMUM OUTFALL TEMPERATURE 86° F TIME 1130

SIZE OF MAXIMUM TEMPERATURE ZONE: Width of outfall and out to about 30' from outfall, shallow - 2' to 4' deep

BELOW OUTFALL (M.P. 20.00) At Power Line

	1	2	3	4	5
Sur.	75.2	75.2	82.4	89.6	89.6
Depth	2' 75.2	5' 75.5	6' 78.8	4' 89.6	2' 89.6
8'					
12'					
16'					
20'					
24'					
28'					
32'					

To Storet R.M.I.

Thermal Pollution Studies

KANAWHA River, M. P. 78.5

KANAWHA RIVER Power Plant

OCTOBER 10, 1968

A. Assume: 426 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(4.26×10^5 KW) = 2.08×10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (2.5 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 5.61 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{2.08 \times 10^9}{5.61 \times 10^8} = 3.7 \text{ °F}$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 66.2 \text{ °F} - 63.9 \text{ °F} = 2.3 \text{ °F}$$

Ralo

THERMAL POLLUTION STUDIES

Date 10-10-68 Location Kanawha River - Appalachian Power Glasgow Plant, M.P. 78.5
Flow 2,500 cfs Plant Name Kanawha River Plant
Air Temperature - Begin ____ °F Finish ____ °F Work Done By Jones, Moser
Relative Humidity = 62%
REFERENCE WATER TEMPERATURE 64.0 M. P. 78.7

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

ABOVE OUTFALL (M. P. 78.6) Above intake at ice breaker and under high wire

Depth	Left Bank	Depth		Depth	Middle	Depth		Depth	Right Bank
Sur.	64.0	Sur.	64.0	Sur.	64.0	Sur.	63.8	Sur.	64.4
8'	64.0	8'	64.0	8'	63.8	8'	63.8	8'	63.8
20'		18 ~~20'~~	64.0	20'	63.5	18' ~~20'~~	64.0	14' ~~20'~~	63.8
30'		30'		30'		30'		30'	

AVERAGE TEMPERATURE : 63.9 °F

BELOW OUTFALL (M. P. 78.4) At coal unloader dock

Depth	Left Bank	Depth		Depth	Middle	Depth		Depth	Right Bank
Sur.	69.8	Sur.	71.4	Sur.	68.5	Sur.	68.0	Sur.	66.2
4'	66.5	4'	68.0	4'	67.1	4'	66.7	4'	66.2
8'	65.8	8'	64.4	8'	67.1	8'	66.3	8'	66.2
12'	64.7	12'	64.4	12'	64.4	12'	64.9	12'	64.4
16'		16'		16'	64.4	16'	64.4	16'	
20'		20'		20'	64.4	20'	64.4	20'	
24'		24'		24'		24'	64.4	24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVERAGE TEMPERATURE : 66.1 °F

ZONE OF MIXING (M. P. *)

Depth	Left Bank	Depth		Depth	Middle	Depth		Depth	Right Bank
Sur.		Sur.		Sur.		Sur.		Sur.	
4'		4'		4'		4'		4'	
8'		8'		8'		8'		8'	
12'		12'		12'		12'		12'	
16'		16'		16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

DOWNSTREAM PT. NO INCREASE (M. P. 78.2) At boat launch

Depth	Left Bank	Depth		Depth	Middle	Depth		Depth	Right Bank
Sur.	66.2	Sur.	66.2	Sur.	66.2	Sur.	66.2	Sur.	66.2
8'	66.2	8'	66.2	8'	66.2	8'	66.2	8'	66.2
20'		20'		20'		20'		20'	
30'		30'		30'		30'		30'	

* Tow upstream at locks running engines to clean out by dock.

Thermal Pollution Studies

KANAWHA River, M. P. 78.5

KANAWHA RIVER Power Plant

OCTOBER 10, 1968

A. Assume: 426 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(4.26 \times 10^5$ KW$) = 2.08 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (2.5 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 5.61 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{2.08 \times 10^9}{5.61 \times 10^8} = 3.7 \ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 66.2 \ ^\circ F - 63.9 \ ^\circ F = 2.3 \ ^\circ F$$

LAP

THERMAL POLLUTION STUDIES

Monongahela River, M. P. 29.5

Mitchell Power Plant

(July 15, 1968)

A. Assume: 449 MW rated capacity

Maximum efficiency = 35%

Heat loss within plant = 15%

Energy required for 1 Kwh = 3,413 BTU

Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35} = 9,750$ BTU/Kwh heat rate

$(0.85 \times 9,750) - 3,413 = 4,877$ BTU/Kwh Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/Kwh})(4.49 \times 10^5 \text{ KW}) = 2.19 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/hr}) = \text{lbs/Hr}$

$Q = (1.27 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 2.85 \times 10^8$ lbs/Hr

D. Theoretical Stream Temperature Rise:

$$\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{(\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb } ^\circ\text{F})}$$

$$\Delta T_r = \frac{2.19 \times 10^9}{2.85 \times 10^8} = 7.8\ ^\circ\text{F}$$

E. Actual Field Temperature Rise:

$$\Delta T_r = (\text{Avg. Cross-Sect. T, } ^\circ\text{F}) - (\text{Background T, } ^\circ\text{F})$$

$$\Delta T_r = 95.3\ ^\circ\text{F} - 84.0\ ^\circ\text{F} = 11.3\ ^\circ\text{F}$$

Pennsylvania Water Quality Standards for temperature are:

Summer maximum 87 °F

No greater rise than 5 °F

THERMAL POLLUTION STUDIES

Date 7-15-68 Location Monongahela River - Mile Point 29.5

Flow 1270 cfs Plant Name Mitchell - West Penn Power (449 MW)

Air Temperature - Begin 87.8 °F Finish 87.8 °F Work Done By Griffith, Jones, Moser

REFERENCE WATER TEMPERATURE 87.8° F M. P. 29.7

Hot Sunlight

Left Bank		Apx. Distances Between Sampling Points — Middle		Right Bank
	250'		750'	

ABOVE OUTFALL (M. P. 30.3)

Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.
Sur.	91.4	Sur.	91.4	Sur.	91.4	Sur.	91.4	Sur.	93.2
8'	84.2	8'	84.2	8'	84.2	8'	83.4	8'	84.2
20'		16' ~~20'~~	83.4	14' ~~20'~~	83.4	14' ~~20'~~	83.4	20'	
30'		30'		30'		30'		30'	

AVERAGE TEMPERATURE : [illegible]4.0 °F

BELOW OUTFALL (M. P. 29.5)

Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.
Sur.	95.9	Sur.	95.9	Sur.	97.7	Sur.	97.7	Sur.	98.6
4'	95.9	4'	95.9	4'	96.8	4'	97.7	4'	98.6
8'	95.9	8'	95.9	8'	95.9	8'	95.9	8'	95.9
12'		12'	95.9	12'	93.2	12'	94.2	12'	
16'		16'	95.0	16'	86.0	16'	86.9	16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

WT. AV. TEMP. : 95.1 °F

ZONE OF MIXING (M. P. 29.0)

Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.
Sur.	96.8	Sur.	96.8	Sur.	97.7	Sur.	97.7	Sur.	97.7
4'	95.9	4'	96.8	4'	95.9	4'	96.8	4'	96.8
8'	95.0	8'	94.2	8'	95.0	8'	95.0	8'	94.2
12'	94.2	12'	93.2	12'	93.2	12'	93.2	12'	
16'		16'	92.4	16'	89.6	16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

WT. AVG. TEMP. : [illegible].3 °F

DOWNSTREAM PT. NO INCREASE (M. P. 27.8) 35° across stream @ 4' Depth

Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.	Depth	Temp.
Sur.		Sur.		Sur.		Sur.		Sur.	
8'		8'		8'		8'		8'	
20'		20'		20'		20'		20'	
30'		30'		30'		30'		30'	

Thermal Pollution Studies

Monongahela River, M. P. 29.5

West Penn Power Mitchell Power Plant

September 11, 1968

A. Assume: 449 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(4.49 \times 10^5 \text{ KW}) = 2.19 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr})$ = lbs/Hr

$Q = (2.62 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 5.88 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb } ^\circ\text{F})}$

$$\Delta T_r = \frac{2.19 \times 10^9}{5.88 \times 10^8} = 3.7 \ ^\circ\text{F}$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, $^\circ$F)-(Background T, $^\circ$F)

$$\Delta T_r = 80.6 \ ^\circ\text{F} - 74.8 \ ^\circ\text{F} = 5.8 \ ^\circ\text{F}$$

THERMAL POLLUTION STUDIES

Date 9-11-68 Location Monongahela River - M. P. 29.5
Flow [illegible] cfs Plant Name Mitchell - West Penn Power (449 MW)
Air Temperature - Begin 63 °F Finish 63 °F Work Done By Jones & Moser

REFERENCE WATER TEMPERATURE 74.8° F M. P. 29.8

Left Bank	Apx. Distances Between Sampling Points		Middle		Right Bank
	250'			750'	

ABOVE OUTFALL (M. P. 29.8)

← 74.8° F →

Sur.		Sur.		Sur.		Sur.		Sur.	
8'		8'		8'		8'		8'	
20'		20'		20'		20'		20'	
30'		30'		30'		30'		30'	

AVERAGE TEMPERATURE : 74.8°F

BELOW OUTFALL (M. P. 29.4)

Sur.	79.2	Sur.	79.5	Sur.	79.7	Sur.	79.2	Sur.	81.5
4'	78.8	4'	79.2	4'	77.9	4'	78.4	4'	80.6
8'	78.0	8'	77.0	8'	77.4	8'	77.4	8'	80.2
12'	76.1	12'	75.2	12'	76.6	12'	75.5	12'	75.6
16'		16'	74.8	16'	75.2	16'	75.2	16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVERAGE TEMPERATURE : 78.5°F

ZONE OF MIXING (M. P. 29.0)

Sur.	81.0	Sur.	80.6	Sur.	80.6	Sur.	80.6	Sur.	80.6
4'	81.0	4'	80.6	4'	80.6	4'	80.6	4'	80.6
8'	81.0	8'	80.2	8'	79.7	8'	80.2	8'	
12'	81.0	12'	79.5	12'	78.8	12'	78.8	12'	
16'		16'	79.2	16'	77.4	16'	78.0	16'	
20'		20'		20'	77.0	20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVERAGE TEMPERATURE : 79.9 °F

DOWNSTREAM PT. NO INCREASE (M. P. 28.7)

Sur.	80.6	Sur.	80.6	Sur.	80.6	Sur.	80.6	Sur.	80.6
8'	80.6	8'	80.6	8'		8'		8'	80.6
20'		20'	80.6	20'	80.6	20'	80.6	20'	
30'		30'		30'		30'		30'	

THERMAL POLLUTION STUDIES

Monongahela River, M. P. 25.2

Elrama Power Plant

(July 16, 1968)

A. Assume: 425 MW rated capacity

Maximum efficiency = 35%

Heat loss within plant = 15%

Energy required for 1 Kwh = 3,413 BTU

Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35} = 9,750$ BTU/Kwh heat rate

$(0.85 \times 9,750) - 3,413 = 4,877$ BTU/Kwh Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/Kwh})(4.25 \times 10^5 \text{ KW}) = 2.08 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/hr}) = \text{lbs/Hr}$

$Q = (1.1 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 2.47 \times 10^8$ lbs/Hr

D. Theoretical Stream Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{(\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb } ^\circ\text{F})}$

$$\Delta T_r = \frac{2.08 \times 10^9}{2.47 \times 10^8} = 8.4\ ^\circ\text{F}$$

E. Actual Field Temperature Rise: $\Delta T_r = (\text{Avg. Cross-Sect. T, } ^\circ\text{F}) - (\text{Background T, } ^\circ\text{F})$

$$\Delta T_r = 96.4\ ^\circ\text{F} - 90.5\ ^\circ\text{F} = 5.9\ ^\circ\text{F}$$

Pennsylvania Water Quality Standards for temperature are:

Summer maximum 87 $^\circ$F

No greater rise than 5 $^\circ$F

L. A. Parker
[illegible]

THERMAL POLLUTION STUDIES

Date 7-16-68 Location Monongahela River @ M. P. 25.2
Flow 1100 cfs Plant Name ElRama - Duquesne Light Company (+25 MW)
Air Temperature - Begin 75.2 °F Finish 78.8 °F Work Done By Griffith, Jones, Moser

REFERENCE WATER TEMPERATURE ~~32.5° C~~ 90.5°F M. P. 25.8

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank
200' — 600'

ABOVE OUTFALL (M. P. 25.8)

Depth	Left Bank		Middle		Right Bank
Sur.	90.5	90.5	90.5	90.5	90.5
8'	90.5	90.5	90.5	90.5	
20'		16': 90.5	11': 90.5		
30'					

Average Temperature: 90.5 °F

BELOW OUTFALL (M. P. 25.0)

Depth	Left Bank		Middle		Right Bank
Sur.	96.8	95.0	95.9	98.6	102.2
4'	96.8	95.9	95.0	97.7	102.2
8'	95.9	95.9	95.0	95.0	
12'	93.2	93.2	91.4	91.4	
16'		14': 91.4	90.5	14': 91.4	
20'					
24'					
28'					
32'					

Average Temperature: 94.7°F

ZONE OF MIXING (M. P. 24.6) Above J & L Steel

Depth	Left Bank		Middle		Right Bank
Sur.	96.8	96.8	95.9	96.8	95.9
4'	97.7	96.8	96.8	96.8	96.8
8'	96.8	96.8	96.8	96.8	95.8
12'	96.8	95.9	96.8	95.9	96.8
16'	95.9	95.9	95.9		
20'			95.0		
24'					
28'					
32'					

Average Temperature: [illegible] °F

DOWNSTREAM PT. NO INCREASE (M. P. ______)

Depth	Left Bank		Middle		Right Bank
Sur.					
8'					
20'					
30'					

Thermal Pollution Studies

MONONGAHELA River, M. P. 20.2

DUQUESNE LIGHT CO, ELRAMA Power Plant

SEPTEMBER 11, 1968

A. Assume: 425 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(4.25 \times 10^5$ KW$) = 2.08 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (2.62 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 5.88 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{2.08 \times 10^9}{5.88 \times 10^8} = 3.5\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 87.8\ ^\circ F - 80.6\ ^\circ F = 7.2\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 9-11-68 Location Monongahela River - M. P. 25.2
Flow 2-20 cfs Plant Name Elrama Station - Duquesne Light Co. (425 MW)
Air Temperature - Begin 63 °F Finish 63 °F Work Done By Jones & Moser

REFERENCE WATER TEMPERATURE 80.6° F M. P. 25.5

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank
200' 600'

ABOVE OUTFALL (M. P. 25.5)

Depth	Left Bank		Middle		Right Bank
Sur.	80.6	80.6	80.6	80.6	80.6
8'	80.6	80.6	80.6	80.6	80.6
20'		80.6	80.6	80.6	
30'					

AVERAGE TEMPERATURE : 80.6°F

BELOW OUTFALL (M. P. 24.9) Water Tank - Mississippi Glass Co.

Depth	Left Bank		Middle		Right Bank
Sur.	87.4	87.4	87.8	87.4	91.8
4'	86.4	85.7	87.8	86.7	91.4
8'	83.4	85.7	85.7	83.9	88.7
12'	82.0	85.2	84.2	81.0	
16'		83.4	81.0		
20'					
24'					
28'					
32'					

AVERAGE : 86.7° F

ZONE OF MIXING (M. P. 24.7) Could not anchor in this area.

Depth	Left Bank		Middle		Right Bank
Sur.					
4'					
8'					
12'					
16'					
20'					
24'					
28'					
32'					

DOWNSTREAM PT. NO INCREASE (M. P. 24.5)

Depth	Left Bank		Middle		Right Bank
Sur.	87.8	87.8	87.8	87.8	88.2
8'	87.8	87.8	87.8	87.8	88.2
20'		87.8	87.8	86.9	
30'					

Thermal Pollution Studies

MUSKINGUM River, M. P. 118

CONESVILLE STA., COL & SOUTH ELECT Power Plant

SEPTEMBER 25, 1969

A. Assume: 433 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(4.33 $\times 10^5$ KW) = 2.12 $\times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (2.43 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 5.45 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{2.12 \times 10^9}{5.45 \times 10^8} = 3.9 \ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 70.9 \ ^\circ F - 62.6 \ ^\circ F = 8.3 \ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 9-25-69 Location Muskingum River @ Conesville
Flow 2420 cfs Plant Name Conesville Station - Columbus & Southern Electric
Air Temperature - Begin- 68 °F Finish 72 °F Work Done By Bailey & Moser
Relative Humidity 46 % Beginning Time 1015

Left Bank	Apx. Distances Between Sampling Points Middle	Right Bank

Beginning Reference Water Temperature (M.P. 118.0)

	Left	Middle	Right
Sur.	62.6	62.6	62.6
Mid.	62.6	62.6	62.6
Bot.	62.6	62.6	62.6
Depth	2.0	2.0	2.0

AVG. 62.6° F

ABOVE OUTFALL (M.P. 117.9)

	1	2	3	4	5
Sur.	62.6	62.6	62.6	62.6	62.6
4'	62.6	62.6	62.6	62.6	62.6
20'					
30'					

AVG 62.6° F

EVIDENCE OF THERMAL SHORT CIRCUIT? No
DESCRIPTION OF FINDINGS - MAGNITUDE AND TYPE

MAXIMUM OUTFALL TEMPERATURE 84.6° F TIME 1030

SIZE OF MAXIMUM TEMPERATURE ZONE: Triangular shape 50' wide and extending out 50' on downstream side.

BELOW OUTFALL (M.P. 117.8)

1		2		3		4		5	
Sur.	62.9	Sur.	63.3	Sur.	72.3	Sur.	80.6	Sur.	82.4
3'	62.9	3'	62.9	3'	66.2	4'	79.2	4'	82.4
8'		8'		8'		7'	71.6	5'	82.4
12'		12'		12'		12'		12'	
16'		16'		16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

Thermal Pollution Studies

MUSKINGUM River, M. P. 68.3

PHILO, OHIO POWER CO. Power Plant

SEPTEMBER 23, 1969

A. Assume: 500 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(5.0 \times 10^5$ KW$) = 2.44 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (1.9 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 4.26 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{2.44 \times 10^9}{4.26 \times 10^8} = 5.7 \,°F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 73.9\,°F - 68.8\,°F = 5.1\,°F$$

THERMAL POLLUTION STUDIES

Date 9-23-69 Location Muskingum River @ Philo
Flow 1900 cfs Plant Name Philo
Air Temperature - Begin- 76 °F Finish 75 °F Work Done By Bailey & Moser
Relative Humidity 66 % Beginning Time 1445

Left Bank	Apx. Distances Between Sampling Points Middle	Right Bank

Beginning Reference Water Temperature (M.P. 68.8)

Sur.	69.4	Sur.	69.4	Sur.	69.4
Mid.	69.4	Mid.	69.4	Mid.	69.4
Bot.	69.4	Bot.	69.4	Bot.	69.4
Depth		Depth		Depth	

ABOVE OUTFALL (M.P. 68.4) Above Salt Creek

Sur.	69.0	Sur.	69.0	Sur.	69.0	Sur.	68.7	Sur.	68.7
4' ~~8'~~	69.0	8'	69.0	4' ~~8'~~	69.0	4' ~~8'~~	68.7	8'	
20'		20'		20'		20'		20'	
30'		30'		30'		30'		30'	
	[illegible]		[illegible]	Avg.	[illegible]		[illegible]		[illegible]

EVIDENCE OF THERMAL SHORT CIRCUIT? No - Intake is above dam, outfalls below
DESCRIPTION OF FINDINGS - MAGNITUDE AND TYPE

MAXIMUM OUTFALL TEMPERATURE 82.8° Upper - 78.8° Lower TIME 1515

SIZE OF MAXIMUM TEMPERATURE ZONE: Upper Outfall 4' x 10' out x 2' Deep

Lower Outfall 10' x 40' out x 4' deep

BELOW OUTFALL (M.P. 68.2) 100' D.S. of upper Power Line

Sur.	75.2	Sur.	73.4	Sur.	76.6	Sur.	69.4	Sur.	69.4
4'	77.4	4'	73.0	4'	70.1	4'	69.4	2' ~~4'~~	69.4
8'		7' ~~8'~~	73.4	8'		8'		8'	
12'		12'		12'		12'		12'	
16'		16'		16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

Thermal Pollution Studies

MUSKINGUM River, M. P. 22.15

OHIO POWER, BEVERLEY Power Plant

SEPTEMBER 23, 1969

A. Assume: 876 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(8.76×10^5 KW) = 4.28×10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (1.9 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 4.26 \times 10^8$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{4.28 \times 10^9}{4.26 \times 10^8} = 10.0 \text{ °F}$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 76.8 \text{ °F} - 70.0 \text{ °F} = 6.8 \text{ °F}$$

THERMAL POLLUTION STUDIES

Date 9-23-69 Location Muskingum River at Beverley

Flow 1900 cfs Plant Name Lower Plant

Air Temperature - Begin- 67 °F Finish 71 °F Work Done By Moser, Bailey

Relative Humidity 88 % Beginning Time 10:30

Left Bank	Apx. Distances Between Sampling Points Middle	Right Bank

Beginning Reference Water Temperature (M.P. 28.2) See zone of mixing

	Left	Middle	Right
Sur.	70.1	70.1	70.1
Mid.		69.8	69.8
Bot.	70.1	69.8	69.8
Depth	4'	12'	8'

ABOVE OUTFALL (M.P. 28.15) Half way between Creek and Outfall

Sur. 71.6	Sur. 72.3	Sur. 73.0	Sur. 73.4	Sur. 74.4
6' 71.6	6' 71.6	8' 72.6	8' 73.0	8' 73.7
20'	20'	14' 71.2	17' 71.2	20'
30'	30'	30'	30'	30'
71.6	72.0	AVG. TEMP 72.5 72.3°F	72.5	74.1

EVIDENCE OF THERMAL SHORT CIRCUIT? Yes

DESCRIPTION OF FINDINGS - MAGNITUDE AND TYPE About 1.0° F rise in intake Thermal Loop - from outfall on Left Bank, across to Right Bank, upstream to above intake, 150' or so, back across to intake

MAXIMUM OUTFALL TEMPERATURE 80.6° F TIME 1050

SIZE OF MAXIMUM TEMPERATURE ZONE: 30' wide by 30' long on left bank and 10' or so deep

Zone of Mixing ~~BELOW OUTFALL~~ (M.P. 28.0)

	1	2	3	4	5
Sur.	75.9	76.6	76.6	77.0	76.6
4'	75.5	76.2	76.6	76.6	
8'	75.5	76.2	76.6		
12'	75.5	76.2	76.2		
16'		75.9	75.9		
20'			74.8		
24'					
28'					
32'					

Thermal Pollution Studies

OHIO River, M. P. 2.1

DUQUESNE LIGHT Co. REED Power Plant

JULY 17, 1968

A. Assume: 180 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35} = 9,750$ BTU/KWH heat rate

$(0.85 \times 9,750) - 3,413 = 4,877$ BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(1.8 \times 10^5 \text{ KW}) = 8.78 \times 10^8$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr}) = \text{lbs/Hr}$

$Q = (8.88 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 2.0 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb }^\circ\text{F})}$

$$\Delta T_r = \frac{8.78 \times 10^8}{2.0 \times 10^9} = 0.5\ ^\circ\text{F}$$

E. Actual Field

Temperature Rise: $\Delta T_r = (\text{Avg. Cross-Sect. T, }^\circ\text{F}) - (\text{Background T, }^\circ\text{F})$

$$\Delta T_r = 86.9\ ^\circ\text{F} - 84.8\ ^\circ\text{F} = 2.1\ ^\circ\text{F}$$

THERMAL POLLUTION STUDIES

Date 7-17-68 Location Ohio River, M. P. 2.1
Flow [illegible] cfs Plant Name Reed - Duquesne Light Company
Air Temperature - Begin 82.4 °F Finish 82.[illegible] °F Work Done By Griffith, Jones, Moser

REFERENCE WATER TEMPERATURE 85.9° F M. P. 1.9

Left Bank — Apx. Distances Between Sampling Points — Right Bank
200' — Middle — 600'

ABOVE OUTFALL (M. P. 1.9 - Tip of Island)

Left Bank				Middle				Right Bank	
Sur.	86.0	Sur.	86.0	Sur.	86.0	Sur.	86.0	Sur.	86.0
7' ~~20'~~	86.0	8'	85.2	8'	84.2	8'	84.2	8'	83.4
20'		14' ~~20'~~	84.2	20'	83.4	16' ~~20'~~	83.4	16' ~~20'~~	83.4
30'		30'		30'		30'		30'	

[illegible] 84.5 F

BELOW OUTFALL (M. P. 2.2 - At Power Lines)

Left Bank				Middle				Right Bank	
Sur.	86.9	Sur.	86.9	Sur.	87.8	Sur.	86.0	Sur.	86.0
4'	86.9	4'	86.9	4'	86.9	4'	86.0	4'	86.0
8'	86.9	8'	86.9	8'	86.9	8'	86.0	8'	86.0
12'	86.9	12'	86.9	12'	86.0	12'	86.0	12'	86.0
16'		16'	86.0	16'	86.0	16'	85.2	16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

[illegible] 86.9 F

ZONE OF MIXING (M. P. 2.4)

Max. Varience of .4 - L to R

Left Bank				Middle				Right Bank	
Sur.	86.5	Sur.		Sur.		Sur.		Sur.	86.9
4'	86.5	4'		4'		4'		4'	86.9
8'	86.5	8'		8'		8'		8'	86.9
12'		12'		12'		12'		12'	
16'		16'		16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

[illegible] 86.7 F

DOWNSTREAM PT. NO INCREASE (M. P. 2.7)

Max. Varience of .4 - L to R

Left Bank				Middle				Right Bank	
Sur.	86.0	Sur.		Sur.		Sur.		Sur.	86.4
8'	86.0	8'		8'		8'		8'	86.4
20'		20'		20'		20'		20'	
30'		30'		30'		30'		30'	

Thermal Pollution Studies

OHIO River, M. P. 15.2

DUQUESNE LIGHT & POWER Power Plant

JULY 18, 1968

A. Assume: 315 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3{,}413 \text{ BTU}}{0.35} = 9{,}750$ BTU/KWH heat rate

$(0.85 \times 9{,}750) - 3{,}413 = 4{,}877$ BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(3.15 \times 10^5 \text{ KW}) = 1.38 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr}) = \text{lbs/Hr}$

$Q = (8.88 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 2.0 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb } ^\circ\text{F})}$

$$\Delta T_r = \frac{1.38 \times 10^9}{2.0 \times 10^9} = 0.7\ ^\circ\text{F}$$

E. Actual Field

Temperature Rise: $\Delta T_r = (\text{Avg. Cross-Sect. T, } ^\circ\text{F}) - (\text{Background T, } ^\circ\text{F})$

$$\Delta T_r = 86.6\ ^\circ\text{F} - 85.5\ ^\circ\text{F} = 1.1\ ^\circ\text{F}$$

THERMAL POLLUTION STUDIES

Date 7-19-68 Location Ohio River - M. P. 15.2
Flow 3380 cfs Plant Name Phillips - Duquesne Light Company
Air Temperature - Begin 91.4 °F Finish 91.4 °F Work Done By Griffith, Jones, Moser

REFERENCE WATER TEMPERATURE 86.0° F M. P. 14

Apx. Distances Between Sampling Points: Left Bank — 300' — Middle — 900' — Right Bank

ABOVE OUTFALL (M. P. 15.0 - Dock)

Depth	Left Bank	300'	Middle	900'	Right Bank
Sur.	86.0	86.0	86.0	86.0	86.0
8'	86.0	85.2	85.2	85.2	85.2
~~20'~~	15': 85.2	12': 85.2	18': 85.2	18': 85.2	10': 85.2
30'					

AVERAGE TEMPERATURE : 85.5° F

BELOW OUTFALL (M. P. 15.5)

Depth	Left Bank	300'	Middle	900'	Right Bank
Sur.	86.0	86.0	86.0	89.6	89.6
4'	86.0	86.0	85.2	86.9	86.0
8'	85.2	85.2	85.2	86.0	85.2
12'	85.2		85.2	86.0	85.2
16'	85.2		85.2	85.2	
20'				85.2	
24'					
28'					
32'					

AVERAGE TEMPERATURE : 85.9° F

ZONE OF MIXING (M. P. 16.0)

Depth	Left Bank	300'	Middle	900'	Right Bank
Sur.	87.8	87.8	87.8	86.9	89.6
4'	86.9	87.8	86.9	86.9	87.8
8'	86.0	86.9	86.0	86.0	86.0
12'	86.0	86.0	86.0	85.2	86.0
16'		86.0	86.0	85.2	
20'		19': 85.2	86.0		
24'					
28'					
32'					

AVERAGE TEMPERATURE : 86.6° F

DOWNSTREAM PT. NO INCREASE (M. P. 16.7)

Depth	Left Bank	300'	Middle	900'	Right Bank
Sur.	87.8	86.9	86.9	86.9	86.0
8'	86.9	86.9	86.0	86.0	86.0
20'					
30'					

Thermal Pollution Studies

OHIO River, M. P. 15.2

DUQUESNE LIGHT Co PHILLIPS Power Plant

JULY 18, 1969

A. Assume: 315 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH)$(3.15 \times 10^5$ KW) = 1.38×10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (1.1 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 2.47 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{1.38 \times 10^9}{2.47 \times 10^9} = 0.6\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 83.8\ ^\circ F - 82.6\ ^\circ F = 1.2\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 7-18-69 Location Ohio River @ South Heights, M. P. 15.2
Flow 11,000 cfs Plant Name Phillips - Duquesne Light Company
Air Temperature - Begin 88 °F Finish ____ °F Work Done By Richards - Moser
Relative Humidity - 64%
REFERENCE WATER TEMPERATURE 82.4° ____ M. P. 14.2

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

ABOVE OUTFALL (M. P. 15.2) Between Outfall and Intake

Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp
Sur.	82.8	Sur.	82.8	Sur.	82.8	Sur.	82.8	Sur.	82.8
8'	82.8	8'	82.4	8'	82.4	8'	82.4	8'	82.4
20'		11'	82.4	20'	82.4	20'	82.4	14'	82.4
30'		30'		30'		30'		30'	

AVG. TEMP. : 82.6 °F

BELOW OUTFALL (M. P. 15.4) At Power Line

Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp
Sur.	83.5	Sur.	82.8	Sur.	83.5	Sur.	86.0	Sur.	85.0
4'	82.8	4'	82.8	4'	82.8	4'	84.2	4'	83.5
8'	82.8	8'	82.4	8'	82.8	8'	82.8	8'	
12'	82.8	12'		12'	82.4	12'	82.8	12'	
16'		16'		16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVG. TEMP. [illegible]

ZONE OF MIXING (M. P. 15.8 or 9)

Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp
Sur.	85.7	Sur.	85.4	Sur.	83.9	Sur.	86.0	Sur.	85.4
4'	85.7	4'	84.6	4'	83.5	4'	84.2	4'	83.9
8'	85.0	8'	84.2	8'	83.5	8'	83.9	8'	82.8
12'		12'	83.2	12'	82.8	12'	82.8	12'	82.8
16'		16'	82.8	16'	82.8	16'	82.8	16'	82.8
20'		20'		18'	82.4	20'	82.8	20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVG. TEMP. [illegible]

DOWNSTREAM PT. NO INCREASE (M. P. 16.6)

Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp	Depth	Temp
Sur.	86.0	Sur.	89.6	Sur.	85.4	Sur.	84.2	Sur.	84.2
8'	83.2	8'	83.9	8'	83.2	8'	82.8	8'	84.2
20'	82.3	20'	82.8	16'	82.8	16'	82.8	20'	82.4
30'		30'		30'		30'		26'	82.4

(All six stacks going)

THERMAL POLLUTION STUDIES

Ohio River, M. P. 53.9

Sammis Power Plant

Low Flow Thermal Load

A. Assume: Present rated capacity - 1,640 MW

Future capacity (1971) - 2,240 MW

Maximum efficiency = 40%

Heat loss within plant = 15%

Energy required for 1 Kwh = 3,413 BTU

Adequate mixing of effluent

B. Heat Load: $\frac{3{,}413 \text{ BTU}}{0.40} = 8{,}500$ BTU/Kwh heat rate

(0.85 x 8,500) - 3,413 = 3,837 BTU/Kwh Heat to Cooling water

Present: $(3.84 \times 10^3 \text{ BTU/Kwh})(1.64 \times 10^6 \text{ KW}) = 6.3 \times 10^9$ BTU/Hr Heat Load

Future: $(3.84 \times 10^3 \text{ BTU/Kwh})(2.24 \times 10^6 \text{ KW}) = 8.6 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/hr}) = \text{lbs/Hr}$

Low Flow: $(5.0 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 1.12 \times 10^9$ lbs/Hr

D. Theoretical Stream Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{(\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb }^\circ\text{F})}$

Present: $\Delta T_r = \frac{6.3 \times 10^9}{1.12 \times 10^9} = 5.6\ ^\circ\text{F}$

Future: $\Delta T_r = \frac{8.6 \times 10^9}{1.12 \times 10^9} = 7.7\ ^\circ\text{F}$

L. A. Pa[illegible]er
[illegible]

Thermal Pollution Studies

OHIO River, M. P. 54.9

OHIO EDISON, SAMMIS Power Plant

SEPTEMBER 13, 1968

A. Assume: 1,960 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(1,960 \times 10^6$ KW$) = 9.55 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (1.2 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 2.7 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{9.55 \times 10^9}{2.7 \times 10^9} = 3.5 \ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 77.2 \ ^\circ F - 73.4 \ ^\circ F = 3.8 \ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 9-13-68 Location Ohio River - Mile Point 53.9
Flow 12,000 cfs Plant Name Sammis - Ohio Edison (1,560 MW)
Air Temperature - Begin 68 °F Finish 68 °F Work Done By J. Moser & W. West

REFERENCE WATER TEMPERATURE 73.9° F M. P. 54.5

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank (East)

600' — 1200'

ABOVE OUTFALL (M. P. 53.5)

Depth	Left Bank	600'	Middle	1200'	Right Bank (East)
Sur.	74.3	73.7	73.7	73.7	73.7
8'	74.3	73.7	73.7	73.7	73.7
20'					
30'					

Average Temperature: 73.4 °F

BELOW OUTFALL (M. P. 54.3) (425' above dam)

Outfall submerged on northeast side of lockwall.

Depth	Left Bank	600'	Middle	1200'	Right Bank (East)
Sur.	87.8	81.0	80.6	80.6	79.7
4'	82.4	80.6	77.0	79.7	80.2
8'	77.0	78.8	76.6	77.0	79.7
12'	76.6	77.9	76.6	76.6	77.0
16'	76.6	76.6	76.1	76.6	76.6
20'	76.1	76.1		76.1	76.6
24'	76.1			76.1	76.1
28'	76.1			75.5	75.5
32'				75.5	
36'				75.5	
40'				75.5	

Average Temperature: 77.2 °F

ZONE OF MIXING (M. P. At Dam)

Depth	Left Bank	600'	Middle	1200'	Right Bank (East)
Sur.					
4'					
8'					
12'					
16'					
20'					
24'					
28'					
32'					

DOWNSTREAM PT. NO INCREASE (M. P.) End of south lockwall

Depth	Left Bank	600'	Middle	1200'	Right Bank (East)
Sur.	77.0	77.0	77.0	77.0	77.0
8'					
20'					
30'					

(Good mixing at dam indicated.)

Thermal Pollution Studies

OHIO River, M. P. 539

OHIO EDISON, SAMMIS Power Plant

DECEMBER 20, 1968

A. Assume: 1,960 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(1.96 \times 10^6$ KW$) = 9.55 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (4.45 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 1.0 \times 10^{10}$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb }^\circ\text{F})}$

$$\Delta T_r = \frac{9.55 \times 10^9}{1.0 \times 10^{10}} = 1.0\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, $^\circ$F)-(Background T, $^\circ$F)

$$\Delta T_r = 36.5\ ^\circ F - 34.4\ ^\circ F = 2.1\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 12-20-68 Location Ohio River - Mile Point 53.9
Flow 44,500 cfs Plant Name Sammis - Ohio River (1,660 Mw)
Air Temperature - Begin 32 °F Finish 32 °F Work Done By Roger Griffith and Bob Donaghy

REFERENCE WATER TEMPERATURE 33.8 M. P. 53.5

Left Bank Upstream — Apx. Distances Between Sampling Points — Right Bank Upstream

600' — Middle — 900' — 1200'

ABOVE OUTFALL (M. P. 53.5)

Depth	Left Bank	Depth	600'	Depth	Middle	Depth	900'	Depth	Right Bank
Sur.	33.8	Sur.	33.8	Sur.	33.8	Sur.	33.8	Sur.	33.8
8'	33.8	8'	34.3	8'	34.5	8'	34.3	8'	34.3
20'		20'	34.6	20'	34.6	20'	34.6	20'	34.6
30'		29' ~~XXX~~	34.5	28' ~~XXX~~	34.6	30'	34.6	30'	
	33.8		34.3	Avg	34.4° F		34.2		34.2

BELOW OUTFALL (M. P. 54.3) 425' above dam

Outside wall of dam

50' out Temp. 38.3° F — 8'

Readings 50' out from wall (12'–20')

Depth	Left Bank	Depth	600'	Depth	Middle	Depth	900'	Depth	Right Bank
Sur.	46.2	Sur.	41.9	Sur.	33.8	Sur.	33.8	Sur.	33.8
4'	42.8	4'	41.1	4'	34.1	4'	34.6	4'	33.9
8'	42.8	8'	40.6	8'	34.3	8'	34.6	8'	34.1
12'	36.5	12'	38.3	12'	34.5	12'	34.6	12'	34.5
16'	35.6	16'	38.8	bottom 16'	34.6	16'	34.6	16'	34.6
20'	36.1	20'	37.4	20'		20'	34.6	20'	
24'		21' ~~XXX~~	38.3	24'		24'	34.6	24'	
28'		28'		28'		28'	34.6	28'	
32'		32'		32'		32'	34.6	32'	
	40.5		39.5		34.3		-- bottom 34.6		34.2

Left bank upstream below outfall Avg 36.5° F

ZONE OF MIXING (M. P.)

Inside wall of dam

Depth	Left Bank	Depth	600'	Depth	Middle	Depth	900'	Depth	Right Bank
Sur.	33.8	Sur.		Sur.		Sur.		Sur.	
4'	34.1	4'		4'		4'		4'	
8'	34.3	8'		8'		8'		8'	
9' ~~XXX~~	34.1	12'		12'		12'		12'	
16'		16'		16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

DOWNSTREAM PT. NO INCREASE (M. P.)

Depth	Left Bank	Depth	600'	Depth	Middle	Depth	900'	Depth	Right Bank
Sur.		Sur.		Sur.		Sur.		Sur.	
8'		8'		8'		8'		8'	
20'		20'		20'		20'		20'	
30'		30'		30'		30'		30'	

Continuous moniter into disc. along pier wall (100' out)

From breast	500'	600'	700'	800'	850'	900'	950'
	37.4°	38.3°	42.8°	42.6°	45.5°	46.4°	39.2° (outside edge of disc. turbulence)

[illegible] of wall upstream from disc. 35.6°

41.1° (50' from wall)

Thermal Pollution Studies

OHIO River, M. P. 53.9

OHIO EDISON, SAMMIS Power Plant

JULY 2, 1969

A. Assume: 1,960 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3{,}413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

$(0.85 \times 9{,}750) - 3{,}413 = 4{,}877$ BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(1.96 \times 10^6 \text{ KW}) = 9.55 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr}) = \text{lbs/Hr}$

$Q = (1.1 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 2.47 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb }^\circ\text{F})}$

$$\Delta T_r = \frac{9.55 \times 10^9}{2.47 \times 10^9} = 3.9\ ^\circ F$$

E. Actual Field

Temperature Rise: $\Delta T_r = (\text{Avg. Cross-Sect. T, }^\circ\text{F}) - (\text{Background T, }^\circ\text{F})$

$$\Delta T_r = 85.5\ ^\circ F - 83.9\ ^\circ F = 1.6\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 7-2-69 Location Ohio River @ New Cumberland Lock and Dam
Flow 11,000 cfs Plant Name Sammis - Ohio Edison (1,660 MW)
Air Temperature - Begin 93 °F Finish ____ °F Work Done By Badway - Moser
Relative Humidity - 55%
REFERENCE WATER TEMPERATURE ____ M. P. 52.5

Left Bank		Apx. Distances Between Sampling Points	Middle		Right Bank
	600'			1200'	

ABOVE OUTFALL (M. P. 53.8) By intake and across

Sur.	85.2	Sur.	86.0	Sur.	86.4	Sur.	87.4	Sur.	88.2
8'	83.9	8'	84.6	8'	84.2	8'	84.2	8'	86.0
20'	82.4	20'	82.4	20'	82.4	20'	83.2	20'	83.2
26'	82.4	25'	82.4	30'	82.4	30'	82.4	25'	82.4
						41'	82.0		
	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]

Avg. 83.9° F

BELOW OUTFALL (M. P. 54.2) About three light poles from end

Sur.	96.4	Sur.	91.0	Sur.	88.2	Sur.	88.4	Sur.	88.5
4'	90.4	4'	89.6	4'	88.2	4'	88.4	4'	88.2
8'	87.4	8'	86.0	8'	86.7	8'	88.4	8'	88.2
12'	84.2	12'	83.9	12'	84.2	12'	88.4	12'	87.8
16'	83.2	16'	82.8	16'	82.8	16'	84.2	16'	83.2
20'	82.8	20'	82.8	20'	82.4	20'	82.8	20'	82.4
24'	82.8	24'	82.8	24'	82.4	24'	82.4	24'	82.4
28'		28'	82.4	28'		28'	82.4	28'	
32'		32'		32'		32'	82.4	32'	
	[illegible]		[illegible]		84.9		85.3		[illegible]

Avg. 85.5 °F

ZONE OF MIXING (M. P. 54.7) Below Lock and Dam

Sur.	85.4	Sur.	85.0	Sur.	85.0	Sur.	84.6	Sur.	85.4
4'	85.4	4'	85.0	4'	85.0	4'	84.6	4'	85.4
8'	85.4	8'	85.0	8'	85.0	8'	84.6	8'	85.4
12'		12'	85.0	12'	85.0	12'	84.6	12'	85.4
16'		16'	85.0	16'	85.0	16'	84.6	16'	
20'		20'	85.0	20'		20'	84.6	20'	
24'		24'		24'		24'	84.6	24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	
	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]

Avg. [illegible] 85.1

DOWNSTREAM PT. NO INCREASE (M. P. ____)

Sur.		Sur.		Sur.		Sur.		Sur.	
8'		8'		8'		8'		8'	
20'		20'		20'		20'		20'	
30'		30'		30'		30'		30'	

THERMAL POLLUTION STUDIES

Ohio River, M. P. 76.5

Cardinal Power Plant

(October 3, 1968)

A. Assume: 1230 MW (Cardinal) + 222 MW (Tidd) = 1452 MW Output

Maximum efficiency = 40%

Heat loss within plant = 15%

Energy required for 1 Kwh = 3,413 BTU

Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.40} = 8,500$ BTU/Kwh heat rate

$(0.85 \times 8,500) - 3,413 = 3,837$ BTU/Kwh Heat to cooling water

$(3.84 \times 10^3 \text{ BTU/Kwh})(1.45 \times 10^6 \text{ KW}) = 5.65 \times 10^9$ BTU/Hr heat load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/hr}) = \text{lbs/Hr}$

$Q = (6.0 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 1.35 \times 10^9$ lbs/Hr

D. Theoretical Stream Temperature Rise:

$$\Delta T_r = \frac{\text{Total Heat load to Cooling Water, BTU/Hr}}{(\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb } ^\circ\text{F})}$$

$$\Delta T_r = \frac{5.65 \times 10^9}{1.35 \times 10^9} = 4.2 \ ^\circ\text{F}$$

E. Actual Field Temperature Rise:

$$\Delta T_r = (\text{Avg. Cross Sect. T, } ^\circ\text{F}) - (\text{Background Sect. T, } ^\circ\text{F})$$

$$\Delta T_r = 78.7 \ ^\circ\text{F} - 75.2 \ ^\circ\text{F} = 3.5 \ ^\circ\text{F}$$

[illegible] Parker
[illegible]

THERMAL POLLUTION STUDIES

Date 10-3-68 Location Ohio River M. P. 76.5
Flow 6,000 cfs Plant Name Cardinal
Air Temperature - Begin 68 °F Finish 71 °F Work Done By Moser, Bailey
Relative Humidity 86%
REFERENCE WATER TEMPERATURE 75.2 M. P. 75.5

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

ABOVE OUTFALL (M. P. 76.5) Between Tidd and Cardinal (Cardinal Intake)

Sur.	80.6	Sur.	81.2	Sur.	81.5	Sur.	81.7	Sur.	82.4
8'	80.6	8'	80.2	8'	79.2	8'	80.6	8'	80.6
20'	76.1	20'	75.2	20'	75.5	20'	75.2	20'	75.5
30'	75.2	30'	75.2	27'	75.2	28'	75.2	25'	75.2

AVERAGE TEMPERATURE: [illegible] F

BELOW OUTFALL (M. P. 76.7) Power Line

Sur.	86.0	Sur.	84.2	Sur.	85.7	Sur.	82.8	Sur.	82.4
4'	84.6	4'	82.4	4'	82.4	4'	81.5	4'	82.4
8'	81.5	8'	79.7	8'	80.6	8'	81.2	8'	82.4
12'	77.0	12'	77.9	12'	78.8	12'	78.4	12'	80.6
16'	75.2	16'	76.1	16'	77.0	16'	76.6	16'	76.6
20'	75.2	20'	75.3	20'	75.7	20'	75.7	20'	75.5
24'		24'	75.2	24'	75.3	24'	75.2	24'	75.2
28'		28'	75.0	28'	75.2	28'	75.2	28'	76.1
32'		32'	75.0	32'		32'		32'	

AVERAGE TEMPERATURE: 78.1 °F

ZONE OF MIXING (M. P. 77.4) (At Sand and Gravel Dock - Don Swart)

Sur.	81.5	Sur.	81.7	Sur.	82.4	Sur.	82.0	Sur.	82.0
4'	81.0	4'	81.0	4'	82.4	4'	82.4	4'	81.7
8'	79.4	8'	80.6	8'	80.6	8'	81.0	8'	82.0
12'	78.4	12'	78.8	12'	78.8	12'	78.4	12'	80.6
16'	77.4	16'	78.4	16'	77.0	16'	77.0	16'	80.2
20'	77.0	20'	77.0	20'	76.1	20'	76.2	20'	77.4
24'	76.8	24'	75.5	24'	75.7	24'	76.1	24'	
28'	76.8	28'	75.5	28'	75.5	28'	75.7	28'	
32'	76.4	32'		32'	75.5	32'		32'	
34'	75.2								

AVERAGE TEMPERATURE: 78.7 °F

DOWNSTREAM PT. NO INCREASE (M. P. 78.3) (At Red Marker Buoy) (Can)

Sur.	77.9	Sur.	77.9	Sur.	77.9	Sur.	77.9	Sur.	77.9
8'	77.5	8'	77.5	8'	77.4	8'	77.5	8'	77.2
20'	77.0	20'	77.0	20'	77.0	20'	77.0	20'	76.6
30'	77.0	30'		30'		30'		30'	75.7

Strong breeze blowing U. S. [illegible]
Overcast sky
Cardinal Plant - one stack smoke stack - lower stack smoke intermittent
Tidd Plant - two of three stacks smoking

Thermal Pollution Studies

OHIO River, M. P. 76.5

OHIO POWER CARDINAL Power Plant

SEPTEMBER 30, 1969

A. Assume: 1,452 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3{,}413 \text{ BTU}}{0.35} = 9{,}750$ BTU/KWH heat rate

$(0.85 \times 9{,}750) - 3{,}413 = 4{,}877$ BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(1.45 \times 10^6 \text{ KW}) = 7.08 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr}) = \text{lbs/Hr}$

$Q = (6.5 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 1.46 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb } ^\circ\text{F})}$

$$\Delta T_r = \frac{7.08 \times 10^9}{1.46 \times 10^9} = 4.8\ ^\circ\text{F}$$

E. Actual Field

Temperature Rise: $\Delta T_r = (\text{Avg. Cross-Sect. T, } ^\circ\text{F}) - (\text{Background T, } ^\circ\text{F})$

$$\Delta T_r = 77.1\ ^\circ\text{F} - 72.5\ ^\circ\text{F} = 4.6\ ^\circ\text{F}$$

THERMAL POLLUTION STUDIES

Date 9-30-69 Location Brilliant, Ohio
Flow 6500 cfs Plant Name Cardinal and Tidd Plants
Air Temperature - Begin- 75 °F Finish 77 °F Work Done By Lorentz & Moser
Relative Humidity 62 % Beginning Time 1200

Left Bank	Apx. Distances Between Sampling Points Middle	Right Bank

Beginning Reference Water Temperature (M.P. 74.7)

Sur.	72.5	Sur.	72.5	Sur.	72.5
Mid.	72.5	Mid.	72.5	Mid.	72.5
Bot.	72.5	Bot.	72.5	Bot.	72.5
Depth		Depth		Depth	

[illegible] 72.5°F

ABOVE OUTFALL (M.P. 76.1) At Upper Power Line

Sur.	77.0	Sur.	77.0	Sur.	78.4	Sur.	78.8	Sur.	79.2
8'	73.0	8'	73.4	8'	74.1	8'	75.2	8'	74.3
20'		20'	73.0	20'	72.6	20'	73.0	20'	72.6
30'		23' ~~BOX~~	72.5	24' ~~BOX~~	72.3	30'	72.5	30'	
	[illegible]		73.9		[illegible]		[illegible]		75.4

[illegible] 74.7°F

EVIDENCE OF THERMAL SHORT CIRCUIT? Yes

DESCRIPTION OF FINDINGS - MAGNITUDE AND TYPE Large (1 mile) loop in whole area, direct short circuit from outfall to intake of large (lower) plant. Extending U. S. to M. P. 75.1

MAXIMUM OUTFALL TEMPERATURE 87.4 Upper 89.6 Lower TIME 1240

SIZE OF MAXIMUM TEMPERATURE ZONE: 20' wide and 50' out and 8' deep

60' wide and at end of barricade and 10' deep

BELOW OUTFALL (M.P. 76.7) Lower Power Lines

Sur.	86.0	Sur.	84.2	Sur.	79.9	Sur.	80.2	Sur.	81.0
4'	82.4	4'	78.8	4'	79.2	4'	80.2	4'	81.0
8'	76.2	8'	76.2	8'	78.4	8'	80.2	8'	80.6
12'	73.4	12'	75.2	12'	75.9	12'	80.2	12'	80.2
16'	73.0	16'	73.0	16'	75.2	16'	75.2	16'	
20'	73.0	20'	73.0	20'	73.0	20'	73.0	20'	
24'		24'	73.0	24'	72.6	24'	72.6	24'	
28'		28'	72.6	28'	72.6	28'	72.6	28'	
32'		32'	72.5	32'		32'		32'	

Thermal Pollution Studies

OHIO River, M. P. 102.5

Ohio Edison, Burger Power Plant

October 4, 1968

A. Assume: 544 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

$(0.85 \times 9,750)-3,413 = 4,877$ BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(5.44 \times 10^5 \text{ KW}) = 2.65 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr}) = \text{lbs/Hr}$

$Q = (1.5 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 3.36 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb }^\circ\text{F})}$

$$\Delta T_r = \frac{2.65 \times 10^9}{3.36 \times 10^9} = 0.8\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 74.4\ ^\circ F - 72.4\ ^\circ F = 2.0\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 10-4-68 Location Ohio River M. P. 102.5 - Moundsville
Flow 15,000 cfs Plant Name Burger Plant
Air Temperature - Begin 50 °F Finish 55 °F Work Done By Bailey, Moser
Relative Humidity 56%
REFERENCE WATER TEMPERATURE 73.4 M. P. 102.2

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

ABOVE OUTFALL (M. P. 102.4) (By Intake)

Depth	Left Bank		Middle		Right Bank
Sur.	72.5	72.5	73.0	72.5	69.8
8'	73.0	73.0	73.0	72.8	71.6
20'	16' (20' struck out): 73.4	73.0	14' (20' struck out): 73.0		
30'					

AVERAGE TEMPERATURE : 72.4 °F

BELOW OUTFALL (M. P. 102.8)

Depth	Left Bank		Middle		Right Bank
Sur.	78.8	77.9	75.2	72.5	71.6
4'	77.9	74.8	73.7	72.5	71.6
8'		73.7	73.4	72.5	
12'			73.0	72.5	
16'					
20'					
24'					
28'					
32'					

AVERAGE TEMPERATURE : 74.4 °F

ZONE OF MIXING (M. P. 103.5)

Depth	Left Bank		Middle		Right Bank
Sur.	76.4	75.5	75.2	76.1	75.2
4'	76.1	74.6	75.0	75.2	75.2
8'		74.3	73.7	74.3	73.7
12'		73.7	73.0	73.7	73.7
16'			73.0	73.7	
20'			73.0		
24'			72.8		
28'					
32'					

AVERAGE TEMPERATURE : 74.4 °F

DOWNSTREAM PT. NO INCREASE (M. P. 104.0) (Tow Preceding)

Depth	Left Bank		Middle		Right Bank
Sur.	74.3		73.4		73.4
8'	73.9	73.4	73.0		73.7
20'	15' (20' struck out): 73.9				
30'					

Thermal Pollution Studies

OHIO River, M. P. 102.5

OHIO EDISON, BURGER Power Plant

OCTOBER 1, 1970

A. Assume: 544 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(5.44 x 10^5 KW) = 2.65 x 10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

Q = (6.9 x 10^3)(6.24 x 10)(3.6 x 10^3) = 1.55 x 10^9 lbs/Hr

D. Theoretical Stream

Temperature Rise: ΔT_r = $\frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{2.65 \times 10^9}{1.55 \times 10^9} = 1.7 \ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 74.8 \ ^\circ F - 71.8 \ ^\circ F = 3.0 \ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 10-1-69 Location Ohio River @ Moundsville
Flow 6900 cfs Plant Name Burger - Ohio Edison Company
Air Temperature - Begin- 60 °F Finish 73 °F Work Done By Lorentz & Moser
Relative Humidity 90 % Beginning Time 1000

Left Bank	Apx. Distances Between Sampling Points Middle	Right Bank

Beginning Reference Water Temperature (M.P. 102.0) At Ferry Ramp - Moundsville

Left		Middle		Right	
Sur.	72.3	Sur.	72.6	Sur.	71.9
Mid.	72.3	Mid.	72.6	Mid.	71.9
Bot.	72.3	Bot.	72.6	Bot.	71.9
Depth	12	Depth	16	Depth	8

ABOVE OUTFALL (M.P. 102.6)

Sur.	71.9	Sur.	72.3	Sur.	71.9	Sur.	71.9	Sur.	71.6
3'	71.9	8'	71.9	8'	71.9	8'	71.9	4'	71.6
12'	71.9	12'	71.9	12'	71.9	11'	71.9	20'	
30'		30'		30'		30'		30'	

EVIDENCE OF THERMAL SHORT CIRCUIT? No
DESCRIPTION OF FINDINGS - MAGNITUDE AND TYPE

MAXIMUM OUTFALL TEMPERATURE 89.6 TIME 1100

SIZE OF MAXIMUM TEMPERATURE ZONE: 10' wide - depth indeterminate - about 25' out from discharge

BELOW OUTFALL (M.P. 102.9)

Sur.	80.6	Sur.	78.8	Sur.	73.4	Sur.	71.9	Sur.	71.9
4'	80.2	4'	77.4	4'	73.4	4'	72.3	4'	71.9
8'		8'	74.8	8'	73.7	8'	72.3	8'	71.9
12'		12'	73.7	12'	73.4	12'	72.3	12'	
16'		16'		14'	73.0	15'	72.3	16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

Thermal Pollution Studies

OHIO River, M. P. 111.1

OHIO POWER CO KAMMER Power Plant

OCTOBER 11, 1968

A. Assume: 675 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

$(0.85 \times 9,750)-3,413 = 4,877$ BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(6.75 \times 10^5$ KW$) = 3.3 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: $Q = (\text{cfs})(62.4 \text{ lbs/ft}^3)(3600 \text{ sec/Hr})$ = lbs/Hr

$Q = (1.0 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 2.24 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr})(1 \text{ BTU/lb }^{\circ}\text{F})}$

$$\Delta T_r = \frac{3.3 \times 10^9}{2.24 \times 10^9} = 1.5 \ ^{\circ}\text{F}$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 71.0 \ ^{\circ}\text{F} - 69.9 \ ^{\circ}\text{F} = 1.1 \ ^{\circ}\text{F}$$

THERMAL POLLUTION STUDIES

Date 10-11-68 Location Ohio River @ Captina Creek - M. P. 111.1
Flow 10,[illegible]00 cfs Plant Name Kammer Plant
Air Temperature - Begin 51 °F Finish 55 °F Work Done By Jones, Moser
Relative Humidity 80%
REFERENCE WATER TEMPERATURE 70.7 M. P. 109.6

Left Bank		Apx. Distances Between Sampling Points Middle		Right Bank

ABOVE OUTFALL (M. P. 110.7) (2 Stacks

Depth					
Sur.	69.8	69.8	69.8	69.8	69.8
8'	69.8	69.8	70.1	69.8	70.1
20'	69.8	69.8	70.1	70.1	
30'					

AVERAGE TEMPERATURE : 69.9 °F

BELOW OUTFALL (M. P. 111.2) Mile Mark

Depth					
Sur.	70.1	70.1	70.1	73.7	74.3
4'	70.1	70.1	70.1	73.4	74.3
8'	70.1	70.1	70.1	71.6	74.3
12'	70.1	70.1	70.1	71.2	
16'		70.1	70.1	70.7	
20'		70.1	70.1	70.1	
24'		70.1	70.1		
28'			70.1		
32'					

AVERAGE TEMPERATURE : 70.9 °F

ZONE OF MIXING (M. P. 111.4) Below Upper Hi Wire 111.4 M. P.

Depth					
Sur.	70.3	71.2	72.6	73.4	73.4
4'	70.1	71.2	71.9	71.9	71.6
8'	70.1	71.2	71.2	70.8	70.1
12'	70.1	70.1	70.7	70.3	70.1
16'	70.1	70.1	70.1	70.1	69.8
20'		70.1	70.1	70.1	
24'		69.8	70.1	70.1	
28'					
32'					

AVERAGE TEMPERATURE : 70.7 °F

DOWNSTREAM PT. NO INCREASE (M. P. 111.8) By Creek in Power

Depth					
Sur.	71.5	71.6	71.6	70.7	69.8
8'	71.6	71.6	71.6	70.1	69.8
20'		71.6	71.6	70.1	
30'					

Thermal Pollution Studies

OHIO River, M. P. 161.5

MON. POWER - WILLOW ISL. Power Plant

OCT 4, 1969

A. Assume: 215 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3{,}413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(2.15 \times 10^5$ KW$) = 1.05 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (10.1 \times 10^3)(6.24 \times 10)(3.6 \times 10^3) = 2.27 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{1.05 \times 10^9}{2.27 \times 10^9} = 0.5\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 84.0\ ^\circ F - 82.8\ ^\circ F = 1.2\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 8-4-69 Location Ohio River @ Willow Island
Flow [illegible] cfs Plant Name
Air Temperature - Begin ____ °F Finish ____ °F Work Done By Bailey & Moser

REFERENCE WATER TEMPERATURE 82.8° F M. P. 158.1
Relative Humidity 50%

Left Bank		Apx. Distances Between Sampling Points		Middle				Right Bank	

* ABOVE OUTFALL (M. P. 160.6) At intake structure

Sur.	82.8	Sur.	82.8	Sur.	82.8	Sur.	82.8	Sur.	82.8
8'	82.8	8'	82.8	8'	82.8	8'	82.8	8'	82.8
20'		13' ~~20'~~	82.8	13' ~~20'~~	82.8	15' ~~20'~~	82.8	20'	
30'		30'		30'		30'		30'	

BELOW OUTFALL (M. P. 160.7) 28.5 from tow except 16' = 28.2

Sur.	82.8	Sur.	82.8	Sur.	86.0	Sur.	86.0	Sur.	84.6
4'	82.8	4'	82.8	4'	84.6	4'	84.2	4'	84.2
8'	82.8	8'	82.8	8'	84.2	8'	84.2	8'	83.9
12'	82.8	12'	82.8	12'	83.9	12'	83.5	12'	83.4
16'		16'	82.8	16'	83.9	16'	83.4	16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

ZONE OF MIXING (M. P. 161.0)

Sur.	84.6	Sur.	85.4	Sur.	86.0	Sur.	84.6	Sur.	83.9
4'	83.9	4'	83.9	4'	83.9	4'	84.2	4'	83.9
8'	83.5	8'	83.5	8'	83.9	8'	83.9	8'	
12'	83.5	12'	83.5	12'	83.9	12'		12'	
16'		16'	83.5	16'		16'		16'	
20'		20'		20'		20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

DOWNSTREAM PT. NO INCREASE (M. P. 161.6)

Sur.	83.9	Sur.	83.2	Sur.	83.2	Sur.	82.8	Sur.	83.9
8'	83.5	8'	83.2	8'	82.8	8'	82.8	8'	83.9
12' ~~20'~~	83.5	16' ~~20'~~	82.8	12' ~~20'~~	82.8	20'		20'	
30'		30'		30'		30'		30'	

* [illegible] for thermal short circuiting. no evidence of such for this flow [illegible] at plant.

Thermal Pollution Studies

OHIO River, M. P. 241.6

PHILLIP SPORN Power Plant

OCTOBER 10, 1968

A. Assume: 1060 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3 \text{ BTU/KWH})(1.06 \times 10^6 \text{ KW}) = 5.18 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (1.18 \times 10^5)(6.24 \times 10)(3.6 \times 10^3) = 2.65 \times 10^{10}$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{5.18 \times 10^9}{2.65 \times 10^9} = 2.0\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 69.7\ ^\circ F - 67.2\ ^\circ F = 2.5\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 10-10-68 **Location** Ohio River [illegible] M. P. 241.6
Flow 11,600 **cfs** Plant Name Phillip [illegible]
Air Temperature - **Begin** 61 °F Finish [illegible] °F Work Done By [illegible]
Relative Humidity [illegible]
REFERENCE WATER **TEMPERATURE** 67.4 M. P. [illegible]

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

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ABOVE OUTFALL (M. P. 241.5 **)** Top Intake

Depth	Left Bank		Middle		Right Bank
Sur.	67.1	67.1	67.1	67.1	67.1
8'	67.6	67.1	67.4	67.4	67.1
20'		67.6	67.1	67.6	67.1
30'					

AVERAGE TEMPERATURE : 67.2

BELOW OUTFALL (M. P. 242.1 **)** Hi Wire Crossing

Depth	Left Bank		Middle		Right Bank
Sur.	72.5	73.0	71.6	70.3	70.3
4'	72.8	71.6	68.0	68.0	68.0
8'	72.5	69.8	68.0	68.0	68.0
12'		68.5	68.0	68.0	
16'		68.0	68.0		
20'		68.0			
24'					
28'					
32'					

AVERAGE TEMPERATURE : 69.6

ZONE OF MIXING (M. P. 242.3 **)** Coal Tipple

Depth	Left Bank		Middle		Right Bank
Sur.	71.2	76.1	77.9	73.4	73.7
4'	70.7	69.8	68.9	68.0	68.3
8'		69.2	68.0	68.0	68.0
12'		69.2	68.0	68.0	68.0
16'		68.9	68.0	68.0	
20'			68.0	68.0	
24'			68.0		
28'					
32'					

AVERAGE TEMPERATURE : 69.7 °F

DOWNSTREAM PT. NO INCREASE (M. P. 242.5 **)**

Depth	Left Bank		Middle		Right Bank
Sur.	71.6	71.6	71.7	70.3	70.7
8'	68.0	68.0	68.0	68.0	68.0
20'	68.0	68.0	68.0	68.0	68.0
30'					

Barges Anchored in path of effluent, affecting flow.

AVERAGE TEMPERATURE : [illegible]

Thermal Pollution Studies

OHIO River, M. P. 246

PHILLIP SPORN Power Plant

JUNE 26, 1969

A. Assume: 1060 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

(4.88×10^3 BTU/KWH)(1.06×10^6 KW) = 5.18×10^9 BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

Q = (3.15×10^4)(6.24×10)(3.6×10^3) = 7.09×10^9 lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{5.18 \times 10^9}{7.09 \times 10^9} = 0.8\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 80.5\ ^\circ F - 79.2\ ^\circ F = 1.3\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 6-26-69 Location Phillip Sporn Power Plant, Ohio River
Flow 31,500 cfs Plant Name
Air Temperature - Begin 90 °F Finish 95 °F Work Done By Moser - Bedway
Relative Humidity - 60%
REFERENCE WATER TEMPERATURE 79.4° F M. P.

Left Bank — Apx. Distances Between Sampling Points — Middle 1200' wide — Right Bank

Correct all depths by 0.9 (strong current)

ABOVE OUTFALL (M. P. 241.5)

Left Bank				Middle				Right Bank	
Sur.	80.6	Sur.	79.5	Sur.	79.2	Sur.	79.2	Sur.	79.2
8'	79.5	8'	79.5	8'	79.2	8'	78.8	8'	78.8
12' (20' struck)	79.5	20'	79.5	20'	78.8	20'	78.8	20'	78.8
30'		30'	79.2	28' (30' struck)	78.8	28' (30' struck)	78.8	30'	

[illegible] 79.2 [illegible]

BELOW OUTFALL (M. P. 242)

Left Bank				Middle				Right Bank	
Sur.	80.6	Sur.	80.2	Sur.	80.2	Sur.	86.0	Sur.	86.0
4'	80.6	4'	79.9	4'	79.9	4'	82.8	4'	83.5
8'	80.2	8'	79.5	8'	79.5	8'	81.0	8'	80.2
12'		12'	79.5	12'	79.5	12'	80.2	12'	79.9
16'		16'	79.5	16'	79.2	16'	79.2	16'	
20'		20'	79.5	20'	79.2	20'	75.5	20'	
24'		24'	79.5	24'	79.2	24'	79.2	24'	
28'		28'		28'	79.2	28'		28'	
32'		32'		32'		32'		32'	

[illegible] 85.5 [illegible]

ZONE OF MIXING (M. P. 242.1) Power Line

Left Bank				Middle				Right Bank	
Sur.	80.2	Sur.	79.9	Sur.	85.4	Sur.	84.2	Sur.	81.0
4'	79.9	4'	79.5	4'	80.6	4'	81.0	4'	80.6
8'	79.9	8'	79.2	8'	79.9	8'	79.5	8'	79.2
9' (12' struck)		12'	79.2	12'	79.5	12'	79.5	10' (12' struck)	79.2
16'		16'	79.2	16'	79.2	16'	79.2	16'	
20'		20'		20'	79.2	20'		20'	
24'		24'		24'	79.2	24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

[illegible]

DOWNSTREAM PT. NO INCREASE (M. P. 243.0)

Left Bank				Middle				Right Bank	
Sur.	81.7	Sur.	81.7	Sur.	81.7	Sur.	81.4	Sur.	81.7
8'	80.6	8'	80.2	8'	80.2	8'	79.9	8'	79.9
20'	80.6	20'	80.2	20'	80.2	20'	79.9	15' (20' struck)	79.5
30'		30'		30'		30'		30'	

Thermal Pollution Studies

OHIO River, M. P. 261.6

PHILLIP SPORN Power Plant

AUGUST 8, 1970

A. Assume: 1060 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(1.06 \times 10^6$ KW$) = 5.18 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (2.2 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 4.94 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb °F)}}$

$$\Delta T_r = \frac{5.18 \times 10^9}{4.94 \times 10^9} = 1.1\ ^\circ F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, °F)-(Background T, °F)

$$\Delta T_r = 82.8\ ^\circ F - 80.6\ ^\circ F = 2.2\ ^\circ F$$

THERMAL POLLUTION STUDIES

Date 6-8-59 Location Ohio River at New Haven
Flow 22.500 cfs Plant Name Philip Sporn
Air Temperature - Begin 74 °F Finish ____ °F Work Done By Petrone, Moser
Relative Humidity 84%
REFERENCE WATER TEMPERATURE 80.6° F M. P. 241.0

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

ABOVE OUTFALL (M. P. 241.6)

Sur.	80.6	Sur.	80.6	Sur.	80.6	Sur.	80.6	Sur.	80.6
8'	80.6	8'	80.6	8'	80.6	8'	80.6	8'	80.5
20'		22' ~~20'~~	80.6	20'	80.6	20'	80.6	16' ~~20'~~	80.6
30'		30'		24' ~~30'~~	80.6	24' ~~30'~~	80.5	30'	

AVG. TEMP. 80.[illegible] °F

BELOW OUTFALL (M. P. 241.7) By upper loading dock

Sur.	80.6	Sur.	80.6	Sur.	85.7	Sur.	87.4	Sur.	87.8
4'	80.6	4'	80.6	4'	83.9	4'	83.5	4'	86.0
8'		8'	80.6	8'	82.4	8'	81.4	8'	82.4
12'		12'	80.6	12'	80.6	12'	80.6	12'	81.4
16'		16'	80.6	16'	80.6	18' ~~16'~~	80.6	16'	81.0
20'		20'	80.6	20'	80.6	20'		20'	
24'		24'	80.6	24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVG. TEMP. 81.9 °F

ZONE OF MIXING (M. P. 242.5)

Fill

Sur.	83.9	Sur.	85.7	Sur.	85.4	Sur.	85.0	Sur.	84.2
4'	82.4	4'	84.6	4'	84.6	4'	84.6	4'	82.4
8'		8'	82.8	8'	82.4	8'	81.4	8'	82.4
12'		12'	81.0	12'	81.0	12'	81.0	12'	
16'		16'	81.0	16'	80.6	16'	80.6	16'	
20'		20'		20'	80.6	20'		20'	
24'		24'		24'		24'		24'	
28'		28'		28'		28'		28'	
32'		32'		32'		32'		32'	

AVG. TEMP. 82.8 °F

DOWNSTREAM PT. NO INCREASE (M. P. 243.3)

Sur.	82.4	Sur.	82.4	Sur.	83.9	Sur.	83.9	Sur.	82.4
8'	81.7	8'	82.0	8'	82.4	8'	82.0	8'	82.0
20'		12' ~~20'~~	81.7	20'	81.7	20'	81.7	12' ~~20'~~	82.0
30'		30'		30'		30'		30'	

No evidence of thermal short circuiting at this flow and power loading.

Thermal Pollution Studies

OHIO River, M. P. 260

KYGER CREEK Power Plant

OCTOBER 9, 1968

A. Assume: 1086 MW rated capacity

Maximum efficiency = 35%
Heat loss within plant = 15%
Energy required for 1 KWH = 3,413 BTU
Adequate mixing of effluent

B. Heat Load: $\frac{3,413 \text{ BTU}}{0.35}$ = 9,750 BTU/KWH heat rate

(0.85 x 9,750)-3,413 = 4,877 BTU/KWH Heat to Cooling Water

$(4.88 \times 10^3$ BTU/KWH$)(1086 \times 10^6$ KW$) = 5.3 \times 10^9$ BTU/Hr Heat Load

C. Stream Quantity: Q = (cfs)(62.4 lbs/ft^3)(3600 sec/Hr) = lbs/Hr

$Q = (1.24 \times 10^4)(6.24 \times 10)(3.6 \times 10^3) = 2.78 \times 10^9$ lbs/Hr

D. Theoretical Stream

Temperature Rise: $\Delta T_r = \frac{\text{Total Heat Load to Cooling Water, BTU/Hr}}{\text{Stream quantity, lbs/Hr)(1 BTU/lb }^{o}\text{F)}}$

$$\Delta T_r = \frac{5.3 \times 10^9}{2.78 \times 10^9} = 1.9\ ^{o}F$$

E. Actual Field

Temperature Rise: ΔT_r = (Avg. Cross-Sect. T, ^{o}F)-(Background T, ^{o}F)

$$\Delta T_r = 72.0\ ^{o}F - 68.7\ ^{o}F = 3.3\ ^{o}F$$

THERMAL POLLUTION STUDIES

Date 10-9-68 **Location** Kyger Creek Plant - Ohio River - M. P. 260
Flow 12,400 **cfs** **Plant Name** Kyger Creek Plant
Air Temperature - **Begin** 64 °F Finish 62 °F Work Done By ______
Relative Humidity 62%
REFERENCE WATER TEMPERATURE 68.7 M. P. 259.0

Left Bank — Apx. Distances Between Sampling Points — Middle — Right Bank

ABOVE OUTFALL (M. P. 259.7) Top Unloader

Depth	Left Bank		Middle		Right Bank
Sur.	68.9	68.9	69.4	69.8	69.8
8'	68.5	68.5	68.9	69.0	69.8
20'	68.0	68.0	68.0	68.3	69.8
30'	68.0	68.0	68.0	68.0	

AVERAGE TEMPERATURE: 68.7 °F

BELOW OUTFALL (M. P. 260.5) Power Lines - top of old Lock and Dam

Depth	Left Bank		Middle		Right Bank
Sur.	73.4	75.2	73.4	71.2	71.6
4'	73.0	71.6	71.6	71.2	71.6
8'	71.6	70.7	70.7	71.2	71.6
12'	69.8	70.1	70.1	71.2	71.6
16'		69.8	69.4	71.2	71.6
20'		69.4	68.9	68.9	71.2
24'		68.9	68.9	68.3	69.8
28'				68.3	
32'					

AVERAGE TEMPERATURE: 70.[illegible] °F

ZONE OF MIXING (M. P. 261.0)

Depth	Left Bank		Middle		Right Bank
Sur.	73.4	73.4	73.4	73.0	73.7
4'	73.0	72.5	71.9	72.5	72.0
8'	72.5	71.9	71.6	71.9	71.6
12'		71.2	71.2	71.6	71.6
16'		70.7	70.7	69.8	69.8
20'		70.1	70.3	69.8	
24'		69.9	70.1	69.4	
28'			69.8	68.3	
32'				68.3	

AVERAGE TEMPERATURE: 71.[illegible] °F

DOWNSTREAM PT. NO INCREASE (M. P. 261.5)

Depth	Left Bank		Middle		Right Bank
Sur.	73.7	73.5	73.4	73.2	73.0
8'	72.8	72.8	72.5	72.5	72.5
20'	69.8	69.3	69.8	69.8	71.6
30'					