The Toxicity of Some Industrial Effluents and Their Effects Upon Fox River Water Quality

ERL-D

U.S. EPA
Environmental Research Laboratory-Duluth
6201 Congdon Boulevard
Duluth, Minnesota 55804

Introduction

Toxicity tests were performed on industrial effluents to the Fox River from Lake Winnebago at Neenah, Wisconsin to the river mouth at Green Bay. A graduated series of effluent concentrations were made with Fox River water (taken just upstream of the effluent discharge) as the diluent. Tests were also performed on river water collected from ten stations situated along the course of the Fox River.

From Neenah to Green Bay there are 22 municipal and major industrial waste discharges to the Fox River, of which 14 are paper mill effluents. The dilution water for effluent tests was taken immediately upstream of the discharge, so that progressing from upstream to downstream, each downstream discharge was diluted with river water bearing materials from any upstream discharges. Thus, in our testing, we measured not the specific toxicity of a given effluent, but rather the total toxicity of the effluent and its receiving water.

Test Methods

For the effluent dilution (ED) tests, river water was collected on the same day as the effluent as a grab sample just upstream of each discharge. The effluent was collected as a 24-hour composite sample by continuously pumping a small flow from the discharge. The ambient water samples were collected as grab samples from stations identified in Figure 1.

At the end of the sampling, the samples were brought to the laboratory and placed in a constant-temperature room at 6°C. Tests were begun the following day. A portion of the sample was used daily and the remainder retained in cold storage. At the beginning of each test day, the sample portion to be used was obtained from the cold room and warmed to 24°C prior to use. The effluent concentrations were made by measuring proportionate effluent and diluent (river) water in graduated cylinders and mixing each concentration in a 4000 m beaker. The samples were near to or above DO saturation following warming to 24°C, so aeration was used briefly to bring DO levels to 9 mg/l or less if supersaturation was present. The pH, DO and temperature were measured daily both as the initial values of test water to be used and as final values in test water before it was discarded.

As test solutions were changed daily, fish larvae and daphnids were exposed to a fresh sample of the effluent or river water each day.

The glass, fathead minnow, larval, test chambers were 12" x 6" x 4" deep and were divided by 3 glass partitions, resulting in 4 compartments 5" x 3" x 4" deep. A narrow channel was left along one side 1" x 12" x 4" deep; each of the 4 compartments was connected by a stainless steel screen end to it. The compartments could thus be filled and drained using the channel without seriously disturbing the test fish. As there was a water connection between compartments, they cannot be considered true replicates in the statistical sense. There was essentially no interchange of water between compartments and accordingly, on a practical basis they were considered to be working replicates.

The larval compartments wre cleaned of wastes daily by siphoning. Great care must be taken in this procedure not to siphon the larval fish, but by using a small diameter siphon with a glass tube on the cleaning end, this problem was minimized. Additional test solution was removed from the common channel to 1 cm depth. Then 2000 ml of new test solution was slowly added into the channel, refilling all compartments.

Newly hatched brine shrimp were fed at the rate of .1 ml per compartment 3 times daily. With this feedig regime, live brine shrimp nauplii were available as food to the larval fish during the entire daylight period of 16 hours. Fish were counted daily and at test termination, the fish were counted and preserved in 4% formalin in glass vials. Larval fish were rinsed in distilled water as preparation for weighing. The weighing procedure consisted of pre-weighing labeled weigh boats, placing the specimens on the boat (fish were oven dried 2 hours at 100°C) and obtaining the total fish weight by subtraction. Weights were measured on a 5-place analytical balance.

Fish were obtained from the ERL-Duluth culture facility and were less than 20-hours. These larvae were placed one or two at a time ito each replicate of each treatment, and then 1 or 2 more were added until all had 10 fish.

Daphnids were obtained from the ERL-D culture and placed one to each of 10-30 ml containers for each concentration or sample tested. For tests from March 24 to May 25, glass 30 ml beakers were used. Subsequently, 1 oz hard, transparent plastic portion cups were used and discarded each day. Fifteen ml of test water was used in each beaker. One drop of yeast suspension containing 250 ug was added daily as food. The daphnid was transferred daily with an eye dropper to a clean beaker containing a new 15 ml volume. Counts of daphnids for survival and numbers of young were made daily, and after counting, the young were discarded. Both methods were based on those of Mount & Norberg, 1984 and Norbert & Mount, 1985.

Chemical-Physical Conditions

Water temperatures were maintained at 24 ± 1°C by thermostatic control of room air temperature. Dissolved oxygen was measured daily in the renewal water used for both fatheads and daphnids and daily again before discarding the test waters which had been in use for 24 hours. Initial DO's were almost always high (5.4-9.6), only twice falling below 7.1 mg/l. Final DO's, precictably, were lower (2.0-8.8), but in only 5 cases fell below 5.0 mg/l and only twice below 4.0 mg/l. The pH varied little between initial and final values and from day to day in any given sample from a station or effluent. There was some variation between river stations and between individual effluent discharges. The initial DO values are the same for both fatheads and daphnids. Tables 29 through 37 and Table 39 contain the final DO data for daphnids. The chemistry data for initial values for both fathead and daphnid tests and the final DO data for fatheads only are contained in Tables 20 through 28 and Table 38.

Results

Ambient Tests

Table 1 contains the data for the ambient tests for samples collected on 3/24, 4/15 and 4/29/83. (These tests utilize undiluted Fox River water collected at various stations.) For the 3/24 samples, the fathead minnows and Ceriodaphnia evidenced no toxicity. In both instances, some stimulation of growth or reproduction occurred at all stations. This most likely is due to the additional food contained in the Fox River water.

The 4/15 samples showed no stimulation or toxicity to fatheads. The daphnid test was lost due to a failure of the dishwasher rinse cycle, leaving detergent residue on the test vessels.

For the 4/29 samples, growth was low in all treatments and rather consistent. Station 10 was significantly lower than the control value and growth at station 9 was reduced but not significantly so. The daphnid reproduction was increased at all stations compared to the control value and especially at stations 4, 5 and 6.

Effluent Tests

Tables 2 through 19 contain the effluent test data for survival and growth for fatheads and survival and young production for daphnids. Since the purpose of the study was not to compare discharges to each other, the tables are arranged by effluent tested. The significant features of each test will be discussed without comparison to each other.

1.) Green Bay S.T.P., 1/26/84, Table 2
Fathead survival and growth were affected at 25% but not 12.5%. The control water was toxic to daphnids as was the 100% effluent and so were all mixtures. The NOEL for fatheads is 17.7% and the daphnid NOEL is less than 100% but cannot be calculated due to toxic dilution water.

2.) Kerwin Paper (2), 1/26,84, Table 3

The 100% effluent had no measurable toxicity to fatheads. Both the dilution water and 100% effluent were toxic to daphnids with evidence that the 50 and 25% mixtures were less toxic. The fathead NOEL is greater than 100% and the daphnid NOEL is less than 100%.

3.) Mid Tech (2), 1/26/84, Table 4

The fatheads displayed no toxicity at any effluent concentration but rather a stimulation increasing with effluent concentration in a reasonably uniform manner. The dilution water was toxic to daphnids, but concentrations of 12.5, 25, 50, and 100% effluent were not as toxic as the control water. The young production was lower than usually measured in productive waters. The fathead NOEL was greater than 100% and the daphnid NOEL, while not readily calculable appears to be less than 50%.

4.) Proctor and Gamble, 11/2/83, Table 5

Fathead survival and growth were significantly reduced at 100% but not at 50%. There was a marked growth stimulation at 12, 25, and 50% exposures. Daphnid survival and young production were both eliminated at 100% but no significant effects at 50% or less. The daphnids did not show the stimulation evidenced by the fatheads. The fathead and daphnid NOEL is 70.7%.

5.) Green Bay Packaging, 11/2/83, Table 6

Fathead survival was unaffected at all concentrations. Growth was highest at 100% and the uniform size at all other concentrations compared to the controls suggests toxic dilution water. Daphnid survival was excellent at all concentrations and young production was good and uniform. The NOEL for both species is greater than 100%.

6.) James River Paper, 11/2/83, Table 7

The survival and growth of fatheads was unaffected at all exposures. Daphnids evidenced toxicity at 100 and 50%. The low young production at 6.25% is significant but gives an atypical dose response curve. However, this response has been frequently seen in other effluents and seems to be real. There is no evidence of abnormal chemical measurements (Tables 27 and 30) to explain the results. The fathead NOEL is greater than 100% and the daphnid NOEL cannot reliably be calculated.

7.) Bergstrom, 6/15/83, Table 8

There was no survival or young production at 100% but all other exposures were not toxic for fatheads. Likewise, daphnids were all killed at 100% but normal survival at 50% and less except that the young production was low in the control and suggests toxic dilution water. The NOEL's were 70.7% for both species.

8.) Kimberly-Clark-J, 6/15/83, Table 9

Fathead survival was reduced at 100% and so was growth although not significantly so. The low growth at other treatments suggest toxicity in the dilution water as well. Except for 6.25%, daphnid survival was good in all treatments and reproduction was excellent in all treatments. The low survival in 6.25% probably should be ignored. The NOEL for daphnids is greater than 100% but one should not be calculated for the fatheads because of the abnormally low growth.

9.) Kimberly-Clark-L, 6/15/83, Table 10

The fatheads were not sensitive to any treatment but stimulated at the higher effluent concentrations. While control growth is much lower, it is on the very low end of the normal range so toxic dilution

water would not be suspected. Daphnid survival was not affected at 50% and young production was unaffected at 25% and less. The NOEL for fatheads is greater than 100% and for daphnids it is 35.4%.

10.) Fort Howard Paper, 1/12/84, Table 11

Both survival and growth were zero at 100% but both were normal at all other exposures. The daphnid data cannot be interpreted with certainty. The dilution water was toxic and young production was lower but in the normal range at 6.25%. At 12.5% and greater, young production was very low which may be due either to the effluent or dilution water or both. The fathead NOEL is 70.7% but one probably should not be calculated for the daphnids.

11.) Appleton S.T.P., 1/12/84, Table 12

Survival and growth were reduced at 50% but unaffected at 25% for fatheads. Daphnid survival was not reduced at 50% but young production was. The NOEL's are 35.4 for both species.

12.) Mid Tech Paper. 5/5/83, Table 13

Survival of fatheads was reduced at 25% effluent. An incorrect balance was used for weights and the weight data are not reliable. Daphnid survival was very low at 25% as was young production but the low young production in the control suggests toxic dilution water. The NOEL's cannot be calculated for either species.

13.) Appleton Paper, 5/25/83, Table 14

Fathead survival was reduced at 50% but the weight data were invalid due to use of a wrong balance. Daphnid survival was unaffected at 100% but young production was reduced. No fathead NOEL can be calculated but the daphnid NOEL is 70.7%

14.) Thilmany Paper, 7/8/83, Table 15

Both survival and growth data suggest some effluent toxicity and dilution water toxicity for fatheads. No toxicity was observed in the daphnid test. A fathead NOEL cannot be calculated but the daphnid NOEL is greater than 100%.

15.) Neenah-Menasha S.T.P., 1/12/84, Table 16

The growth and survival of fatheads was unaffected at all exposures. The dilution water and the 100% effluent was toxic to daphnids, but less so in mixtures. The fathead NOEL is greater than 100% and none can be calculated for the daphnids.

16.) Nicolet Paper, 7/8/83, Table 17

Survival and growth of fatheads indicate toxicity in the effluent and dilution water which is mitigated at 25% concentration. Daphnids

were unaffected at all treatments. The fathead NOEL cannot be calculated and the daphnid NOEL is greater than 100%.

17. Wisconsin Tissue, 7/8/83, Table 18

Although less pronounced than for the other two tests run with dilution water collected on the same day (Tables 17 and 15), the dilution water appears toxic to fatheads based on low control survival and growth. Daphnid survival was reduced at 100% effluent and also at 25% as well as at 12.5 and 6.25% to a lesser extent. There is a slight hint of additive toxicity or alternatively, an abnormal dose response curve which we have often seen for effluents. Prudence suggests that NOEL's should not be calculated.

18.) Kerwin Paper, 5/25/83, Table 19

Fathead survival was reduced at 12.5% effluent but the weight data was invalid due to use of an incorrect balance. The dilution water was toxic to daphnids as was the 100% effluent so NOEL"s cannot be calculated for either species.

Discussion

Table 40 is a summary of the test results, the concentration of each effluent in the stream after mixing at the time of sampling, and the expected effluent concentration at the 7Q10 flow. Several observations are rather striking. Of most significance is the high frequency of occurrence of toxic dilution water. Of 6 effluent collecting trips, each involving 3 different dilution water samples, 5 had 2 or 3 of the dilution water samples toxic to at least one test organism. The collection on 11/2/83 did not display ambient toxicity. Collection on 1/26/84 showed toxicity from the river mouth to above Kerwin Paper and the collection on 1/12/84 showed toxicity from above Fort Howard Paper to above Neenah-Menasha Paper which between the two trips (only 2 weeks apart) includes much of the river length. The fatheads showed toxicity 6 times and Ceriodaphnia 8 times. Never did both species show marked toxicity on the same sample.

Of the three ambient toxicity surveys done in March and April 1983, one of the sets of samples (4/29/83) showed toxicity clearly at 1 and maybe 2 stations, and had considerably lower growth at all stations than was commonly found in most other tests. In the test of 4/29/83, the Lake Superior control was also low which makes the above test interpretation subjective.

Based on the consistent mitigation of ambient toxicity by many effluents, the low toxicity displayed by those that we were able to successfully test, and the concentrations that existed in the river, the ambient toxicity is not attributable to any one effluent. In fact, if the tests are indicative of what happens in the river, the addition of effluent is likely to reduce ambient toxicity.

We have found unexplained ambient toxicity in many streams in many parts of the country in our effluent testing program. The Fox River is yet another one. Possible explanations are products of decay (i.e., H_2S), non-point sources (i.e., old land-fills or runoff from land), other point sources that are small (i.e., plating wastes or pesticide formulation) and some common chemical or chemicals found in many effluents and resulting in cumulative effects. The latter would have to involve chemicals that are "released" after discharge and then "antagonized" by fresh effluent to be consistent with the toxicity seen.

Whatever the case, these tests strongly suggest a source or sources of toxicity that cause much of the river to have toxicity frequently and the toxicity is not directly due to one or a few of the effluents tested. Further, since the toxicity was usually not "sensed" by both species at the same time, the toxicity must be due to different toxicants at various times and places.

References

Mount and Norberg, 1984. A Seven-day Life-cycle Cladoceran Toxicity Test. Environ. Tox. Chem. 3: 425-434.

Norberg and Mount (In Press). A New Sub-chronic Fathead Minnow (*Pimephales promelas*) Toxicity Test. Environ. Tox. Chem.

Table 1a. Toxicity Test Data for Fathead Minnows and Ceriodaphnia dubia/affinis exposed to Fox River water collected on March 24, 1983.

	Sampling Station										
	1	2	3	4	5	6	7	8	9	10	Control[a]
Replicate	Fathead Minnow Survival (Percent)										
A	80	90	60	50	80	90	70	80	80	70	80
B	90	90	80	70	100	60	80	80	90	90	50
C	90	70	80	90	70	100	100	100	90	90	60
D	80	90	50	100	70	80	70	90	80	70	40
Mean	85.0	85.0	67.5	77.5	80.0	85.0	80.0	87.5	85.0	80.0	57.5
Replicate	Fathead Minnow Weight (mg)										
A	.52	.55	.63	.51	.43	.38	.49	.56	.49	.46	.30
B	.59	.58	.62	.61	.44	.55	.50	.42	.42	.44	.37
C	.58	.64	.54	.60	.42	.52	.51	.44	.51	.42	.32
D	.47	.45	.61	.53	.51	.54	.53	.47	.53	.52	.24
Mean	.54	.55	.60	.56	.45	.49	.50	.50	.48	.46	.30
SD	.05	.07	.04	.04	.04	.07	.01	.06	.04	.04	.05
	Ceriodaphnia Survival (Percent)										
Mean	70	70	90	90	100	100	100	90	90	80	90
	Ceriodaphnia Young Production (No. per Female)										
Mean	22.3	24.1*	29.2*	32.2*	29.4	33.4*	26.0	26.6	29.2*	39.2*	17.4
(95% Confidence Intervals)	24.1-34.4	28.7-34.7	28.6-33.2	29.9-34.4	21.7-37.1	29.8-38.0	22.5-28.9	24.9-28.5	26.2-33.3	34.0-44.4	13.7-23.7

(a) Lake Superior water

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 1b. Toxicity Test Data for Fathead Minnows and Ceriodaphnia dubia/affinis exposed to Fox River water collected on April 15, 1983.

	Sampling Station										
	1	2	3	4	5	6	7	8	9	10	Control[a]
Replicate	Fathead Minnow Survival (Percent)										
A	60	80	70	100	100	100	100	90	90	100	100
B	70	100	100	80	80	90	70	80	90	70	100
C	90	100	80	100	100	100	100	70	60	90	100
D	100	90	80	70	90	100	90	80	90	60	90
Mean	80.0	92.5	82.5	87.5	92.5	97.5	90.0	80.0	82.5	80.0	97.5
Replicate	Fathead Minnow Weight (mg)										
A	.45	.42	.43	.43	.42	.50	.49	.51	.51	.59	.46
B	.46	.37	.36	.43	.45	.27	.55	.50	.42	.59	.35
C	.37	.38	.38	.35	.40	.44	.52	.47	.53	.60	.43
D	.33	.39	.46	.42	.35	.46	.44	.36	.35	.39	.46
Mean	.40	.39	.40	.40	.40	.41	.50	.46	.45	.54	.42
SD	.02	.02	.04	.03	.04	.10	.04	.06	.08	.10	.05
	Ceriodaphnia Survival (Percent)										
Mean	Test not valid due to container contamination										
	Ceriodaphnia Young Production (No. per Female)										
Mean	Test not valid due to container contamination										
Mean (95% Confidence Interval)	Test not valid due to container contamination										

(a) Lake Superior water

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 1c. Toxicity Test Data for Fathead Minnows and Ceriodaphnia dubia/affinis exposed to Fox River water collected on April 29, 1983.

	Sampling Station										
	1	2	3	4	5	6	7	8	9	10	Control[a]
Replicate	Fathead Minnow Survival (Percent)										
A	90	80	80	80	100	60	100	80	60	50	50
B	60	90	70	90	70	60	30	80	80	90	70
C	80	90	80	80	90	70	50	100	50	80	70
D	90	80	70	90	70	60	40	80	70	90	90
Mean	80.0	85.0	75.0	85.0	82.5	62.5	55.0	85.0	65.0	77.5	70.0
Replicate	Fathead Minnow Weight (mg)										
A	.16	.16	.18	.16	.18	.14	.13	.14	.14	.10	.15
B	.14	.18	.24	.21	.22	.23	.21	.18	.07	.05	.14
C	.20	.15	.18	.36	.22	.17	.24	.23	.05	.07	.14
D	.21	.21	.20	.28	.20	.15	.20	.27	.13	.04	.15
Mean	.17	.17	.17	.25	.20	.17	.19	.20	.09	.06*	.14
SD	.03	.02	.05	.08	.01	.04	.04	.05	.04	.02	.005
	Ceriodaphnia Survival (Percent)										
Mean	80	80	90	90	90	100	80	90	80	80	90
	Ceriodaphnia Young Production (No. per Female)										
Mean	23.2	24.2	26.1	31.1	36.6*	38.3*	23.8	25.1	26.8*	24.8*	14.7
(95% Confidence Intervals)	16.4-32.8	19.9-28.7	19.2-33.3	20.9-37.4	31.7-41.6	24.8-44.2	17.1-30.4	15.5-31.9	25.0-32.3	21.5-30.3	9.8-20.0

(a) Lake Superior water

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 2. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from Green Bay STP effluent collected January 26, 1984

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	0	0	0	100	80	100
B	0	0	0	100	100	100
C	0	0	0	100	100	100
D	0	0	0	90	100	100
Mean	0*	0*	0*	97.5	95	100
Replicate	Fathead Minnow Weight (mg)					
A	0	0	0	1.02	.83	1.03
B	0	0	0	.94	.94	.93
C	0	0	0	1.09	.63	1.08
D	0	0	0	.84	.95	.96
Mean	0*	0*	0*	.97	.83	1.00
SD	0	0	0	.10	.14	.06
	Ceriodaphnia Survival (Percent)					
Mean	0	0	0	0	0	0
	Ceriodaphnia Young Production (No. per Female)					
Mean	0	0	0	0	0	0
95% CI	0	0	0	0	0	0

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 3. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from Kerwin Paper (2) effluent collected January 26, 1984

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	80	100	100	100	100	100
B	80	100	100	100	100	100
C	80	90	100	100	100	100
D	90	100	100	100	100	100
Mean	82.5	97.5	100	100	100	100
Replicate	Fathead Minnow Weight (mg)					
A	1.00	.92	.95	.90	.79	.87
B	.92	.95	.95	1.00	.80	.88
C	.74	1.01	.82	.84	.78	.85
D	.80	.78	.76	.92	.89	.91
Mean	.86	.91	.87	.91	.81	.87
SD	.11	.09	.09	.06	.05	.02
	Ceriodaphnia Survival (Percent)					
Mean	0	40*	30	0	0	0
	Ceriodaphnia Young Production (No. per Female)					
Mean	0	0	7.02*	0	0	0
95% CI	-	-	-2.3-16.4	-	-	-

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 4. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from Mid Tech (2) effluent collected January 26, 1984

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	90	90	100	100	100	100
B	90	100	100	100	100	100
C	90	100	100	100	100	100
D	90	100	100	100	100	100
Mean	90	97.5	100	100	100	100
Replicate	Fathead Minnow Weight (mg)					
A	1.11	.91	.90	.92	1.08	.69
B	1.09	1.03	1.04	1.07	.83	.62
C	.82	.91	1.04	.92	.99	.86
D	1.06	.82	.98	.99	.95	.88
Mean	1.02*	.91	.99	.97	.96	.76
SD	.13	.06	.06	.07	.10	.12
	Ceriodaphnia Survival (Percent)					
Mean	70*	100*	100*	50*	0	0
	Ceriodaphnia Young Production (No. per Female)					
Mean	12.9*	17.8*	11.9*	12.2*	0	0
95% CI	10.8-14.9	14.6-21.0	8.73-15.1	6.05-18.4		

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 5. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from Proctor and Gamble effluent collected November 2, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	0	90	100	90	100	100
B	0	60	100	90	100	100
C	0	90	80	90	100	100
D	0	90	100	100	100	100
Mean	0*	82.5	95	92.5	100	100
Replicate	Fathead Minnow Weight (mg)					
A	0	1.05	.85	1.07	.22	.27
B	0	1.32	.98	.87	.19	.23
C	0	.89	.90	.67	.19	.45
D	0	1.10	.99	.76	.62	.98
Mean	0*	1.09*	.93*	.84	.30	.48
SD	0	.17	.06	.17	.21	.34
	Ceriodaphnia Survival (Percent)					
Mean	0*	70	60	80	80	70
	Ceriodaphnia Young Production (No. per Female)					
Mean	0*	11.3	13.5	11.2	19.5	18.4
95% CI		7.72-14.9	8.32-19.0	6.89-15.5	16.0-23.1	12.0-24.8

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 6. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from Green Bay Packaging effluent collected November 2, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	80	90	90	100	100	100
B	80	90	100	100	100	100
C	90	90	100	90	100	100
D	80	90	90	100	90	100
Mean	82.5	90	95	97.5	97.5	100
Replicate	Fathead Minnow Weight (mg)					
A	1.01	.21	.18	.19	.17	.16
B	.84	.13	.16	.18	.16	.18
C	.52	.16	.17	.22	.14	.18
D	.87	.18	.13	.18	.18	.17
Mean	.81*	.17	.16	.19	.16	.17
SD	.20	.03	.02	.01	.01	.009
	Ceriodaphnia Survival (Percent)					
Mean	100	100	100	100	90	90
	Ceriodaphnia Young Production (No. per Female)					
Mean	17.4	14.2	15.4	18.2	18.3	18.6
95% CI	13.5-21.3	10.9-17.5	13.0-17.8	15.4-21.0	16.7-20.0	15.9-21.3

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 7. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the James River paper effluent collected November 2, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	90	90	100	100	100	100
B	80	80	100	100	100	100
C	90	80	100	100	100	100
D	90	90	100	100	100	100
Mean	87.5	85	100	100	100	100
Replicate	Fathead Minnow Weight (mg)					
A	.64	.32	.55	.37	.77	.46
B	.54	.44	.87	.49	.32	.58
C	.26	.48	.44	.61	.86	.45
D	.37	.55	.40	.82	.40	.21
Mean	.45	.44	.56	.57	.58	.42
SD	.17	.09	.21	.19	.26	.15
	Ceriodaphnia Survival (Percent)					
Mean	100	90	100	90	90	90
	Ceriodaphnia Young Production (No. per Female)					
Mean	0.20*	11.0*	13.6	18.9	11.4*	17.9
95% CI	-0.25-0.65	7.42-14.5	10.9-16.3	16.9-20.9	8.57-14.4	13.4-22.3

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 8. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Bergstrom effluent collected June 15, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	0	90	90	100	90	100
B	0	100	90	90	100	90
C	0	100	100	100	70	100
D	0	100	90	90	100	100
Mean	0*	97.5	92.5	95	90	97.5
Replicate	Fathead Minnow Weight (mg)					
A	0	.83	.63	.79	.72	.93
B	0	.89	.48	.78	.84	.82
C	0	.78	.79	.89	.62	.73
D	0	.38	.57	.92	.89	.74
Mean	0*	.72	.62	.85	.77	.80
SD	0	.22	.13	.06	.12	.09
	Ceriodaphnia Survival (Percent)					
Mean	0*	90	80	90	100	100
	Ceriodaphnia Young Production (No. per Female)					
Mean	0*	14.2	22.1*	17.3*	14.7	9.7
95% CI		11.1-17.1	19.6-24.7	12.0-22.9	9.64-19.8	7.59-11.8

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 9. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Kimberly Clark-J effluent collected June 15, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	0	100	100	100	100	100
B	50	90	100	80	90	100
C	70	100	100	100	70	100
D	0	60	80	90	100	100
Mean	30*	87.5	95	92.5	90	100
Replicate	Fathead Minnow Weight (mg)					
A	0	.21	.20	.21	.28	.29
B	.22	.22	.22	.21	.30	.20
C	.24	.22	.23	.24	.28	.09
D	0	.22	.21	.21	.26	.09
Mean	.11	.22	.22	.22	.28	.17
SD	.13	.00	.01	.01	.01	.09
	Ceriodaphnia Survival (Percent)					
Mean	90	100	90	100	50*	100
	Ceriodaphnia Young Production (No. per Female)					
Mean	27.4	24.1	29.4	25.8	25.5	24.4
95% CI	22.1-32.9	19.4-28.8	28.2-30.7	18.9-32.7	21.0-29.9	19.8-29.0

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 10. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Kimberly-Clark L effluent collected June 15, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	80	100	90	100	100	100
B	70	100	60	100	100	100
C	100	90	100	100	100	90
D	90	100	100	90	100	100
Mean	85	97.5	87.5	97.5	100	97.5
Replicate	Fathead Minnow Weight (mg)					
A	.81	1.20	1.03	.31	.40	.28
B	.76	1.23	.82	.43	.28	.27
C	.89	1.16	.97	.36	.28	.19
D	1.00	.89	1.07	.31	.27	.29
Mean	.87*	1.12*	.97*	.35	.31	.26
SD	.10	.15	.11	.05	.06	.04
	Ceriodaphnia Survival (Percent)					
Mean	0*	90	90	90	90	70
	Ceriodaphnia Young Production (No. per Female)					
Mean	0*	8.78*	19.9	16.8	18.2	16.9
95% CI		6.25-11.3	15.9-23.9	13.6-20.1	17.0-19.5	13.5-20.1

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 11. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Fort Howard paper effluent collected January 12, 1984

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	0	90	90	100	100	100
B	0	100	60	100	100	90
C	0	90	90	100	80	80
D	0	90	90	80	100	100
Mean	0*	92.5	82.5	95	95	92.5
Replicate	Fathead Minnow Weight (mg)					
A	0	1.09	1.13	.90	1.02	.91
B	0	.96	1.13	.90	.94	.89
C	0	1.02	1.15	1.08	1.05	.99
D	0	.82	.96	1.09	.97	.97
Mean	0*	.97	1.09	.99	.99	.94
SD	0	.11	.08	.10	.04	.04
	Ceriodaphnia Survival (Percent)					
Mean	0	40	60	80*	100*	20
	Ceriodaphnia Young Production (No. per Female)					
Mean	0	0.33*	2.40	3.50	14.3*	2.50
95% CI		-0.48-1.14	1.20-3.67	1.88-5.11	12.4-16.2	1.99-3.01

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 12. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Appleton STP effluent collected January 12, 1984

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	0	0	70	90	90	90
B	0	0	80	80	90	90
C	0	0	70	80	100	100
D	0	0	70	90	90	90
Mean	0*	0*	72.5	85	92.5	92.5
Replicate	Fathead Minnow Weight (mg)					
A	0	0	1.18	.81	1.19	1.08
B	0	0	1.03	.86	.99	1.06
C	0	0	.94	1.07	.79	.82
D	0	0	.86	.87	.77	.90
Mean	0*	0*	1.00	.90	.93	.96
SD	0	0	.13	.11	.19	.12
	Ceriodaphnia Survival (Percent)					
Mean	0*	70	90	100	100	100
	Ceriodaphnia Young Production (No. per Female)					
Mean	0*	4.34*	11.9	13.6	14.5	15.6
95% CI		3.64-5.07	10.3-13.5	11.7-15.5	12.7-16.3	13.4-17.8

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 13. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Mid Tech Paper effluent collected May 25, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	70	80	70	60	80	90
B	50	60	50	70	90	90
C	60	70	70	80	90	100
D	70	60	60	80	80	90
Mean	62.5*	67.5*	62.5*	72.5	85	92.5
Replicate	Fathead Minnow Weight (mg)					
A						
B						
C	No Data					
D						
Mean						
	Ceriodaphnia Survival (Percent)					
Mean	0*	0*	40	70	80	60
	Ceriodaphnia Young Production (No. per Female)					
Mean	0*	0*	4.95*	11.2	10.8	11.4
95% CI			3.42-6.49	8.66-13.7	8.27-13.2	6.67-16.1

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 14. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Appleton Paper effluent collected May 25, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	80	70	90	100	90	90
B	70	70	90	60	90	100
C	40	70	90	70	90	100
D	70	70	90	90	90	100
Mean	65*	70*	90	80	90	97.5
Replicate	Fathead Minnow Weight (mg)					
A						
B						
C	No Data					
D						
Mean						
	Ceriodaphnia Survival (Percent)					
Mean	100	80	80	80	80	100
	Ceriodaphnia Young Production (No. per Female)					
Mean	12.3*	15.6	19.6	19.6	18.1	20.7
95% CI	9.96-14.6	12.5-18.6	16.7-22.6	17.6-21.6	13.5-22.8	16.5-24.9

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 15. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Thilmany Paper effluent collected July 8, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	80	90	80	80	80	40
B	70	70	80	90	50	50
C	80	70	80	60	90	80
D	70	70	80	60	90	60
Mean	75	75	80	72.5	77.5	57.5
Replicate	Fathead Minnow Weight (mg)					
A	.10	.20	.20	.20	.10	.20
B	.10	.10	.20	.10	.20	.10
C	.20	0	.20	.20	.20	.20
D	.10	0	.20	.20	.10	.20
Mean	.13	.15	.20	.18	.15	.18
SD	.05	.07	.00	.05	.06	.05
	Ceriodaphnia Survival (Percent)					
Mean	100	100	90	100	80	90
	Ceriodaphnia Young Production (No. per Female)					
Mean	15.9	23.6	27.4	17.2	34.3*	22.9
95% CI	9.67-22.1	18.6-28.6	22.3-32.3	12.2-22.2	30.9-37.5	16.4-29.5

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 16. *Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis* from the Neenah-Menasha STP effluent collected January 12, 1984

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	80	100	100	100	100	100
B	90	80	100	100	100	90
C	90	90	100	100	100	100
D	80	90	100	100	100	100
Mean	85	90	100	100	100	97.5
Replicate	Fathead Minnow Weight (mg)					
A	1.04	.83	.92	1.06	.90	1.00
B	1.18	1.00	.89	.96	.92	1.10
C	.93	.91	.80	.96	1.07	1.00
D	1.13	.91	.89	.81	1.01	.90
Mean	1.07	.91	.85	.94	.97	1.00
SD	.10	.06	.05	.10	.07	.08
	Ceriodaphnia Survival (Percent)					
Mean	0	0	60	100*	100*	30
	Ceriodaphnia Young Production (No. per Female)					
Mean	0	0	3.35	12.0*	14.5*	3
95% CI			1.41-5.36	10.2-13.8	13.1-15.9	1.97-4.15

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 17. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Nicolet Paper effluent collected July 8, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	40	90	90	90	80	50
B	30	70	80	70	90	80
C	60	50	100	70	60	50
D	30	10	90	70	90	70
Mean	40*	55	90	75	80	62.5
Replicate	Fathead Minnow Weight (mg)					
A	.08	.02	.90	.20	.20	.20
B	.10	.10	.90	.20	.10	.10
C	.08	.20	.20	.20	.20	.10
D	.10	.20	.20	.20	.20	.10
Mean	.09	.13	.55*	.20	.18	.13
SD	.01	.09	.40	.00	.05	.05
	Ceriodaphnia Survival (Percent)					
Mean	100	100	100	100	100	80
	Ceriodaphnia Young Production (No. per Female)					
Mean	19.2	27.0	17.8	25.4	31.9*	22.3
95% CI	15.4-23.0	22.2-31.8	13.3-22.3	18.7-32.1	25.4-38.4	16.3-28.2

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 18. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Wisconsin Tissue effluent collected July 8, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	100	90	100	10	100	50
B	90	80	60	40	50	90
C	90	60	80	90	60	90
D	100	90	90	90	90	50
Mean	95	80	82.5	57.5	75	70
Replicate	Fathead Minnow Weight (mg)					
A	.10	.30	.60	.20	.30	.20
B	.20	.20	.60	.20	.20	.20
C	.10	.10	.20	.30	.20	.20
D	.10	.60	.00	.50	.30	.30
Mean	.13	.30	.35	.30	.25	.23
SD	.05	.22	.30	.14	.06	.05
	Ceriodaphnia Survival (Percent)					
Mean	60*	100	100	100	100	100
	Ceriodaphnia Young Production (No. per Female)					
Mean	24.2	19.6	10.6*	13.4	12.2	16.2
95% CI	16.6-31.9	13.8-25.4	7.79-13.4	9.25-17.5	7.85-16.6	13.2-19.2

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 19. Toxicity test data for fathead minnows and Ceriodaphnia dubia/affinis from the Kerwin Paper effluent collected May 25, 1983

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Replicate	Fathead Minnow Survival (Percent)					
A	0	40	60	60	90	100
B	0	40	80	70	90	100
C	0	40	70	70	90	70
D	0	30	60	60	90	80
Mean	0*	37.5*	67.5*	65*	90	87.5
Replicate	Fathead Minnow Weight (mg)					
A						
B						
C	No Data					
D						
Mean						
	Ceriodaphnia Survival (Percent)					
Mean	0*	0*	0*	30	50	80
	Ceriodaphnia Young Production (No. per Female)					
Mean	0*	0*	0*	2.0*	6.26	7.5
95% CI				-1.19-5.15	2.46-10.0	3.94-11.2

Note: Significant differences at $P < 0.05$ are indicated by an asterisk

Table 20. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Fort Howard Paper Effluent - January 12, 1984					
pH	8.0	8.1	8.2	8.2	8.2	8.2
(range)	8.0-8.1	8.1-8.2	8.2-8.2	8.2-8.2	8.2-8.2	8.2-8.2
Initial DO (mg/l)	8.7	8.8	8.7	8.7	8.8	8.8
(range)	8.5-8.9	8.6-9.1	8.6-8.8	8.6-8.9	8.7-9.0	8.7-8.9
Final DO (mg/l)	5.2	6.4	6.5	6.7	6.8	7.0
(range)	4.6-7.1	6.3-7.2	6.3-7.4	6.4-7.6	6.5-7.6	6.7-7.8
	Appleton STP Effluent - January 12, 1984					
pH	7.9	8.1	8.1	8.2	8.2	8.2
(range)	7.9-8.0	8.1-8.1	8.1-8.1	8.2-8.2	8.2-8.2	8.2-8.3
Initial DO (mg/l)	8.7	8.7	8.8	8.7	8.8	8.8
(range)	8.6-8.9	8.6-9.0	8.6-9.0	8.6-8.9	8.7-9.0	8.7-8.9
Final DO (mg/l)	6.0	6.2	6.4	6.5	6.7	6.9
(range)	5.8-7.2	6.0-7.3	6.2-7.3	6.3-7.5	6.5-7.8	6.7-8.1

Table 21. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Green Bay STP Effluent - January 26, 1984					
pH	7.3	7.8	8.0	8.0	8.1	8.2
(range)	7.3-7.3	7.8-7.8	7.9-8.0	8.0-8.0	8.1-8.1	8.2-8.2
Initial DO (mg/l)	8.7	8.8	8.8	8.8	8.8	8.8
(range)	8.6-8.9	8.8-8.8	8.7-9.0	8.7-8.9	8.7-8.9	8.7-9.0
Final DO (mg/l)	5.2	5.9	6.3	6.8	6.8	7.1
(range)	-	-	6.2-6.5	6.7-6.9	6.7-6.9	7.0-7.1
	Neenah-Menasha STP Effluent - January 12, 1984					
pH	8.1	8.0	8.2	8.2	8.2	8.2
(range)	8.1-8.1	7.9-8.1	8.2-8.2	8.2-8.2	8.2-8.2	8.2-8.2
Initial DO (mg/l)	8.7	8.8	8.8	8.7	8.8	8.8
(range)	8.6-8.8	8.7-9.0	8.7-9.0	8.6-8.9	8.6-9.0	8.7-8.9
Final DO (mg/l)	6.2	6.3	6.5	6.5	6.7	6.8
(range)	6.0-7.4	6.1-7.4	6.2-7.5	6.4-7.5	6.6-7.7	6.6-7.7

Table 22. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Kerwin Paper (2) Effluent - January 26, 1984					
pH	7.7	7.7	7.7	7.9	8.1	8.1
(range)	7.7-7.7	7.7-7.8	7.7-7.7	7.9-8.0	8.0-8.1	8.1-8.1
Initial DO (mg/l)	8.8	8.8	8.8	8.8	8.8	8.8
(range)	8.7-8.9	8.7-8.9	8.7-9.0	8.7-9.0	8.7-8.9	8.8-9.0
Final DO (mg/l)	4.3	5.0	5.5	5.8	6.4	6.7
(range)	4.3-4.5	4.4-5.3	4.8-5.8	5.7-6.0	6.4-6.5	6.6-6.8
	Mid Tech (2) Effluent - January 26, 1984					
pH	8.0	8.1	8.1	8.1	8.1	8.2
(range)	8.0-8.0	8.0-8.1	8.1-8.1	8.1-8.1	8.1-8.2	8.2-8.2
Initial DO (mg/l)	8.7	8.7	8.8	8.7	8.8	8.8
(range)	8.6-8.9	8.6-8.9	8.7-9.0	8.6-8.9	8.7-9.0	8.7-9.0
Final DO (mg/l)	5.8	6.4	6.6	6.3	6.7	7.0
(range)	5.7-6.1	6.3-6.6	6.5-6.7	6.3-6.5	6.7-6.9	7.0-7.2

Table 23. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Kimberly Clark-J Effluent - June 15, 1983					
pH	7.9	8.1	8.1	8.2	8.2	8.2
(range)	7.8-8.0	8.0-8.3	8.0-8.3	8.0-8.3	8.1-8.3	8.1-8.3
Initial DO (mg/l)	8.8	8.8	8.7	8.8	8.8	8.8
(range)	8.6-9.1	8.4-9.2	8.4-9.1	8.3-9.1	8.4-9.2	8.2-9.2
Final DO (mg/l)	6.5	7.1	7.4	7.5	7.4	7.3
(range)	4.2-8.3	7.0-8.4	7.1-8.6	7.0-8.8	7.1-8.6	6.8-8.6
	Kimberly Clark-L Effluent - June 15, 1983					
pH	8.0	7.9	8.0	8.1	8.1	8.2
(range)	7.7-8.1	7.8-8.1	7.9-8.2	8.0-8.3	8.0-8.2	8.1-8.3
Initial DO (mg/l)	8.3	8.5	8.6	8.7	8.6	8.7
(range)	7.8-8.8	7.8-9.0	8.1-9.0	8.3-9.1	8.2-9.1	8.3-9.2
Final DO (mg/l)	6.2	6.5	7.0	6.9	6.5	7.0
(range)	5.4-7.1	6.3-6.8	6.8-7.3	6.4-7.6	6.0-7.0	7.0-7.1

Table 24. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Kerwin Paper Effluent - May 25, 1983					
pH	7.4	7.6	7.8	8.2	8.2	8.4
(range)	7.4-7.5	7.5-7.6	7.8-8.0	8.1-8.2	8.2-8.3	8.3-8.4
Initial DO (mg/l)	7.8	7.8	7.9	7.9	8.0	8.1
(range)	7.4-8.3	7.3-8.3	7.6-8.3	7.6-8.3	7.6-8.3	7.6-8.3
Final DO (mg/l)	4.1	5.1	5.6	5.8	6.0	6.3
(range)	2.0-5.3	3.9-5.9	4.7-6.2	5.5-6.2	5.8-6.7	6.0-7.0
	Bergstrom Paper Effluent - June 15, 1983					
pH	8.3	8.3	8.2	8.3	8.2	8.3
(range)	8.0-8.6	8.1-8.5	8.1-8.5	8.2-8.4	8.2-8.4	8.2-8.3
Initial DO (mg/l)	8.5	8.8	8.7	8.8	9.0	9.0
(range)	8.2-8.8	8.7-9.0	8.5-9.1	8.8-9.0	8.9-9.3	8.9-9.3
Final DO (mg/l)	5.9	6.8	6.8	6.9	7.2	7.2
(range)	5.9-6.0	6.0-7.4	6.4-7.4	6.6-7.4	7.0-7.5	6.8-7.6

Table 25. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Appleton Paper Effluent - May 25, 1983					
pH	7.5	7.8	7.9	8.1	8.2	8.2
(range)	7.5-8.0	7.7-8.0	7.9-8.1	8.0-8.2	8.1-8.4	8.2-8.4
Initial DO (mg/l)	8.1	8.1	8.1	8.2	8.1	8.1
(range)	7.6-8.7	7.8-8.7	7.8-8.7	7.8-8.7	7.8-8.7	7.8-8.7
Final DO (mg/l)	6.0	6.5	6.6	6.6	6.4	6.6
(range)	5.0-7.3	5.6-7.5	5.8-7.5	5.9-7.5	5.5-7.5	6.2-7.5
	Mid Tech Paper Effluent - May 25, 1983					
pH	7.3	7.7	8.1	8.2	8.2	8.2
(range)	7.3-7.4	7.6-7.7	8.0-8.2	8.1-8.2	8.2-8.3	8.2-8.3
Initial DO (mg/l)	5.9	7.0	7.6	7.4	7.6	7.8
(range)	5.4-6.3	6.5-7.3	7.6-7.8	7.1-7.9	7.2-8.2	7.6-8.3
Final DO (mg/l)	5.5	5.9	6.1	6.0	6.0	6.1
(range)	5.0-6.7	5.4-7.2	5.6-7.1	5.4-7.3	5.6-7.0	5.9-7.1

Table 26. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Green Bay Packaging Effluent - November 2, 1983					
pH	7.2	7.8	8.0	8.0	8.0	8.2
(range)	7.1-7.2	7.8-7.9	8.0-8.0	8.0-8.1	8.0-8.1	8.1-8.2
Initial DO (mg/l)	8.6	8.6	8.7	8.7	8.8	8.7
(range)	8.5-8.8	8.5-8.9	8.5-8.9	8.5-9.0	8.7-9.1	8.6-8.9
Final DO (mg/l)	6.1	6.1	6.4	6.4	6.6	6.7
(range)	5.9-6.4	6.0-6.3	6.3-6.6	6.3-6.6	6.5-6.8	6.6-7.0
	Proctor-Gamble Effluent - November 2, 1983					
pH	7.8	8.0	8.0	8.0	8.1	8.2
(range)	7.8-7.8	7.8-8.0	7.8-8.0	8.0-8.1	8.0-8.1	8.1-8.2
Initial DO (mg/l)	8.6	8.6	8.7	8.8	8.8	8.7
(range)	8.5-9.0	8.4-8.9	8.6-8.9	8.6-9.0	8.6-9.0	8.5-9.1
Final DO (mg/l)	6.5	6.3	6.2	6.2	6.4	6.4
(range)	6.3-7.0	6.2-6.6	5.9-6.6	6.0-6.3	6.3-6.6	6.3-6.7

Table 27. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Thilmany Paper Effluent - July 8, 1983					
pH	7.6	7.8	8.0	8.0	8.1	8.2
(range)	7.6-7.6	7.8-7.9	8.0-8.0	8.0-8.1	8.1-8.1	8.2-8.2
Initial DO (mg/l)	7.6	7.6	7.9	7.5	8.0	8.2
(range)	6.0-8.6	6.4-8.2	7.0-8.6	7.0-8.2	7.0-8.8	7.2-9.0
Final DO (mg/l)	6.5	6.5	6.6	6.5	6.6	6.6
(range)	6.0-6.9	6.2-6.8	6.2-6.9	6.1-6.8	6.1-7.3	6.1-7.4
	James River Paper Effluent - November 2, 1983					
pH	8.0	8.1	8.1	8.2	8.2	8.2
(range)	8.0-8.0	8.1-8.1	8.1-8.1	8.1-8.2	8.2-8.2	8.1-8.2
Initial DO (mg/l)	8.5	8.6	8.6	8.6	8.8	8.7
(range)	8.1-8.8	8.5-8.8	8.4-8.9	8.4-8.8	8.6-9.1	8.6-9.0
Final DO (mg/l)	6.3	6.4	6.4	6.4	6.4	6.5
(range)	6.2-6.5	6.3-6.6	6.3-6.6	6.3-6.8	6.3-6.7	6.3-6.8

Table 28. Water quality data for the effluent toxicity tests on fathead minnows.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Nicolet Paper Effluent - July 8, 1983					
pH	7.6	8.0	8.3	8.4	8.4	8.5
(range)	7.5-7.6	8.0-8.1	8.3-8.4	8.3-8.4	8.4-8.5	8.4-8.5
Initial DO (mg/l)	6.6	7.3	8.1	8.4	8.4	8.4
(range)	5.7-7.2	6.4-7.8	6.9-8.7	7.2-8.8	7.5-8.9	7.6-9.0
Final DO (mg/l)	5.8	6.0	6.1	6.5	6.6	6.6
(range)	5.1-6.3	5.5-6.6	5.0-6.9	6.0-7.0	6.1-7.1	6.4-6.9
	Wisconsin Tissue Effluent - July 8, 1983					
pH	8.0	8.0	8.1	8.0	8.1	8.1
(range)	7.9-8.0	8.0-8.1	8.1-8.2	8.0-8.1	8.1-8.2	8.1-8.2
Initial DO (mg/l)	8.1	8.1	8.3	8.3	8.5	8.5
(range)	6.2-8.8	6.3-8.7	6.5-8.9	6.8-9.0	7.0-9.0	7.2-8.9
Final DO (mg/l)	6.4	6.3	6.2	6.9	6.4	6.5
(range)	5.1-6.9	5.0-6.8	5.0-6.9	6.6-7.4	5.0-7.6	5.0-7.7

Table 29. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Nicolet Paper Effluent - July 8, 1983					
pH	7.6	8.0	8.3	8.4	8.4	8.5
(range)	7.5-7.6	8.0-8.1	-	8.3-8.4	8.4-8.5	8.4-8.5
DO[a] (mg/l)	6.9	7.2	6.9	7.2	7.2	7.3
(range)	6.8-7.3	7.0-7.6	6.6-7.3	7.1-7.5	7.0-7.5	7.1-7.5
	Wisconsin Tissue Effluent - July 8, 1983					
pH	8.0	8.0	8.1	8.0	8.1	8.1
(range)	7.9-8.0	8.0-8.1	-	8.0-8.1	8.1-8.2	8.1-8.2
DO[a] (mg/l)	7.4	6.5	7.2	6.9	6.8	7.0
(range)	7.2-7.7	6.1-6.9	6.2-7.5	6.1-7.6	6.1-7.3	6.0-7.6

[a] Final daily value

Table 30. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	James River Paper Effluent - November 2, 1983					
pH	8.0	8.1	8.1	8.2	8.2	8.2
(range)	8.0-8.0	8.1-8.1	8.1-8.1	8.1-8.2	8.2-8.2	8.1-8.2
DO[a] (mg/l)	6.4	6.6	6.5	6.4	6.6	6.6
(range)	6.3-6.6	6.5-6.7	6.4-6.6	6.2-6.5	6.5-6.8	6.5-6.9
	Thilmany Paper Effluent - July 8, 1983					
pH	7.6	7.8	8.0	8.0	8.1	8.2
(range)	-	7.8-7.9	-	8.0-8.1	-	-
DO[a] (mg/l)	7.0	7.1	7.0	6.9	6.8	6.6
(range)	6.8-7.3	6.9-7.5	6.6-7.5	6.8-7.4	6.7-7.2	5.6-7.3

[a] Final daily value

Table 31. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Green Bay Packaging Effluent - November 2, 1983					
pH	7.2	7.8	8.0	8.0	8.0	8.2
(range)	7.1-7.2	7.8-7.9	8.0-8.0	8.0-8.1	8.0-8.1	8.1-8.2
DO[a] (mg/l)	6.6	6.4	6.5	6.5	6.8	7.0
(range)	6.5-7.0	6.3-6.6	6.4-6.8	6.3-6.9	6.6-7.0	6.9-7.2
	Proctor-Gamble Effluent - November 2, 1983					
pH	7.8	8.0	8.0	8.0	8.1	8.2
(range)	7.8-7.8	7.8-8.0	7.8-8.0	8.0-8.1	8.0-8.1	8.1-8.2
DO[a] (mg/l)	7.3	6.8	7.1	7.1	7.1	7.2
(range)	-	6.6-7.1	7.0-7.4	7.0-7.3	7.0-7.3	7.0-7.7

[a] Final daily value

Table 32. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Kimberly Clark-J Effluent - June 15, 1983					
pH	7.9	8.1	8.1	8.2	8.2	8.2
(range)	7.8-8.0	8.0-8.2	8.0-8.3	8.0-8.3	8.1-8.3	8.1-8.3
DO[a] (mg/l)	7.3	7.5	7.4	7.4	7.4	7.4
(range)	7.2-7.9	7.4-7.8	7.3-7.8	7.4-7.7	7.3-7.7	7.2-7.7
	Kimberly Clark-L Effluent - June 15, 1983					
pH	8.1	7.9	8.0	8.1	8.1	8.2
(range)	-	7.8-8.1	7.9-8.2	8.0-8.3	8.0-8.2	8.1-8.3
DO[a] (mg/l)	7.3	7.3	7.4	7.4	7.5	7.6
(range)	7.2-7.5	7.3-7.5	7.3-7.4	7.3-7.5	7.4-7.7	7.5-7.7

[a] Final daily value

Table 33. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Mid Tech Paper Effluent - May 25, 1983					
pH	7.3	7.7	8.1	8.2	8.2	8.2
(range)	7.3-7.4	7.6-7.7	8.0-8.2	8.1-8.2	8.2-8.3	8.2-8.3
DO[a] (mg/l)	5.9	6.0	6.5	6.6	6.6	6.8
(range)	5.8-6.0	5.9-6.1	6.5-6.7	6.4-6.7	6.5-6.8	6.7-7.0
	Bergstrom Paper Effluent - June 15, 1983					
pH	8.6	8.3	8.2	8.3	8.2	8.3
(range)	8.5-8.6	8.1-8.5	8.1-8.5	8.2-8.4	8.2-8.4	8.2-8.3
DO[a] (mg/l)	7.3	7.3	7.3	7.3	7.4	7.5
(range)	7.3-7.4	7.2-7.5	7.2-7.5	7.2-7.5	7.3-7.5	7.3-7.9

[a] Final daily value

Table 34. Water quality data for the effluent toxicity tests on *Ceriodaphnia dubia/affinis*.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Kerwin Paper Effluent - May 25, 1983					
pH	7.4	7.6	8.0	8.2	8.2	8.3
(range)	-	-	-	8.1-8.2	8.2-8.3	8.3-8.4
DO[a] (mg/l)	6.7	7.1	7.0	7.1	7.1	7.3
(range)	-	-	6.8-7.2	7.0-7.5	7.0-7.5	7.1-7.6
	Appleton Paper Effluent - May 25, 1983					
pH	7.5	7.8	7.9	8.1	8.2	8.2
(range)	7.5-8.0	7.7-8.0	7.9-8.1	8.0-8.2	8.1-8.4	8.2-8.4
DO[a] (mg/l)	6.7	7.0	6.9	6.3	6.1	6.3
(range)	6.5-7.8	6.8-8.0	6.5-8.1	5.9-8.0	5.8-8.0	6.0-8.1

[a] Final daily value

Table 35. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Kerwin Paper (2) Effluent - January 26, 1984					
pH	7.7	7.7	7.7	7.9	8.1	8.1
(range)	7.7-7.7	7.7-7.8	7.7-7.7	7.9-8.0	8.0-8.1	8.1-8.1
DO[a] (mg/l)	5.0	5.6	6.0	6.4	6.4	6.4
(range)	4.9-5.1	5.5-5.7	5.9-6.1	6.4-6.4	6.3-6.5	6.4-6.5
	Mid Tech (2) Effluent - January 26, 1983					
pH	8.0	8.1	8.1	8.1	8.1	8.2
(range)	8.0-8.0	8.0-8.1	8.1-8.1	8.1-8.1	8.1-8.2	8.2-8.2
DO[a] (mg/l)	6.4	6.4	6.5	6.5	6.7	6.7
(range)	6.4-6.5	6.4-6.5	6.4-6.6	6.5-6.7	6.6-6.8	6.7-6.8

[a] Final daily value

Table 36. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Fort Howard Paper Fffluent - January 12, 1984					
pH	8.0	8.1	8.2	8.2	8.2	8.2
(range)	8.0-8.1	8.1-8.2	8.2-8.2	8.2-8.2	8.2-8.2	8.2-8.2
DO[a] (mg/l)	6.2	6.5	6.6	6.8	6.9	6.9
(range)	5.7-6.8	6.5-6.7	6.3-7.3	6.4-8.0	6.5-7.9	6.4-8.1
	Green Bay STP Effluent - January 26, 1984					
pH	7.3	7.8	8.0	8.0	8.1	8.2
(range)	7.3-7.3	7.8-7.8	7.9-8.0	8.0-8.0	8.1-8.1	8.2-8.2
DO[a] (mg/l)	6.4	6.5	6.3	6.4	6.6	6.4
(range)	-	-	6.3-6.4	6.3-6.5	6.6-6.7	6.3-6.5

[a] Final daily value

Table 37. Water quality data for the effluent toxicity tests on Ceriodaphnia dubia/affinis.

	Percent Effluent Concentrations (vol/vol)					
	100	50	25	12.5	6.25	Control
Mean	Neenah-Menasha STP Effluent - January 12, 1984					
pH	8.1	8.0	8.2	8.2	8.2	8.2
(range)	8.1-8.1	7.9-8.1	8.2-8.2	8.2-8.2	8.2-8.2	8.2-8.2
DO[a] (mg/l)	6.9	6.9	6.8	6.8	6.9	7.1
(range)	6.2-8.0	6.3-7.9	6.3-8.1	6.3-8.1	6.4-8.1	6.7-8.1
	Appleton STP Effluent - January 12, 1984					
pH	7.9	8.1	8.1	8.2	8.2	8.2
(range)	7.9-8.0	8.1-8.1	8.1-8.1	8.2-8.2	8.2-8.2	8.2-8.3
DO[a] (mg/l)	7.0	6.3	6.3	6.5	6.5	6.6
(range)	5.9-7.7	5.7-7.8	5.7-7.8	6.0-7.9	6.0-8.0	6.1-8.0

[a] Final daily value

Table 38. Water quality data for ambient toxicity tests on fathead minnows using Fox River water.

Mean	Sampling Station 1	2	3	4	5	6	7	8	9	10	Control
March 24, 1983											
pH	8.0	8.0	8.1	8.1	8.1	8.0	7.9	8.0	8.0	8.1	7.5
(range)	7.9-8.2	8.0-8.2	7.9-8.2	8.0-8.2	8.0-8.2	8.0-8.3	7.8-8.0	8.0-8.1	8.0-8.2	8.1-8.2	7.4-7.8
Initial DO (mg/l)	8.5	8.5	8.3	8.5	8.5	8.4	8.6	8.6	8.6	8.5	8.4
(range)	8.0-8.9	7.9-9.0	7.6-8.8	8.0-9.0	7.9-9.0	7.6-9.0	8.0-9.0	7.9-9.3	7.7-9.3	7.2-9.6	7.8-8.8
Final DO (mg/l)	6.4	6.5	6.4	6.0	6.0	6.1	5.9	6.0	6.4	6.1	6.2
(range)	6.1-6.9	6.0-6.9	5.9-6.8	5.8-6.3	5.6-6.4	5.8-6.5	5.3-6.3	5.6-6.4	5.8-7.3	5.5-7.1	5.4-6.8
April 15, 1983											
pH	8.0	8.2	8.2	8.1	8.2	8.2	8.3	8.2	8.4	8.3	7.7
(range)	8.0-8.2	8.2-8.4	8.2-8.3	8.0-8.3	8.1-8.4	8.1-8.3	8.2-8.4	8.2-8.3	8.3-8.4	8.3-8.5	7.7-7.8
Initial DO (mg/l)	8.7	8.5	8.8	8.5	8.6	8.7	8.5	8.5	8.5	8.6	8.6
(range)	8.5-8.9	7.4-9.0	8.6-9.0	7.6-9.0	7.6-9.0	8.5-9.0	7.9-8.8	7.8-8.8	7.9-8.8	8.2-8.8	8.4-8.8
Final DO (mg/l)	6.5	6.4	6.6	6.3	5.8	6.1	6.4	6.4	6.6	6.5	6.3
(range)	5.8-7.1	5.8-7.2	6.1-7.4	5.7-7.2	4.7-7.2	5.6-7.1	5.3-7.0	5.9-7.1	5.9-7.1	6.0-6.7	6.0-6.7
April 29, 1983											
pH	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	7.6
(range)	8.3-8.5	8.4-8.6	8.3-8.5	8.3-8.6	8.4-8.7	8.3-8.7	8.3-8.6	8.2-8.7	8.4-8.7	8.3-8.7	7.4-7.9
Initial DO (mg/l)	8.6	8.6	8.5	8.7	8.6	8.5	8.5	8.6	8.5	8.6	8.5
(range)	8.3-8.9	8.3-8.8	7.9-8.9	8.5-8.8	8.2-8.8	8.0-9.0	8.3-8.8	8.4-8.8	7.8-8.8	7.8-9.0	8.4-8.8
Final DO (mg/l)	6.9	7.1	7.1	7.1	7.0	6.8	6.9	6.1	6.5	6.5	6.6
(range)	6.0-7.6	6.8-7.6	6.4-7.8	6.2-7.8	6.3-7.6	5.9-7.9	5.9-7.7	5.4-6.8	5.4-7.2	5.3-7.5	5.6-7.6

Table 39. Water quality data for ambient toxicity tests on Ceriodaphnia dubia/affinis using Fox River water.

Mean	Sampling Station 1	2	3	4	5	6	7	8	9	10	Control
March 24, 1983											
pH	8.0	8.0	8.1	8.1	8.1	8.0	7.9	8.0	8.0	8.1	7.5
(range)	7.9-8.2	8.0-8.2	7.9-8.2	8.0-8.2	8.0-8.2	8.0-8.3	7.8-8.0	8.0-8.1	8.0-8.2	8.1-8.2	7.4-7.8
Dissolved Oxygen[a] (mg/l)	7.1	7.3	7.2	7.2	7.3	7.3	7.3	7.2	7.2	7.4	7.1
(range)	6.3-7.9	6.9-7.6	6.9-7.6	6.9-7.5	7.1-7.5	7.1-7.5	6.8-8.0	6.9-7.5	7.1-7.5	7.3-7.8	6.3-7.5
April 15, 1983											
pH (range)	Test discontinued due to glassware contamination										
Dissolved Oxygen[a] (mg/l) (range)											
April 29, 1983											
pH	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	7.6
(range)	8.3-8.5	8.4-8.6	8.3-8.5	8.3-8.6	8.4-8.7	8.3-8.7	8.3-8.6	8.2-8.7	8.4-8.7	8.3-8.7	7.4-7.9
Dissolved Oxygen[a] (mg/l)	7.6	7.5	7.5	7.6	7.4	7.4	7.2	7.3	7.4	7.3	7.5
(range)	7.4-8.0	7.1-7.8	7.3-7.9	7.4-8.0	7.2-7.6	7.1-7.8	7.1-7.6	7.2-7.5	7.1-7.8	7.0-7.6	7.3-7.9

[a] Final daily value

Figure 1. Fox River Stations

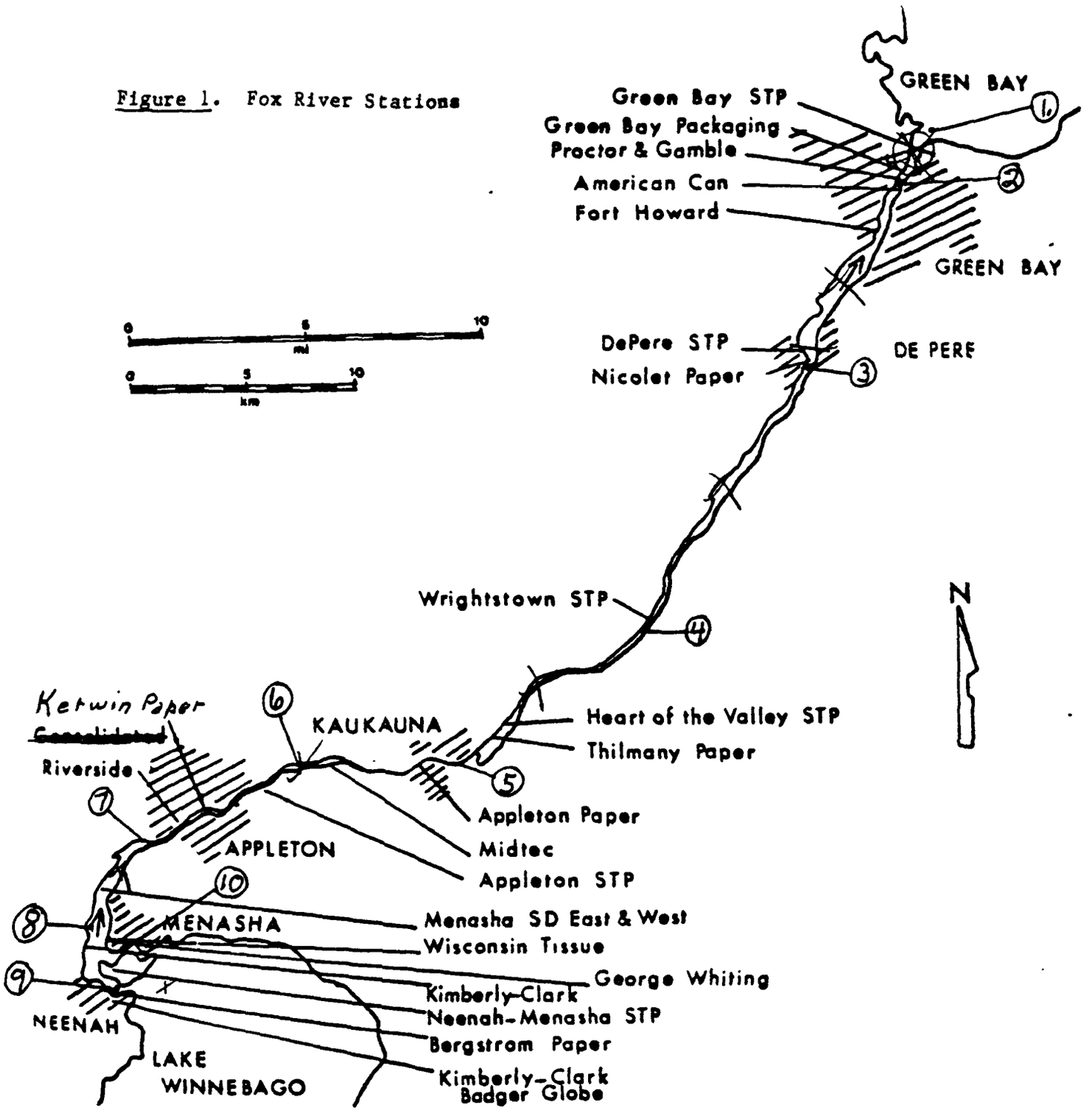

Figure 1. Municipal and Industrial Waste Discharges to the Lower Fox River.