A Final Report Submitted to The National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Alabama

By

Alabama A. & M. University
Normal, Alabama 35762

Investigation of Water Quality Parameters At Selected Points On The Tennessee River

NASA Grant No. NGR 01-001-018

PERIOD OF RESEARCH: June 1, 1972 to September 1, 1973

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Grant Number NGR 01-001-018

Name of Grantee/Organization Alabama A. and M. University

1. Final Cumulative Cost Expenditure Report

a.	Total Funds Awarded	$ 19,690.00
b.	Total Expenditures	$ 19,690.00
c.	Unexpended Balance of Funds (a minus b)	$ 0.00
d.	Cash Received (Per 1031's or Letter of Credit)	$ 19,690.00
e.	Total Expenditures (same as b above)	$ 19,690.00
f.	Excess Funds (d minus e)	* $ 0.00

*A check in the amount of the excess funds shall be made payable to the Treasurer of the United States and submitted to NASA Headquarters Contracts Division, DHC-2, Washington, DC 20546.

2. Certifications

By the signature below I certify the following to be true:
(a) That all expenditures reported or payments received were for appropriate purposes and in accordance with the agreements set forth in the application and award documents; and that all classified material under this grant if any, was reported to the grants officer and disposed of in accordance with his instructions; and that any individual items of equipment, or coherent systems, costing more $1,000.00 were reported to the grants officer; and that any government furnished property has been disposed of in accordance with the instructions of the grants officer and is so indicated on the attached final NASA Form 1018.** (Negative Reports are Required); and that no inventions of the type specified in the grant provisions have been made in the performance of the work accomplished under this grant.
If such inventions were made under this grant, a report in accordance with the NASA Provisions of this grant, was made [illegible] (Date).

Date: March 18, 1974

Signed [signature]

Typed Leander Patton
Authorized Business Representative
& Certifying Officer

**Attach Final NASA Form 1018 or Negative Report

EQUIPMENT:

Hewlett-Packard Quarty thermometer is presently being used on NASA Grant NGR - 01-001-025 in further water quality studies on the Tennessee River.

Hewlett-Packard Quarty thermometer
Serial No 1239A00684

ABSTRACT:

Physical, chemical, and biological water quality parameters have been investigated at the Widow's Creek Steam Plant. The water quality parameters and field site locations have been selected so as to be compatable with the interests and needs of the Environmental Application Office at Marshall Space Flight Center. All sampling and testing was conducted as directed in the 13th Edition of Standard Methods of Analysis for Water and Waste Water or as suggested by NASA'S Technical Officer. Data is presented in a form compatible with that presently being collected by other agencies.

DISCUSSION:

Sampling stations were established at 24 sites located on traverses across the Tennessee River; and one site (13A) was located in the effluent basin used for both power generating facilities at Widows Creek. Sampling stations were located with respect to landmarks - power lines, buildings, ballards etc. - water intakes, and outfalls. Figure 1 shows the location of the sampling sites and their relation to major landmarks. For example station 13 corresponds to the ballard marked 13, located at the mouth of the effluent bay, and station 13A is located in the effluent basin.

Initial water sampling was carried out at all 24 stations. Additional sampling was conducted at several points within the effluent basin and at several "feeder" streams located a short distance past the last transverse. Analysis of these samples indicated no significant difference existing in the main body of the river where the current is approximately five knots or more and mixing occurs. Therefore, we felt three sampling stations on the main body of the river would be adequate for extensive analysis in the laboratory. These stations were chosen because they are representative of the areas of the river which are not effected by the effluent, which make up the plant's intake, and which are effected by the plant's effluent. Station 2 is representative of the river before it is effect by the plant; station 9 is representative of the intake water; and station 22 is representative of the water which receives effluent from the plant. A fourth sampling site, station 13A, is taken within the outfall bay and is representative of the plant effluent.

Temperature profiles of the river were made with measurements of one meter intervals at all 25 stations.

The temperature at one meter intervals was gathered and recorded by a thermocouple recorder provided by NASA. The recorder's accuracy was checked by a Hewitt-Packard, quartz crystal thermometer, temperature probe purchased for the project and found to be accurate within $0.5^{o}F$.

These individual profiles, when accumulated, can give a three dimensional temperature profile of the entire river area. In addition, false color photographs of the area, provided by NASA, show a clear line of demarkation between the warmer water, which is the result of the plant effluent, and the consistently colder water of the main body of the river. Occasionaly this line of demarkation is visable to the naked eye. This physical occurance is graphically illustrated in Figure 1A.

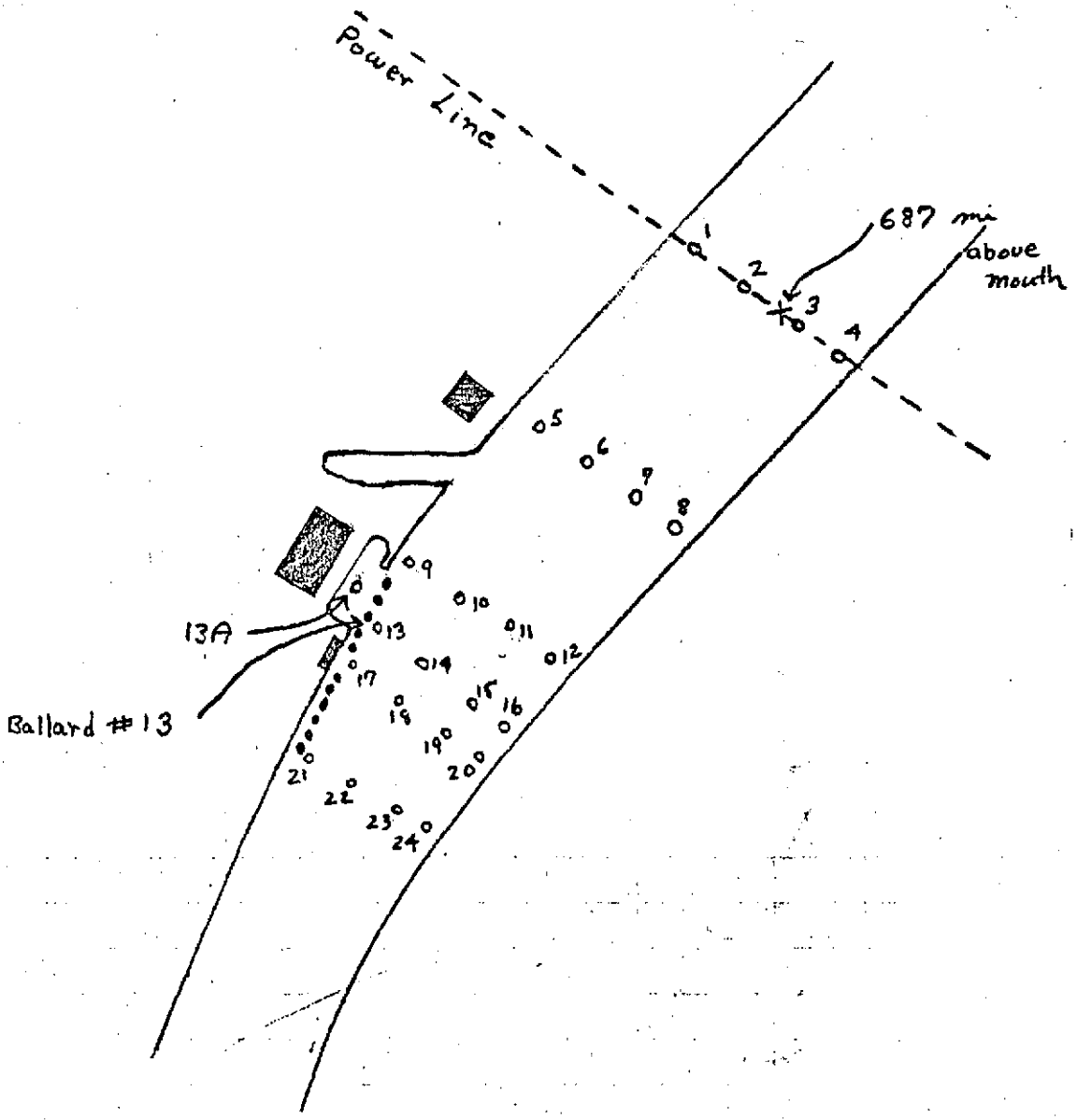
A most interesting phenomena is observed in Figure 2, showing a representative temperature profile at station 17. Temperature differentials of $10^{o}F$ were found to be common at this station; while temperature differentials between the effluent bay and the average river temperature of $22.5^{o}F$ have been observed. The warmer body of water follows a channel along the west bank of the river and is dispersed in the river within a mile of the outfall. Beyond this point, the river temperature appears to be unaltered.

Tables 5 through 8 show the important river parameters of temperature, dissolved oxygen, pH, and specific conductance for sampling sites 2, 9, BA 22. This data is displayed with the date it was taken.

Completing the data is a section of temperature profiles of the river.

Table 1 through 4 show several of the water quality parameters of stations 2, 9, 13A, and 22 respectively. Figure 3 through 6 representing the above stated stations respectively, show the inverse relationship between dissolved oxygen (D.O.) and temperature is apparent while the pH values vary only slightly. Other parameters such as Biochemical Oxygen Demand (B.O.D.) and Chemical Oxygen Demand (C.O.D.'s were found to vary from 50 ppm to 260 ppm over the ten month period; and C.O.D.'s ranged from about 50 ppm to 300 ppm. Total hardness values were found to be in the range of 100 ppm to 140 ppm and silica in the range of 3 ppm to 4 ppm. Phosphates and nitrates were found to be present in unmeasurable trace amounts.

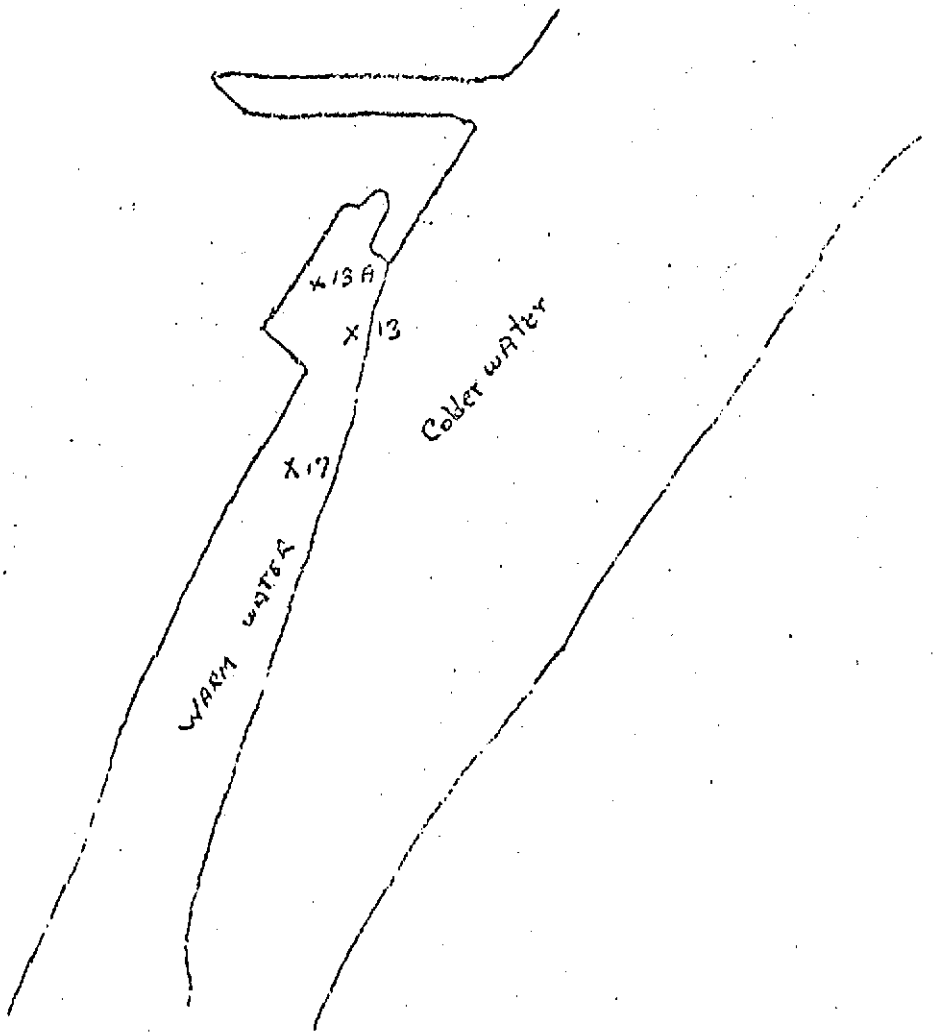
We tried to maintain a schedule of sampling and recording every Tuesday. However, due to mechanical problems with the boat, our weekly schedule was often interrupted and occasionally cancelled. Also on various dates, high water, high winds, and rapid currents hampered both water sampling and temperature recording. Therefore the realization of a completely consistent program was thwarted.



Sampling Sites at Widows Creek Steam Plant

Figure 1

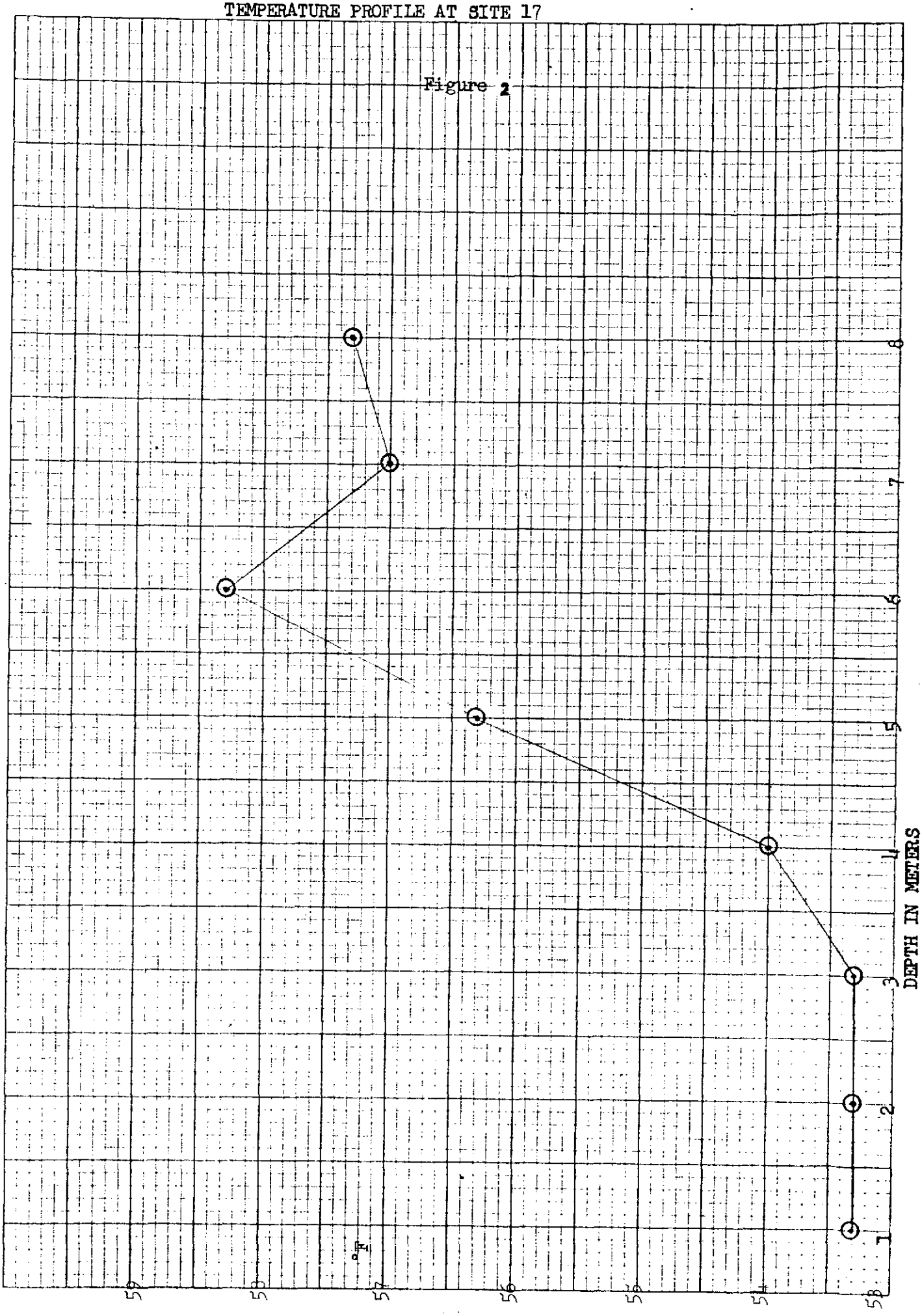
Figure 1A



12-280

TEMPERATURE PROFILE AT SITE 17

Figure 2



DATA:

Table 1

ANALYSIS OF TYPICAL WATER FROM

Site # 2

Constituent or Property	Units	ppm
Specific Conductane	1500 Moh	
pH	6.6	
Color	40	
Turbidity		67
Dissolved Solids		114
Silica		3.7
Iron		0.33
Calcium		37
Magnesium		3
Sodium		2.0
Potassium		0.4
Oil and Grease		Trace
Sulfate		5.6
Chloride		3.8
Floride		Trace
Nitrate		Trace
Phosphate		Trace
B. O. D.		1.0 ppm
C. O. D.		13.2ppm
Alkalinity		2.7 ppm
Total Hardness (as Ca-Mg Hardness)		120 ppm

TABLE 2

ANALYSIS OF TYPICAL FROM

SITE #9

Constituent or Property	Units	ppm
Specific conductane	2600 md	
pH	6.8	
Color	20	
Turbidity		50
Dissolved solids		110
Silica		3.0
Iron		0.33
Calcium		25
Magnesium		2.8
Sodium		3.2
Potassium		Trace
Oil and grease		.011
Sulfate		6.8
Chloride		4.3
Floride		Trace
Nitrate		Trace
Phosphate		Trace
B. O. D		.95
C. O. D		36.8
Alkalinity		43.5
Total hardness (As Ca-Mg hardness)		135

TABLE 3

ANALYSIS OF TYPICAL WATER FROM

SITE # 13A

Constituent or Property	Units	ppm
Specific conductance	1415 moh	
pH	616	
Color	35	
Turbidity		42
Dissolved solids		123
Silica		3.5
Iron		3.2
Calcium		3.6
Magnesium		3
Sodium		.4
Potassium		.2
Oil and grease		Trace
Sulfate		Trace
Chloride		Trace
Floride		Trace
Nitrate		Trace
Phosphate		Trace
B. O. D		.87
C. O. D		27.8
Alkalinity		5.75
Total hardness (As Ca-Mg hardness)		140

TABLE 4

ANALYSIS OF TYPICAL WATER FROM

SITE # 22

Constituent or Property	Units	ppm
Specific conductance	1500 moh	
pH	6.6	
Color	35	
Turbidity		27
Dissolved solids		122
Silica		3.4
Iron		3.3
Calcium		3.3
Magnesium		-
Sodium		3
Potassium		6
Oil and grease		Trace
Sulfate		3.0
Chloride		2.3
Floride		Trace
Nitrate		Trace
Phosphate		Trace
B. O. D		.82
C. O. D		32.5
Alkalinity		5.4
Total hardness (As Ca-Mg hardness)		133

TABLE FIVE
Data From Station 2

Date	Temp. (^{o}F)	D.O. (ppm)	pH	Sp. Cond (mhos)
10-17-72	69.8	4.0	6.7	$1.4x10^3$
11-7-72	60.8	5.4	6.2	$1.3x10^3$
11-14-72	58.0	9.2	6.7	$1.4x10^3$
11-21-72	53.8	9.3	6.7	$1.1x10^3$
11-28-72	51.5	10.0	6.5	$1.4x10^3$
12-5-72	50.5	10.2	6.7	$1.1x10^3$
12-12-72	47.5	10.4	6.4	$1.1x10^3$
12-19-72	49.0	10.6	7.3	$1.2x10^3$
1-11-73	41.5	10.6	7.3	$1.9x10^3$
1-23-73	44.5	-	6.5	$1.4x10^3$
1-30-73	43.4	10.2	6.5	$1.4x10^3$
2-21-73	41.3	-	-	$1.05x10^3$
2-26-73	44.4	10.4	6.6	-
3-28-73	53.5	11.7	6.9	-
4-2-73	54.1	10.2	6.6	$1.5x10^3$
4-10-73	58.3	10.2	7.4	-
4-26-73	61.0	9.7	7.7	-
5-2-73	60.3	9.5	-	$8.0x10^2$
5-8-73	61.5	10.0	6.9	$1.22x10^3$

TABLE SIX
Data From Station 9

Date	Temp (°F)	D.O. (ppm)	pH	Sp. Cond(mhos)
10-3-72	51.7	10.0	6.8	2.64×10^3
10-17-72	69.5	5.8	6.05	1.1×10^3
11-7-72	60.2	9.6	7.4	1.16×10^3
11-14-72	57.5	-	-	-
11-21-72	54.4	10.0	6.3	1.28×10^3
11-28-72	51.4	10.4	6.0	1.4×10^3
12-5-72	51.4	10.2	6.6	1.16×10^3
12-12-72	48.3	10.0	6.4	1.25×10^3
12-19-72	48.3	-	-	-
1-11-73	44.1	-	-	-
1-18-73	43.2	-	-	-
1-23-73	46.5	-	-	-
1-30-73	43.6	10.6	6.5	1.44×10^3
2-26-73	45.0	10.4	6.5	1.42×10^3
3-28-73	54.0	11.0	6.9	-
4-2-73	54.5	10.2	6.6	1.56×10^3
4-10-73	57.8	10.2	7.7	-
4-26-73	61.0	9.5	7.6	-
5-2-73	67.7	9.7	7.0	6.48×10^2
5-8-73	61.0	9.6	7.2	1.2×10^3

TABLE SEVEN
Data From Station 13A

Date	Temp (°F)	D.O.(ppm)	pH	Sp. Cond (mhos)
10-10-72	652	7.9	6.3	2.1×10^3
11-7-72	60.6	9.8	6.4	1.23×10^3
11-14-72*				
12-21-72	64.2	9.0	6.5	1.23×10^3
12-19-72*				
1-11-73*				
1-18-73	54.2	-	-	-
1-23-73	54.4	10.6	6.4	1.2×10^3
1-30-73	51.2	11.2	6.5	1.46×10^3
2-21-73	52.6	-	-	1.5×10^3
2-26-73	53.5	-	-	-
3-28-73	66.0	10.8	7.0	1.25×10^3
4-2-73	62.5	10.2	6.6	1.4×10^3
4-10-73	63.0	11.0	7.7	-
4-26-73	72.0	9.8	7.6	-
5-2-73	70.2	9.6	7.2	5.4×10^2
5-8-73	64.7	9.8	7.2	1.48×10^3

*Data not taken due to weather conditions

TABLE EIGHT
Data From Station 22

Date	Temp (°F)	D.O. (ppm)	pH	Sp. Cond (mhos)
10-17-72	71.0	9.1	7.1	2.0×10^3
11-7-72	61.0	-	-	-
11-14-72*				
11-21-72	54.2	9.1	6.4	1.1×10^3
11-28-72	51.6	10.3	6.45	1.36×10^3
12-12-72	49.5	10.4	6.7	1.2×10^3
12-19-72*				
1-11-73*				
1-18-73	44.5	-	-	-
1-23-73	45.0	-	6.2	1.54×10^3
1-30-73	44.1	10.6	6.2	-
2-21-73	44.1	11.2	6.7	1.35×10^3
2-26-73	49.4	10.4	6.7	-
3-28-73	57.0	9.1	7.0	1.4×10^3
4-2-73	54.7	10.2	6.6	1.5×10^3
4-10-73	58.6	10.2	7.6	-
4-26-73	59.9	9.4	7.4	-
5-2-73	61.5	10.4	7.5	5.7×10^2
5-8-73	61.5	9.4	7.2	1.04×10^3

*Data not taken due to weather conditions

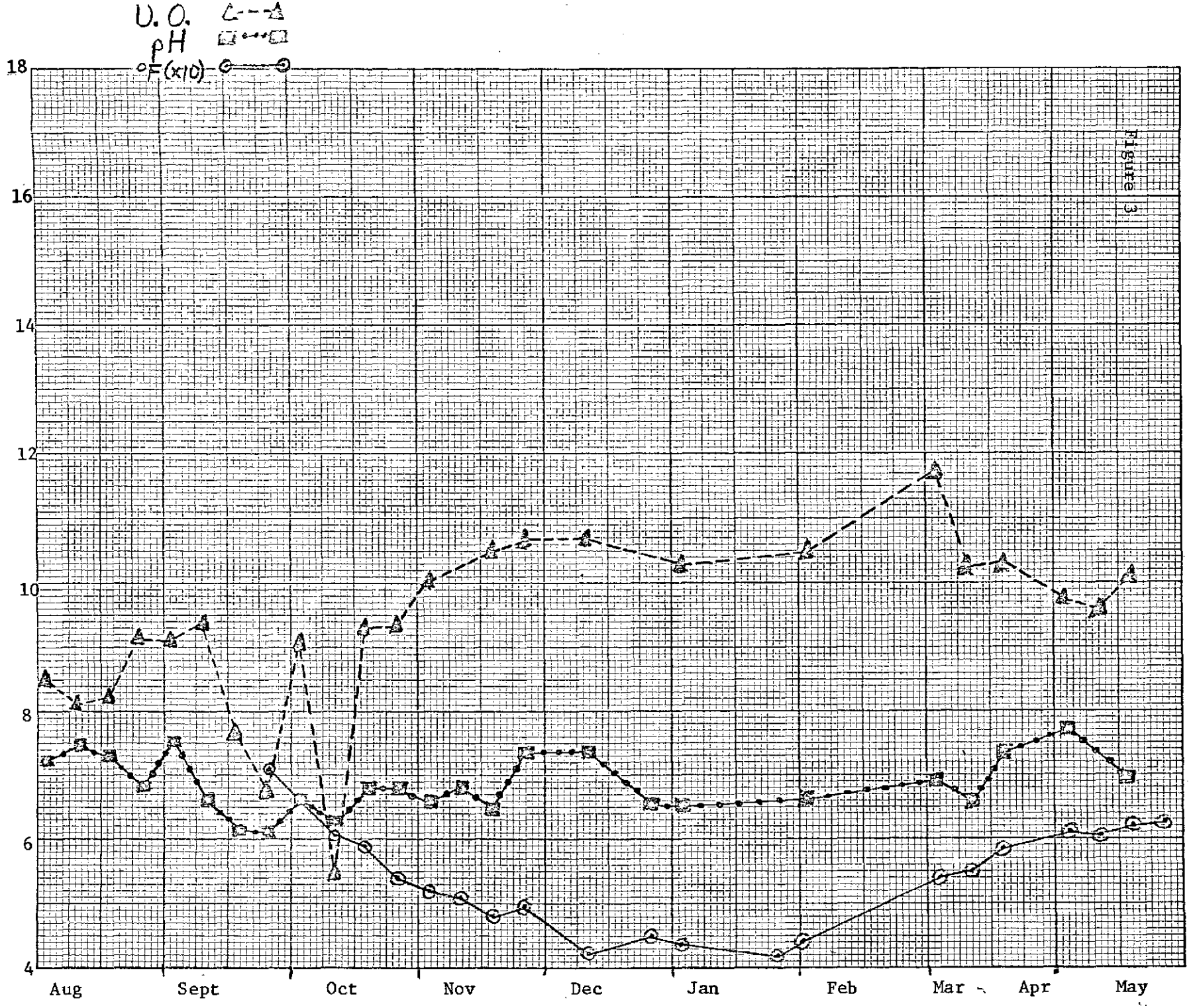

U. O.
pH
°F(x10)
18
16
14
12
10
8
6
4
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May

Figure 3

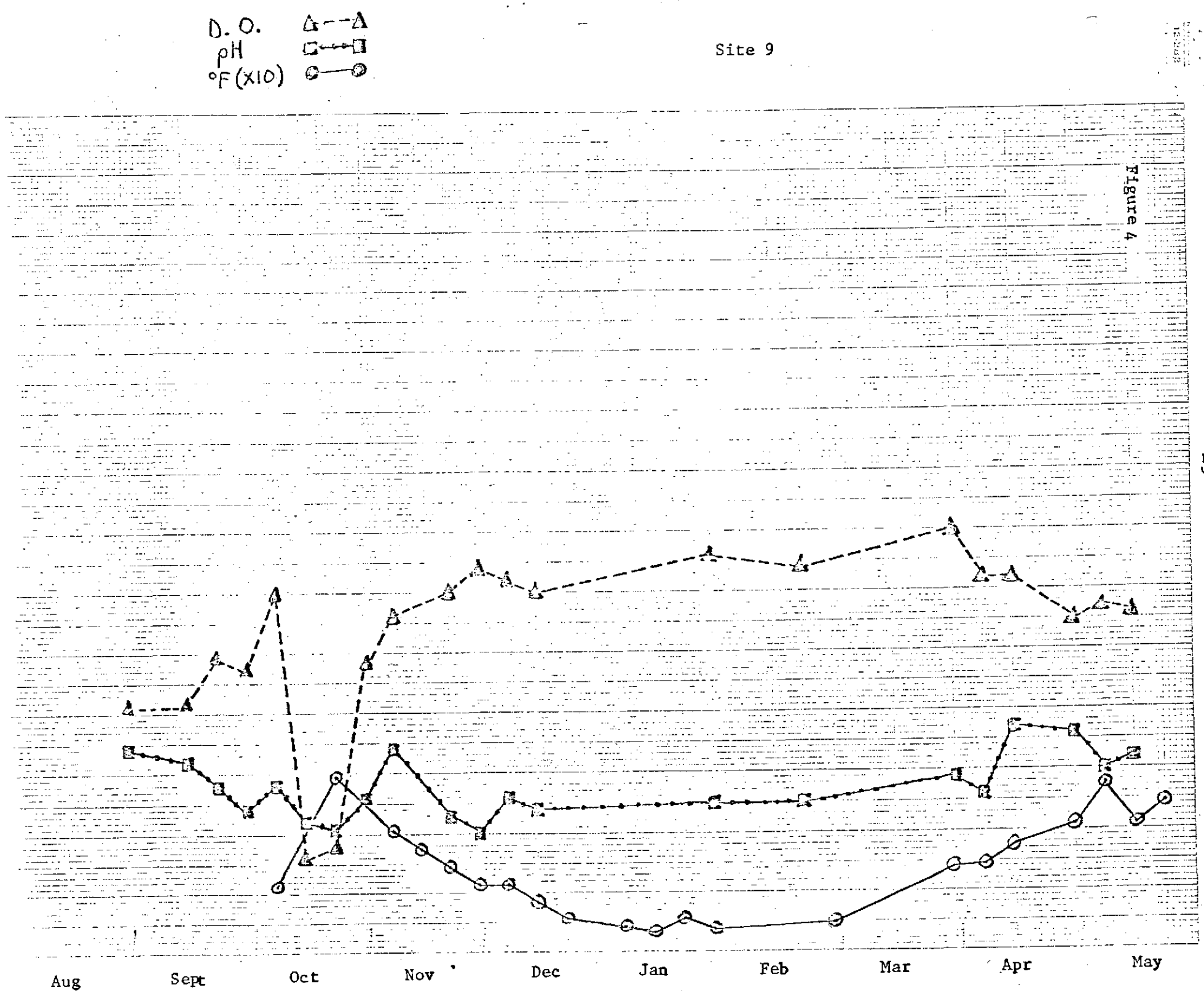


Figure 4

D.O.
pH
°F (x10)

Site 13A

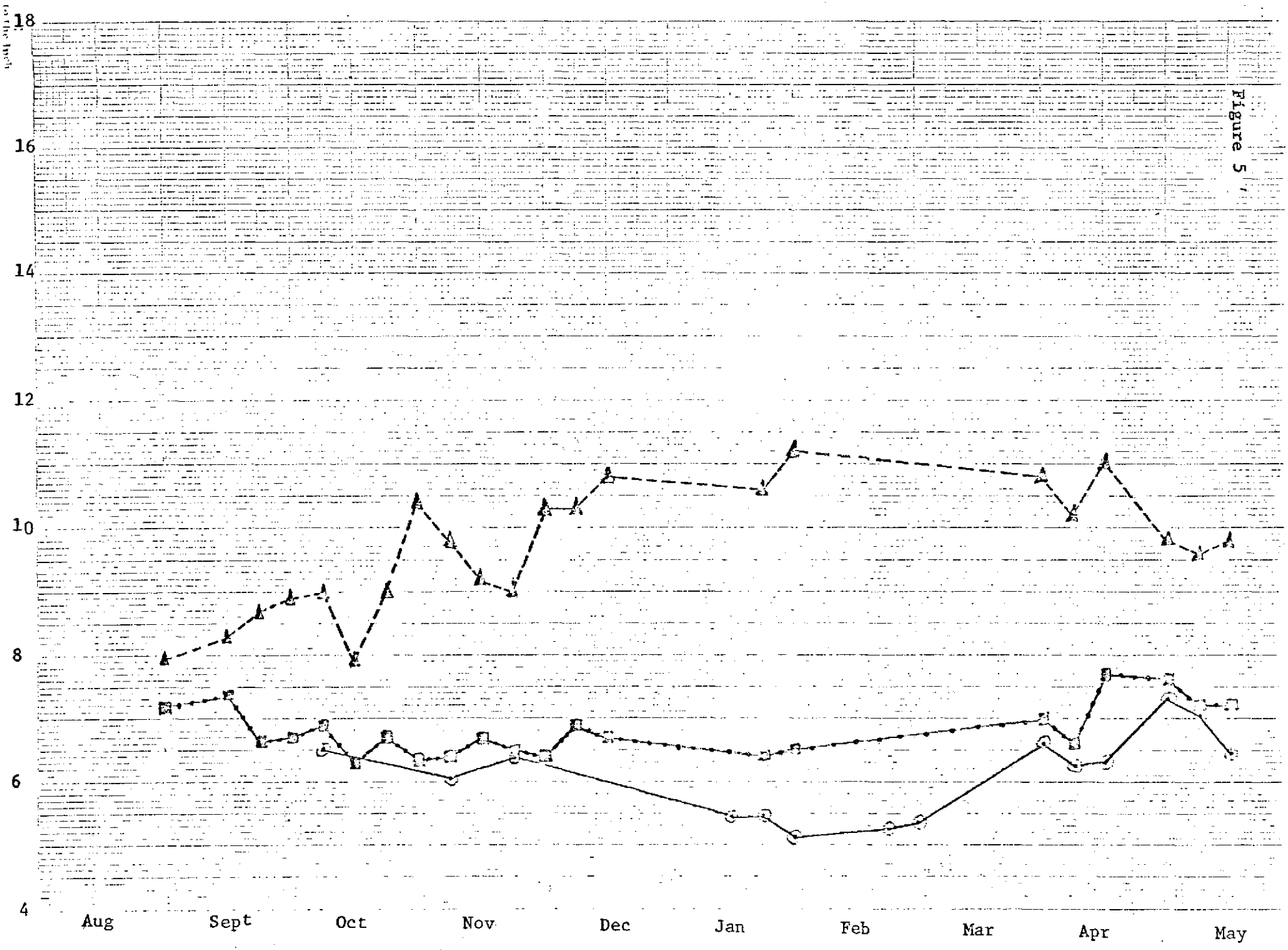


Figure 5

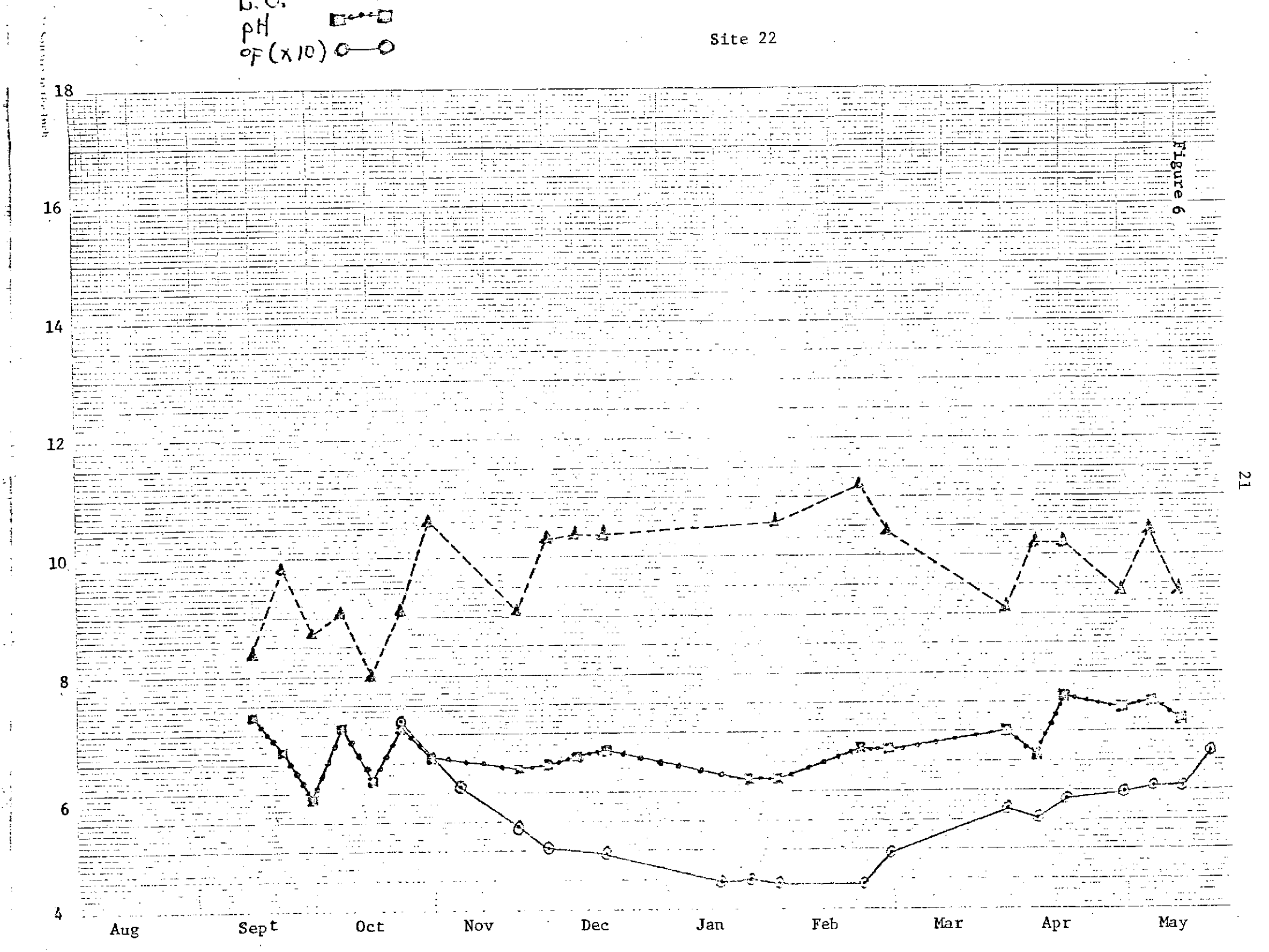

D.O.
pH
°F (x10)
Site 22
18
16
14
12
10
8
6
4
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May

Figure 6

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	49.5	49.5	49.6	49.7					
2	51.6	51.6	51.6	51.6	51.5	51.55			
3	53.3	53.4	53.4	53.4	53.4	53.4			
4	52.2	52.3	52.3						
5	51.0								
6	52.5	-	53.4	53.1	52.8	52.7			
7	53.0	-	53.2	53.0	52.9	52.9			
8	52.0								
9	51.6	-	52.7	52.3	51.9	51.7			
10	51.5	-	53.7	53.2	52.8	52.9			
11	52.4	-	54.0	53.6	53.1	52.8			
12	52.0	-							
13	53.2	-	54.7	54.4	54.3	54.4			
14	53.3	-	55.0	54.1	53.6	53.6	53.3		
15	52.8	-	54.3	53.4	53.2	53.1			
16	52.7	-	55.0	58.5					
17	52.6	53.6							
18	53.2	54.7	53.6	53.0	53.1	52.6			
19									
20									
21	54.5	-	60.0	56.0	55.5				
22	52.0	-	55.0	53.2	52.9	52.8	52.7	52.5	
23	52.6	-	-	53.1	52.9	52.8	52.5	52.5	
24	52.5								
13A	65.0	-	66.5	65.2					

Date 10-4-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	69.0	69.1	69.2	69.2	69.2	69.0			
2	69.9	69.9	69.9	69.8	69.7	69.6			
3	70.3	70.3	70.3	70.3	70.3	70.3			
4	68.3	68.3	68.3	68.3	68.3	68.3			
5	69.1	69.0	69.0	68.9	68.9	68.95	69.3		
6	69.4	69.35	69.4	69.6	69.4	69.3	69.4	69.45	
7	69.75	70.0	69.9	69.75	69.6	69.6	69.5	69.4	
8	68.5	68.75	68.75	68.8					
9	69.5	69.5	69.5	69.5	69.5	69.4			
10	69.6	69.6	69.6	69.6	69.6	69.7	69.7		
11	69.5	69.5	69.5	69.5	69.5	69.5			
12	68.9	69.0	68.8	68.8	68.75	68.75			
13	70.0	70.0	70.2	73.4	75.4	74.9	78.8		
14	69.6	69.6	69.6	69.6	69.5	69.5	69.5		
15	69.0	69.0	69.0	69.0	69.1	69.2	69.1		
16									
17	69.2	69.2	69.35	69.2	69.1	69.1	69.1		
18	69.3	69.5	69.5	69.5	69.5	69.6			
19									
20	70.5	70.55	70.6	70.6	71.75	72.4	72.6	72.6	
21	70.1	70.2							
22									
23									

Date: 10-17-72

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	60.25	60.0	60.2	60.3	60.5	60.25			
2	60.4	60.2	60.1	60.0	60.1	60.0			
3	61.25	61.25	61.25	61.0	61.0	61.0			
4	60.4	60.4	60.4	60.25	60.2	60.1			
5	60.6	60.4	60.4	60.0	60.0				
6	60.6	60.75	60.75	60.8	60.8	60.8			
7	61.4	61.4	61.4	61.4	61.4	61.4			
8	60.6	60.75	60.75	60.75	60.6	60.6	60.6		
9	60.0	60.0	60.25	60.2	60.2	60.25	60.0		
10	60.5	60.5	60.4	60.3	60.25	60.2	60.1		
11	60.9	61.0	61.0	61.0	61.0	61.0	60.6		
12	60.2	60.2	60.4						
13	59.5	60.0	60.0	60.2	60.4	68.0	69.5	71.2	
14	60.6	60.75	60.75	60.8	60.75	60.8	60.6		
15	61.4	61.4	61.4	61.4	61.4	61.4	6i.4		
16	60.75	60.8	60.9	60.9	60.9				
17	60.4	60.4	60.4	62.6	63.5	64.0	64.4	64.4	64.0
18	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5	
19	61.5	61.5	61.5	61.5	61.5	61.5	61.5		
20	61.5	61.5	61.5	61.5	61.5	61.4			
21	60.8	60.75	60.5	60.75	60.6	60.5	60.5	60.5	
22	60.75	60.9	60.9	61.0	61.0	61.1	61.0	61.0	61.0
23	61.6	61.5	61.5	61.5	61.5	61.4	61.3		
24	60.5	60.6	60.7	60.75	60.75	60.75			
13A	60.6	60.6	60.6	60.6	60.6	60.6	60.6	60.6	
13B	73.75	73.75	73.75						

Date : 11/7/72

Meters From Bottom

Site	1	2	3	4	5	6	7	8
1	54.3	54.3	54.2	54.0	53.5			
2	53.9	53.8	53.6	53.7	53.6	53.7		
3								
4	56.0	55.3	54.8	54.8	54.7			
5	52.4	52.5	52.5	52.5				
6	53.2	53.1	53.1	53.0	53.0	53.1		
7	53.0	53.2	53.1	53.1	53.1	53.0		
8	52.9	52.9	52.9	52.9	52.8			
9	55.0	54.7	54.6	54.6	54.4	54.4		
10	53.2	53.0	-	53.0	52.7	52.8		
11	54.0	54.0	-	54.0	53.9			
12	53.7	53.7	53.7	53.7	53.7			
13	52.7	52.7	-	-	54.7	56.7	57.5	58.5
14	53.7	53.7	53.7	53.6	53.6	53.5	53.4	
15	53.5	53.5	53.6	53.4	53.3	53.4		
16	53.4	53.4						
17	53.1	53.2	53.3	54.0	56.3	58.3	56.0	56.3
18	53.2	53.2	53.7	56.4	56.6	57.2	57.2	56.9
19	54.2	53.7	53.7	53.6	53.6	53.5		
20	54.4	54.2	54.0	53.9				
21	54.4	54.4	54.4					
22	54.1	54.2	54.3	54.4	54.3	54.2	54.0	54.1
23	53.5	53.6	53.5	53.6	53.5	53.4	53.4	
24	53.2	53.2	-	53.3	53.2			
13A	64.4	64.4	64.2					

Meters From Bottom

Site	1	2	3	4	5	6	7	8
1	51.5	51.4	-	51.25				
2	51.0	50.8	50.9	50.9	50.8	50.75	50.75	
3	51.5	-	-	51.1	51.0	51.0		
4								
5	63.25	52.3	52.0					
6	50.4	50.45	50.5	50.49	50.49	50.49		
7	53.6	51.6	51.5	51.4	51.3	51.25		
8	50.1	50.2						
9	51.9	51.5	-	51.5	51.4	51.4		
10	51.6	51.5	51.5	51.4	51.4	51.3		
11	52.8	51.6	51.5	51.4	51.2	51.0		
12	50.5	50.5						
13	51.1	54.4	53.8	53.7	54.75	56.25		
14	54.4	52.0	51.8	51.75	51.5	51.5		
15	50.5	50.5	50.5	50.4	50.4	50.3		
16	52.25	52.0						
17	52.0	51.5	51.5	51.5	54.0	53.8		
18	50.8	50.8	50.8	50.850.8		50.8		
19	52.9	52.1	52.1	52.0	51.8	51.7		
20	50.75	50.6	50.5					
21	54.0	54.0	53.9	53.9	53.8			
22	52.4	52.0	52.0	51.9	51.6	51.6	51.0	52.5
23	50.6	50.6	50.6	50.75	50.75	50.75		
24	52.25	51.6	51.6					
25	50.0	51.1	51.4	53.0				

Date: 11/28/72

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	51.6	51.6	51.6	51.4	51.3	51.2	51.1	51.0	51.0
2	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
3	51.4	51.3	51.2	51.1	51.0	50.9	50.8	50.75	50.75
4	50.75	50.75	50.6	50.5	50.5	50.4	50.25	50.2	50.2
5	54.2	54.0	54.0	53.9	53.6	53.6	53.0	53.0	52.65
6									
7	51.5	51.5	51.5	51.5	51.5	51.5	51.4	51.4	51.4
8	51.4	51.25	51.2	51.0	50.9	50.8	50.6	50.5	50.4
9	51.8	51.75	51.7	51.6	51.6	51.5	51.5	51.4	51.4
10									
11									
12									
13	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
14									
15									
16									
17	52.6	52.6	52.6	52.5	52.4	52.4	52.3	52.25	52.1
18	52.0	51.7	51.7	51.6	51.4	51.4	51.1	50.8	50.8
19									
20									
21	51.4	51.3	51.25	51.4	51.25	51.25	50.9	51.1	51.1
22									
23									
24									
13A	56.0	56.0	56.9	57.1	57.1	57.1			

Date: 12/5/72

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	47.5	48.0	48.3	48.5	48.6	48.6			
2	46.3	46.5	46.6	46.6	46.7	46.8			
3	47.6	47.8	47.9	47.9	48.1	48.0	48.2		
4	47.5	47.6	47.8	47.8	47.9	47.8			
5	47	48.1	48.4	48.5	48.4	48.5	48.7		
6	48.4	48.6	48.9	49.0	49.0	49.0			
7	48.0	48.5	48.8	49.0	48.9	48.9			
8	48.5	48.9	49.1	49.2	49.1	49.1			
9	47.9	48.0	48.3	48.3	48.3	48.2	48.3		
10	48.2	48.8	49.3	49.3	49.3	49.3			
11	48.5	48.8	48.9	49.0	48.9	48.9	48.9		
12	47.5	47.9	48.2	48.2	48.2				
13	47.9	48.0	48.8	49.7	50.3	53.9	55.9		
14	47.7	47.8	47.9	48.0	48.0	48.0			
15	48.7	49.2	49.5	49.6	49.6	49.6			
16	48.5	48.8	49.3	49.3	49.3				
17	50.0	50.0	50.0	50.4	52.0	53.0	53.0	53.0	
18	49.4	49.5	49.5	49.6	49.6	49.5	49.4		
19	49.6	49.7	49.75	49.8	49.8	49.8			
20	48.8	48.8	48.9	49.0	48.9	48.8			
21	51.1	51.1	51.1	51.1	51.1	51.1			
22	49.7	49.7	49.8	49.8	49.8	49.8	49.5	49.5	
23	49.6	49.5	49.2	49.1	49.0	49.0			
24	49.7	49.7	49.7	49.6	49.6	49.6			
13A	54.9	55.0							

Date 12/12/72

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	42.6	42.6	42.5	42.5	42.4	42.4	42.3		
2	42.3	42.2	42.1	42.1	42.3	42.4			
3									
4	42.02	41.7	41.7	41.3	41.2	41.4			
5	42.4	42.3	42.4	42.3	42.4				
6	42.4	42.3	42.1	42.2	42.2	42.2			
7	43.3	43.0	42.8	42.9	42.6	42.8	42.6		
8	43.0	42.7	42.65	42.6	42.5	42.6	42.7		
9	43.2	43.3	43.2	43.1	43.2	43.2			
10	42.9	42.8	42.6	42.6					
11	41.7	41.6	41.8	41.8	41.6	41.6	41.6	41.9	
12	42.3	42.4	42.45		42.4	42.4	42.6		
13	43.4	43.4	44.0	47.3	50.5	51.2			
14	45.0	47.7	48.4	48.8	51.3				
15	41.9	41.9	51.8	41.8	4i.6	41.7			
16	42.1	41.8	41.6	41.6	41.5	41.5			
17	44.2	44.2	44.5	47.6	46.9	48.9	52.7	54.4	
18	43.0	42.8	42.6	42.7	42.6	42.6	42.5		
19	42.6	42.5	42.3	42.6	42.4	42.4			
20									
21	47.4	47.5	47.6	47.5	47.5	47.6			
22	44.6	44.6	44.6	44.5	44.5	44.4			
23									
24									
13A	53.7	53.4	54.2						

Date 1-18-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	47.4	46.9	46.9	46.9	46.7	46.7			
2	45.0	44.7	44.75	44.8	44.7	44.6			
3	46.0	-	45.0	44.95	44.75	44.7			
4	44.3	43.9	43.95	44.0	43.8	43.8			
5	47.5	47.4							
6	45.6	54.2	45.1	45.1	44.9	45.0			
7	44.5	44.2	44.2	44.4	44.3	44.4	44.1		
8	45.2	44.9							
9	46.7	46.6	46.6	46.4	46.5	46.35			
10	45.0	44.75	44.6	44.6	44.4	44.4			
11	45.2	45.0	45.045.0		44.75				
12	45.6	44.8	45.1						
13	50.0	50.3	51.1	50.6	50.8	51.4	52.4		
14	45.1	451.	45.2	45.1	45.2	54.1			
15	45.4	45.2	45.2	44.9	44.8	44.8			
16	44.5	44.5	44.6	44.8					
17	50.6	50.7	50.5	50.3	50.1	50.0	51.5		
18	45.0	44.75	44.75	44.8	44.75	44.5			
19	45.2	45.2	45.1	45.1	45.1	45.1			
20	45.1	44.9	44.7						
21	47.8	47.5	47.8	47.8					
22	45.1	45.2	45.4	45.3	45.4	45.2	44.9	44.8	
23	44.9	44.8	44.8	44.8	44.5	44.2	44.0		
24	45.0	45.0	45.0	45.0	44.8				
13A	54.75	54.3	54.4						

Date 1-23-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	44.2	44.1	44.1	44.1	43.9	43.8			
2	43.4	43.35	43.4	43.4	43.4	43.35			
3	43.25	43.25	43.5	43.5	43.4	43.4			
4	44.3	44.1	44.0	44.0	43.9				
5	43.75	43.6	43.8						
6	43.0	42.8	42.9	43.2	43.1	42.9			
7	44.2	43.7	43.8	43.9	43.8	43.6			
8	42.6	44.6	43.2	43.2	43.2				
9	43.6	43.5	43.5	43.8	43.6	43.6			
10	43.5	43.5	43.75	43.75	43.6	43.7			
11	44.1	43.9	43.9	44.0	43.75				
12	42.7	42.6	42.75	43.1					
13	43.8	43.8	43.9	44.4	48.0	50.1	51.6		
14	43.6	43.6	43.8	44.0	43.9	43.9	42.9		
15	43.75	43.5	43.7	43.7	43.6	43.6			
16	42.6	42.3	42.6	42.7	42.7				
17	44.9	44.4	45.3	45.3	46.1	51.6	49.1		
18	43.4	43.3	43.4	43.4	44.2	43.3	43.4		
19	42.75	42.6	42.9						
20	47.6	47.6	48.0						
21									
22	44.0	43.9	44.0	-	44.4	44.1	44.1	43.9	
23	43.3	43.1	43.4	-	43.7	43.5			
24	42.8	42.4	42.5	-	42.9				
13A	51.7	51.2	45.0						
13B	61.0	63.75							

Date: 1-30-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8
1	45.0	44.5	44.4	44.2	44.1	43.9		
2	41.5	41.5	41.5	41.5	41.4	41.3		
3	41.5	41.6	41.6	41.75	41.75			
4	42.0	41.8	41.8	41.75	41.75			
5	43.6	43.5	43.6	43.6				
6	42.0	42.0	42.0	42.0	41.9	41.9		
7	42.0	41.9	41.9	42.0	42.0	42.1		
8	42.0	42.0	42.0	42.1	42.1			
9								
10	41.5	41.4	41.5	54.5	41.5	41.4		
11								
12								
13	44.4	44.4	44.75					
14	42.0	41.9	41.7	41.5	41.5			
15	42.4	42.25	42.25	42.25	42.25	42.2	42.1	
16	41.9	41.85						
17	43.0	43.0	44.0	44.3	45.6	45.8	46.4	48.0
18	41.5	41.6	41.6	41.6	41.6	41.6	41.6	
19	41.4	41.4	41.5	41.5	41.5	41.5		
20	41.4	41.5	41.5	42.0				
21	43.0	43.0	44.1	44.1	441.	44.1	44.1	
23								
23								
24								
25								
13A	52.8	52.7	52.6					

Date 2-21-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	45.00	45.1	45.2	-	45.7				
2	44.0	44.0	44.1	-	44.4				
3	44.5	44.55	44.6	-	45.2				
4	44.4	44.5	44.6						
5	45.7	45.8	45.8						
6	44.1	44.1	43.8	-	44.5				
7	42.9	42.8	42.8	-	42.9	42.8			
8	43.8	43.6	43.6						
9	44.6	44.6	44.6	-	45.0	44.9			
10	43.5	43.6	43.7	-	44.0	43.9			
11	43.0	42.9	43.0	-	43.5				
12	47.4								
13	46.4	44.8	46.5	-	49.0	50.6			
14	44.0	44.0	44.0	-	44.7	44.4			
15	43.1	43.1	43.3	-	43.6				
16	43.9	44.0							
17	44.8	45.7	45.6	-	48.4	48.2	50.0	50.0	50.0
18	43.6	43.5	43.5	-	43.5	43.5			
19	43.8	43.6	43.6	-	44.5	44.1			
20	44.0	44.0							
21	47.5	47.5	47.6						
22	44.2	44.3	44.3	-	45.7	46.4	47.0	49.4	
23	43.7	43.75	43.8						
13A	53.4	53.7	53.5						

Date: 2-27-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	54.0	54.1	54.5	54.6	54.6	54.6			
2	53.4	53.4	53.4	53.25	53.4	53.6	53.3		
3	54.25	54.3	54.25	54.2	54.1	54.1	54.25		
4	54.0	54.0	54.0						
5	54.1	54.2	54.2	-					
6	54.0	53.8	54.0	-	53.75	53.6	53.9	53.6	-
7	53.0	53.2	53.2	53.0	52.9	52.9	52.6		
8	53.0	53.0	53.0						
9	54.0	54.0	54.1	-	53.9	54.0	53.9		
10	53.5	53.5	53.6	-	53.6	53.3	53.2	53.1	53.0
11	53.5	53.5	53.6	-	53.7	54.0	53.9		
12	53.4	53.1							
13	55.0	55.8	56.6	-	60.5	60.5			
14	52.9	52.9	52.9	52.9	52.9	52.9	52.9		
15	53.6	53.6	53.7	-	53.9	53.8	53.6		
16	54.0	54.0	54.0						
17	55.5	55.5	55.5	-	58.2	58.2	58.1	58.1	58.6
18	56.6	56.6	56.75	-	57.75	57.75	57.75	57.6	58.0
19	57.3	57.4	57.4	-	56.2	56.2			
20	60.0	60.0	60.0	-					
21	58.5	58.5	58.5	-	57.0				
22	56.1	56.1	56.2	-	57.0	57.0	57.0	57.0	57.0
23	55.0	55.0	55.0	-	55.1	55.1	55.1	55.1	-
24	56.0	56.0	56.0	-					
25				-					
13A	60.5	66.0	65.9	-					

Date 3-27-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8	9
1	55.0	55.1	55.2	55.2					
2	54.2	54.1	54.1	54.3	54.1	54.2			
3	54.1	54.1	54.3	54.2	54.3	54.2			
4	55.6	55.6	55.6	55.6					
5	56.0	56.0							
6	55.3	55.3	55.4	55.3	55.3	55.3	55.2		
7	54.8	54.9	54.95	55.0	55.0	55.0	54.9		
8	54.3	54.3							
9	54.4	54.45	54.4	54.55	54.5	54.5	54.45		
10	53.75	53.8	53.8	53.9	53.2	53.2	53.2		
11	55.0	55.0	49.9	49.9	49.9	49.8			
12	55.0								
13	57.0	55.8	55.6	60.5	60.1	63.2	64.4		
14	55.3	55.3	55.4	55.4	55.3	55.3	55.3		
15	54.7	54.9	55.0	54.9	54.9	54.9	54.6	54.6	
16	54.5	54.4	54.5	54.9	54.9	54.9	54.6	54.6	
17	57.3	56.6	56.4	56.4	56.3	56.8	57.1	58.2	58.4
18	55.6	55.7	55.7	55.6	55.2	55.0	55.0	55.0	
19	55.0	55.0	55.0	55.0	55.0	55.0	55.0		
20	55.4	55.4							
21	56.0	55.8	56.0	55.9					
22	54.7	54.7	54.6	54.5	54.6	54.7	54.7		
23	54.1	54.1	54.3	54.2	54.2	54.4	54.2		
24	55.5	55.5	55.5	55.3					
13A	62.5	62.5	62.5						
13B	64.9	64.6	64.7	64.4					

Date: 4-3-73

Date 4/11/72

Meters From Bottom

Site	1	2	3	4	5	6	7	8
1	58.00	58.00	58.00	58.00	58.00	58.00		
2	58.50	58.50	58.25	58.25	58.25	58.25		
3	58.0	57.5	57.5	57.5	57.5	57.51		
4	58.0	58.0	57.8	57.75	57.5	57.5	56.25	
5	57.27.	57.75	57.75	57.9				
6	58.7	58.9	58.9	58.9	58.8	54.7		
7	58.7	58.7	58.7	58.8	58.5	58.6	58.5	
8	57.5	57.5	57.7	57.7	57.5	57.5		
9	58.5	58.5	57.8	57.9	57.8	57.8		
10	59.5	59.5	59.5	59.4	59.4	59.3		
11	58.8	58.6	58.75	58.8	58.75			
12	57.8	57.9	57.9	57.9	57.9			
13	57.5	57.5	57.5	57.5	61.2	62.2	64.75	68.0
14	57.4	57.1	57.3	57.5	57.4	57.75		
15	57.8	57.75	57.75	57.6	57.6	57.6		
16	58.3	58.3	58.4	58.4				
17	59.0	59.0	60.25	61.4	61.4	61.3	61.2	
18	58.25	58.25	58.4	58.25	58.1	58.25	57.25	
19	58.0	57.75	57.75	57.6	57.6			
20	57.5	57.5	57.5	57.5	57.5	57.5		
21	57.75	57.8	58.0	58.25		58.9	59.0	
22	59.0	59.0	59.0	59.0	59.0	59.0	58.6	
23	58.25	58.4	58.5	58.5	58.5	58.5	58.0	
24	57.75	57.75	57.6	57.6				
25	58.9	58.9	58.9	59.0	59.4	59.5		
13A	63.0	63.0						

Meters From Bottom

Site	1	2	3	4	5	6	7
1	61.5						
2	61.0	61.0	61.0	61.0	61.0	61.0	
3	60.1	60.4	60.4	60.3			
4	60.4	60.4	60.4	60.3			
5	61.0	61.3					
6	60.5	60.5	60.5	60.8	60.7	60.6	
7	59.8	60.0	60.0	60.0	59.9	59.9	
8	60.8	60.8	60.9				
9	60.7	61.0	60.7	60.7	60.9	60.9	
10	61.0	61.0	61.1	61.0	61.0	61.0	60.9
11	61.1	61.0	61.0	61.0	61.0	60.7	
12	61.0						
13	61.3	61.6	62.6	63.7	-	67.8	67.8
14	60.0	60.0	60.1	60.1	-	60.3	60.1
15	61.3	61.3	61.4	61.4			
16	61.1	61.3	61.5				
17	61.1	61.2	61.3	61.5	63.0	65.0	66.3
18	60.7	60.7	60.8	60.9	60.6		
19							
20	61.0	61.0	61.-	61.0	-	51.9	
21							
22							
23	59.5	59.5	59.5	59.5	-	60.0	59.9
24							
13A	72.0	72.0	72.0				
13B	75.5	78.8	79.0				

Date 4-26-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8
1	-	61.0	61.0					
2	-	60.6	60.3	60.2	-	60.3	60.0	
3	-	61.4	61.0	61.0	-	61.1		
4	-	61.2	61.1					
5	-	61.4	61.2					
6	-	60.7	60.5	60.3	-	60.5	60.4	
7	-	61.1	61.3	61.3	-	61.3	61.1	
8	-	61.2						
9	60.7	60.6	60.5	-	60.5			
10	62.5	61.7	61.5	-	61.0	61.0		
11	60.4	60.3	60.1	-	60.0			
12	-	59.8						
13	-	60.0	60.0	60.5	-	64.0	67.7	67.4
14	-	61.25	60.6	60.5	-	60.6	60.4	
15	-	61.25	61.0	61.0	-	61.3	61.1	
16	-	61.2						
17	-	62.0	-	64.2	-	64.0	63.9	64.0 64(
18	-	60.7	-	61.4	-	60.6		
19	-	61.0	-	61.1	60.9	60.7	60.4	
20	-	61.1						
21	-	61.7	-	61.5				
22	-	61.0	-	62.6	61.6	61.5	61.1	61.1 61.5
23	-	62.2	61.4	61.4	61.3	61.3	61.1	
24	-	61.5	61.3	61.2	61.2			
13A	-	70.5	70.1	70.2				

Date: 5-2-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8
1	64.0							
2	-	-	-	62.2	62.2	62.1	62.0	
3	-	-	-	63.7	63.5	63.5	63.4	
4								
5								
6								
7	63.5	-	-	64.0	-	63.3	63.5	
8	-	-	-	59.0	59.4	63.2		
9	63.5	-	-	64.2	63.9	63.9		
10	64.6	-	-	64.6	64.4	64.5	64.3	
11	64.3	-	-	65.0	64.3	64.6		
12	64.0							
13	63.6	-	-	69.6	73.9	75.5	75.3	
14	63.4	-	-	64.5	63.5	63.5	63.4	
15	64.2	-	-	65.0	64.6	64.5	64.2	
16	63.5							
17	64.0	-	-	64.5	65.3	65.8	66.5	68.0
18	63.5	-	-	64.2	64.0	63.9	63.8	
19	64.5	-	-	64.5	64.5	64.5	64.5	
20	63.4	-	-	64.2				
21								
22	64.0	-	-	64.2	64.0	64.2	65.5	66.5 68.0
23	64.0	-	-	64.3	64.1	64.2	64.0	
24	65.0							
13A	73.6	-	-	74.6				

Date: 5-15-73

Meters From Bottom

Site	1	2	3	4	5	6	7	8
1	59.0							
2	61.25	61.3	-	61.5	61.5	61.5	61.5	
3	61.1	61.2	-	61.5	61.5	61.5		
4	60.5	60.6						
5	60.75	60.75						
6	61.5	61.6	-	62.4	62.5	62.5	62.5	
7	61.6	61.5	-	62.0	62.0	61.75	61.6	
8	61.0							
9	60.5	60.6	-	61.1	61.0	61.0	60.9	
10	61.5	61.5	-	61.9	61.75	61.75	61.5	
11	60.75	60.6	-	61.3	61.0	60.9		
12								
13	62.4	67.3	-	69.6	72.0	72.2		
14	61.25	61.3	-	61.4	61.2	61.2	61.1	61.1
15	61.5	61.6	-	62.0	61.9	61.9	61.75	
16	61.0	61.0						
17	60.0	-		62.8	62.8	63.2	70.3	72.1
18	62.0			62.8	62.8	63.2	70.3	72.1
19	61.0	-	-	61.5	61.3	61.2	61.0	
20	62.0	-	-					
21	61.6	-	-	62.5				
22	61.4	-	-	61.9	61.6	61.5	61.5	61.5
23	62.0	-	-	63.0	62.5	62.5	62.4	
24	61.3	-	61.1					
13A	63.6	-	-	64.7				

Conclusion:

The presentation of this data leaves much interpretation open for discussion. However, undisputably this data does show a definite warming of the river water by the steamgeneration plant. The effluent heat is dissipated quickly by a mixing action of the river. This physical effect is clearly shown. The chemical and biological effects are not so definitive and do warrent further and more complete analysis. This study is being continued under NASA Grant NGR 01-001-025.