FREEDOM PHOPHORUS BAN STUDY - DUCK CREEK

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GENERAL INFORMATION

Drainage Basin: Duck Creek - 120

Receiving Stream: Duck Creek

Classification of Receiving Stream: Noncontinuous, Intermediate Aquatic Life

Study Reach Location: Sections 1, 2, and 11; T22N, R18E, Freedom Township

Point Source: Village of Freedom Publicly Owned Treatment Works, Outagamie Co.

Survey Dates: 7-30, 31-79; 7-17, 18-80; 7-22, 23-81

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SUMMARY AND CONCLUSIONS

1. A phosphorus study was conducted on Duck Creek relative to the Village of Freedom Publicly Owned Treatment Works (POTW) to measure possible changes in phosphorus loading and algal biomass before and after the implimentation of the State of Wisconsin's phosphorus ban which went into effect in July 1979.

2. Monthly 3-hour composite total phosphorus influent and effluent samples were taken of the POTW (beginning July 1979). Total and dissolved phosphorus surveys were conducted in Duck Creek relative to the Village of Freedom POTW once in July 1979, 1980, and 1981. Samples were collected up to 2.5 miles below the POTW. Periphyton samples were collected once during each of the summers of 1979, 1980, and 1981 to measure any possible effect of the ban on algal biomass.

3. The July 1979 24-hour survey is assumed to be the pre-ban 24-hour survey with the July 1980 and July 1981 surveys being post-ban surveys. Pre-July 1979 POTW influent and effluent data are assumed to be pre-ban data. All conclusions listed below are based upon the validity of these assumptions.

4. No significant changes were found in total phosphorus loading to the POTW or total phosphorus loading to Duck Creek from the POTW after implimentation of the ban. Data may be of insufficient amount (especially pre-ban data) to obtain conclusive results.

5. No significant changes were found in total or dissolved phosphorus loading to Duck Creek during the 1980 and 1981 stream surveys as compared to the 1979 survey. These data may also be of insufficient amount (especially pre-ban data) to obtain conclusive results.

6. Periphyton data are too variable and of insufficient amount (pre-ban data as well as downstream data) to obtain definite conclusive results.

7. If the phosphorus ban is extended I suggest this study be extended and expanded to fill data gaps. I suspect at least 3 more years of data are needed to determine if trends exist.

OBJECTIVE

The objective of this phosphorus ban study of Duck Creek in relation to the Village of Freedom Publicly Owned Treatment Works was to determine the effect of phosphorus loading on Duck Creek before and after the establishment of State Statute Chapter 375 Section 100.28 (phosphorus ban) in July 1979.

INTRODUCTION

Phosphorus is one of the nutrients present in surface waters and is an important component of the metabolism of aquatic plants and algae. Phosphorus is a well known limiting nutrient of the growth of aquatic plants. This means that if phosphorus is lowered a significant degree the amount of algae growth should be lowered a significant degree (i.e. the growth of algae should be limited).

In 1978 Assembly Bill 881 was enacted to prohibit the sale ". . . of cleaning agents and water conditioners with specific phosphorus concentrations . . ." within the State of Wisconsin. Therefore from July 1, 1979 to June 30, 1981 a limited ban on phosphorus in cleaning agents was in effect.

It was felt that limiting the amount of phosphorus this way going to publicly owned treatment works (POTW) would limit the phosphorus load to the surface waters of the state. This study of Duck Creek in relation to the Freedom POTW was conducted to measure the effect, if any, of the phosphorus ban on the aquatic environment of Duck Creek.

The Freedom POTW is an activated sludge plant. A polishing pond is used to treat the effluent from the activated sludge plant prior to discharge to Duck Creek. Freedom Sanitary District No. 1 has secondary limits (Table 1) and no phosphorus limits.

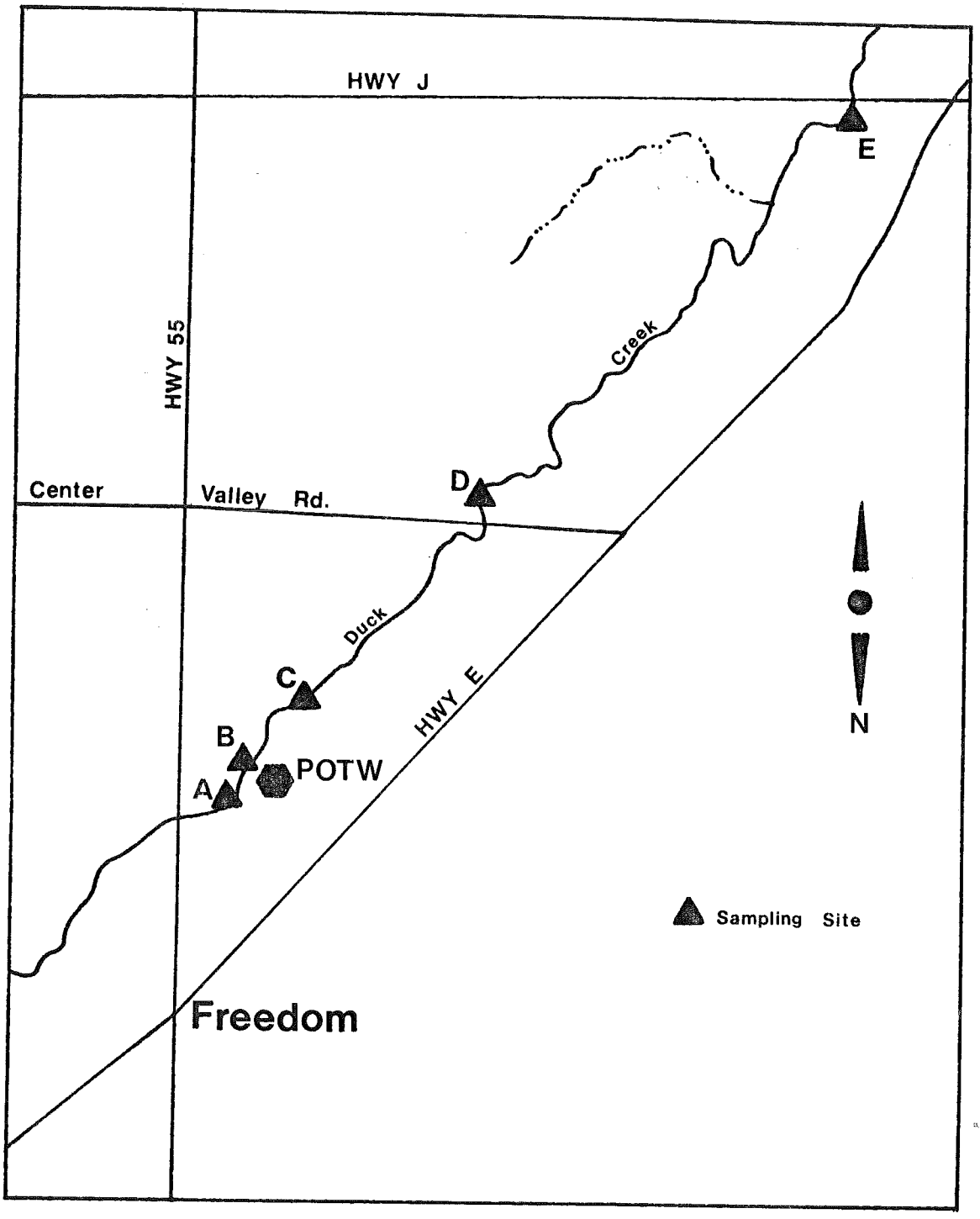
Table 1. WPDES effluent limits for Freedom Sanitary District No. 1.

Parameter	Monthly Average	Weekly Average	Minimum	Maximum
BOD_5 (mg/l)	30	45	-	-
SS (mg/l)	30	45	-	-
pH (s.u.)	-	-	6.0	9.0

DESCRIPTION OF STUDY AREA

Duck Creek is intermittent is the study area (Figure 1). During the 3 sampling surveys conducted for this study (July 30-31, 1979; July 17-18, 1980; and July 22-23, 1981) Duck Creek was dry above the Freedom POTW. In most of

Figure 1. Study area.



the study reach of Duck Creek the stream substrate was 90-100 percent bedrock. This could be seen very vividly at HWY 55 above the POTW during the surveys when there was no flow. The stream bottom looked like a large very irregular layer of cement.

Photographs taken of the study area on September 3, 1981 are in Appendix B. It appears non-point source runoff may be a significant factor above and within the study area. However it was not a factor during any of the 3 stream surveys because flow was nonexistent above the POTW.

Duck Creek was primarily a mixture of approximately 25 percent riffles and 75 percent pools in the upper reaches of the study area and nearly entirely a slow moving pool area at HWY J.

STUDY METHODOLOGY

A map of the study area is in Figure 1 with a table of the sampling site descriptions in Table 2. The study reach extends from HWY 55 above the Village of Freedom POTW to HWY J 2.5 miles below the POTW.

Table 2. Sampling site descriptions for the 3 24-hour surveys.

Site	Description
A	Duck Creek above the POTW (site not sampled because of no flow)
B	Freedom POTW
C	Duck Creek-mix point below POTW
D	Duck Creek-200 feet below Center Valley Road
E	Duck Creek at HWY J

Three 24-hour physical/chemical surveys (July 30-31, 1979; July 17-18, 1980; and July 22-23, 1981) were conducted whereby water samples were collected from each sample point every 3.5 to 4 hours (except site 1 which was dry during all sampling periods) and immediately iced. Temperature and dissolved oxygen (D.O.) analyses were conducted on-site. At the end of the 24-hour period samples were iced and sent to the State Laboratory of Hygiene for dissolved phosphorus (dis-P), total phosphorus (tot-P), and lab pH analyses. Once during each 24-hour survey the POTW average flow for the 24-hours was recorded and stream flow measurements were taken at sites C and D during the July 1979 and 1981 surveys.

Once a month for several months during the past 3 years the Village of Freedom POTW operator collected a tot-P influent and effluent 3-hour composite sample (11:00; 12:00; and 13:00). These samples were iced and sent to the State Laboratory of Hygiene for tot-P analyses. Flow in GPD was recorded at the time of each sampling.

Each of the 3 years periphyton samplers (Periphytometer II made by Design Alliance Inc. of Cincinnati, Ohio) were placed in the stream at sites C and D for an

approximately 2 week incubation period. Samplers were placed in the stream during the 24-hour surveys. An additional sampler was placed in the stream at site E during the summer of 1981. Each sampler contained 8 slides. After each incubation period 4 slides from each site (every other slide) was placed into mailers, iced with dry ice, and sent to the State Laboratory of Hygiene for chlorophyll analyses.

RESULTS AND DISCUSSION

The chemical and physical results from the July 30-31, 1979; July 17-18, 1980; and July 22-23, 1981 24-hour surveys are in Tables A1-A3 and A6 in Appendix A. The average daily tot-P and dis-P data in mg/l and lbs/day for the 3 24-hour surveys are in Table 3. The tot-P (lbs/day) and dis-P (lbs/day) vs miles downstream from the POTW for the 3 24-hour surveys are in Figures 1 and 2.

Since the phosphorus ban went into effect in July 1979 the assumption made for the purposes of this report is that the July 30-31, 1979 24-hour survey is considered the pre-ban survey while the July 17-18, 1980 and July 22-23, 1981 surveys are post-ban surveys. The pre-July 1979 influent and effluent POTW data are considered pre-ban data.

During all 24-hour surveys all flow in Duck Creek was due to the POTW discharge since Duck Creek was dry above the outfall. Streamflow data obtained during the 24-hour surveys are too variable and may be inaccurate. Therefore all loading calculations for each stream survey site were calculated using the 24-hour average POTW flow. The concentrations and loads of tot-P and dis-P decreased by approximately 90 percent by the time the effluent reached site E at HWY J which was 2.5 miles downstream from the POTW. Heavy planktonic algae growth as well as periphyton growth was evident from the POTW throughout most of the study reach (particularly the upper reaches). The stream data collected on all 3 surveys indicate dis-P made up a major portion of the tot-P. Therefore it is apparent the large drop in P was primarily due to algal uptake.

Though a drop in the tot-P load in the effluent occurred between the 1979 and 1980, and the 1979 and 1981 24-hour surveys (Table 4) the changes were only 5 percent and 8 percent respectively which can be considered insignificant changes. Assuming the amount of data is sufficient there has been no significant change in tot-P loads in Duck Creek due to the Freedom POTW.

There were large decreases in tot-P loads between the 1979 and 1980, and between the 1979 and 1981 24-hour surveys at site D (Table 4 and Figure 1). Since the change in tot-P to Duck Creek from the POTW was assumed to be insignificant between surveys and the only tot-P load to Duck Creek appears to be from the POTW within the study reach these decreases in tot-P at site D between 1979 and 1980, and 1979 and 1981 are probably due to differences in primary productivity between surveys in Duck Creek above site D.

A graph of the corrected chlorophyll a (mg/m^2) vs miles downstream from the POTW is in Figure 5 (the data are in Table A5 of Appendix A). Periphyton data are too variable and of insufficient amount to make definite conclusions.

The POTW influent and effluent tot-P data collected by the operator are in Table A4 of Appendix A. The effluent data are graphed (tot-P lbs/day vs month) in Figure 4. This graph illustrates data are highly variable. The average influent and effluent tot-P (lbs/day) are in Table 5 with percentage change between pre-ban and post ban data. No change was found in influent data and only a 3 percent drop was found in effluent data after the ban.

Table 3. The average tot-P and dis-P in mg/l and lbs/day for the 3 24-hour surveys.

	Site											
	B			C			D			E		
Parameter	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Tot-P (mg/l)	5.6	4.5	4.2	4.7	4.8	3.8	3.7	1.39	1.9	0.56	0.80	0.52
Tot-P (lbs/day)	3.9	3.7	3.6	3.3	3.9	3.2	2.7	1.14	1.59	0.39	0.65	0.44
Dis-P (mg/l)	4.6	2.9	3.5	4.0	3.0	3.2	3.0	0.89	1.49	0.37	0.41	0.33
Dis-P (lbs/day)	3.3	2.3	3.0	2.8	2.4	2.7	2.2	0.72	1.25	0.26	0.33	0.28

Table 4. Percent increase or decrease in tot-P (lbs/day) at sites B-E between 1979 and 1980, and between 1979 and 1981 (24-hour stream survey data).

	Site			
Comparison	B	C	D	E
1979-80 % Change in Tot-P	-5	+18	-58	+67
1979-81 % Change in Tot-P	-8	-3	-41	+15

Table 5. Average influent and effluent tot-P at the Freedom POTW before and after the implimentation of the phosphorus ban (i.e. before and after July 1979).

	Before July 1979*	After July 1979+	% Change
Avg. Influent Tot-P (lbs/day)	11.5	11.5	0
Avg. Effluent Tot-P (lbs/day)	3.5	3.4	-3

*Based on 5 3-hour composite samples.
+Based on 11 3-hour composite samples.

Figure 2. Tot-P (lbs/day) vs miles downstream from the POTW for the 3 24-hour surveys.

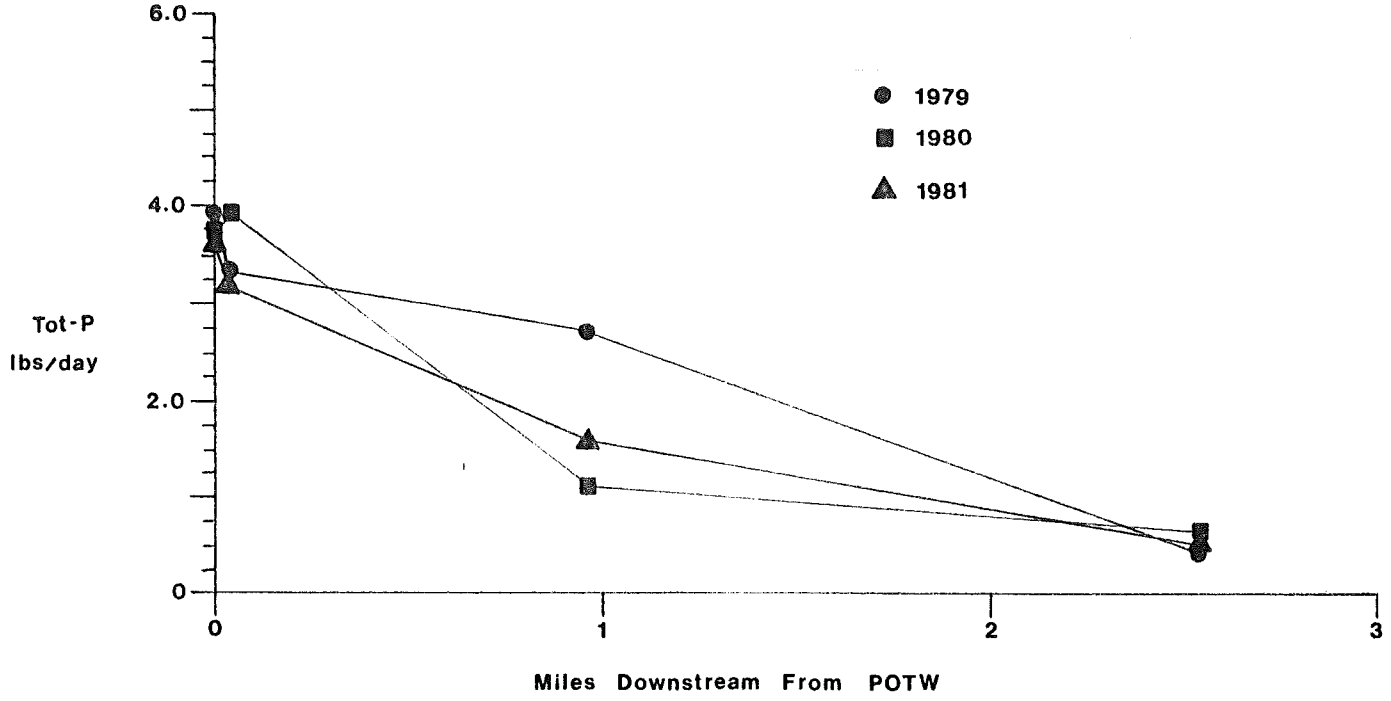


Figure 3. Dis-P (lbs/day) vs miles downstream from the POTW for the 3 24-hour surveys.

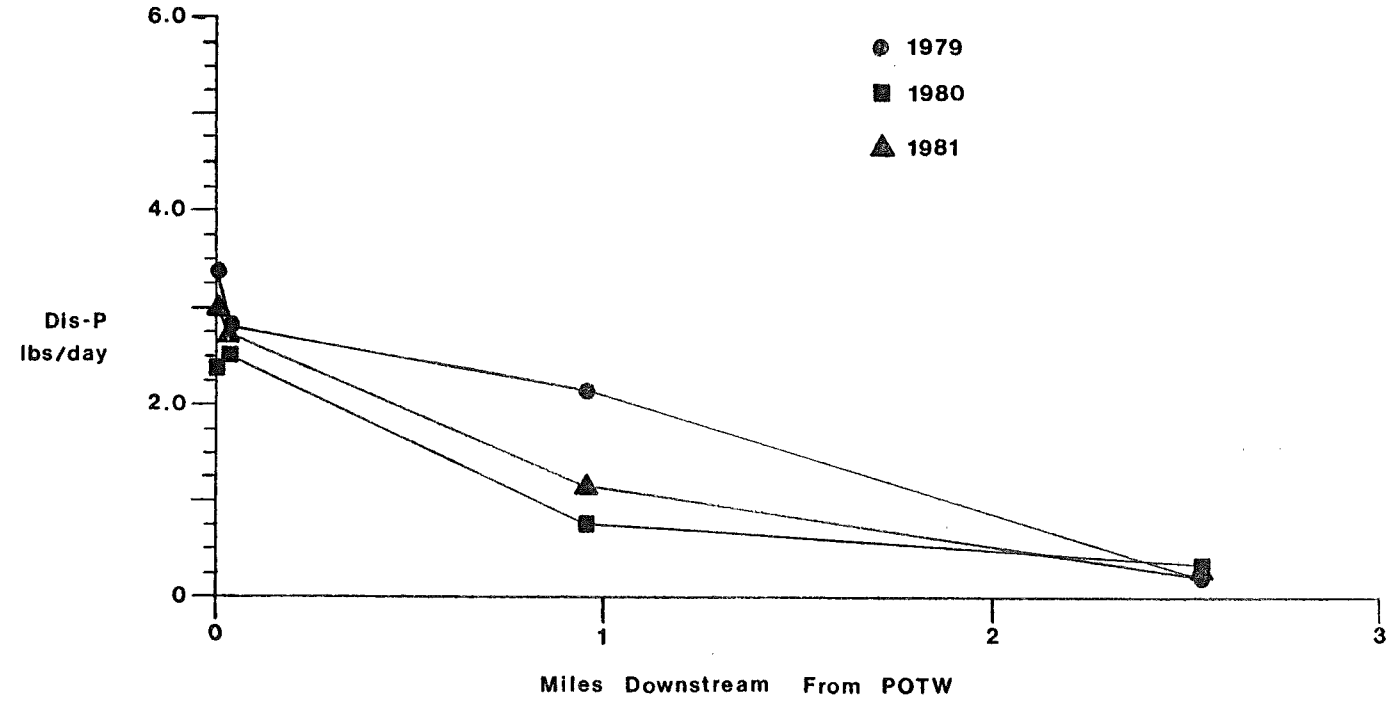


Figure 4. Monthly POTW effluent tot-P (lbs/day).

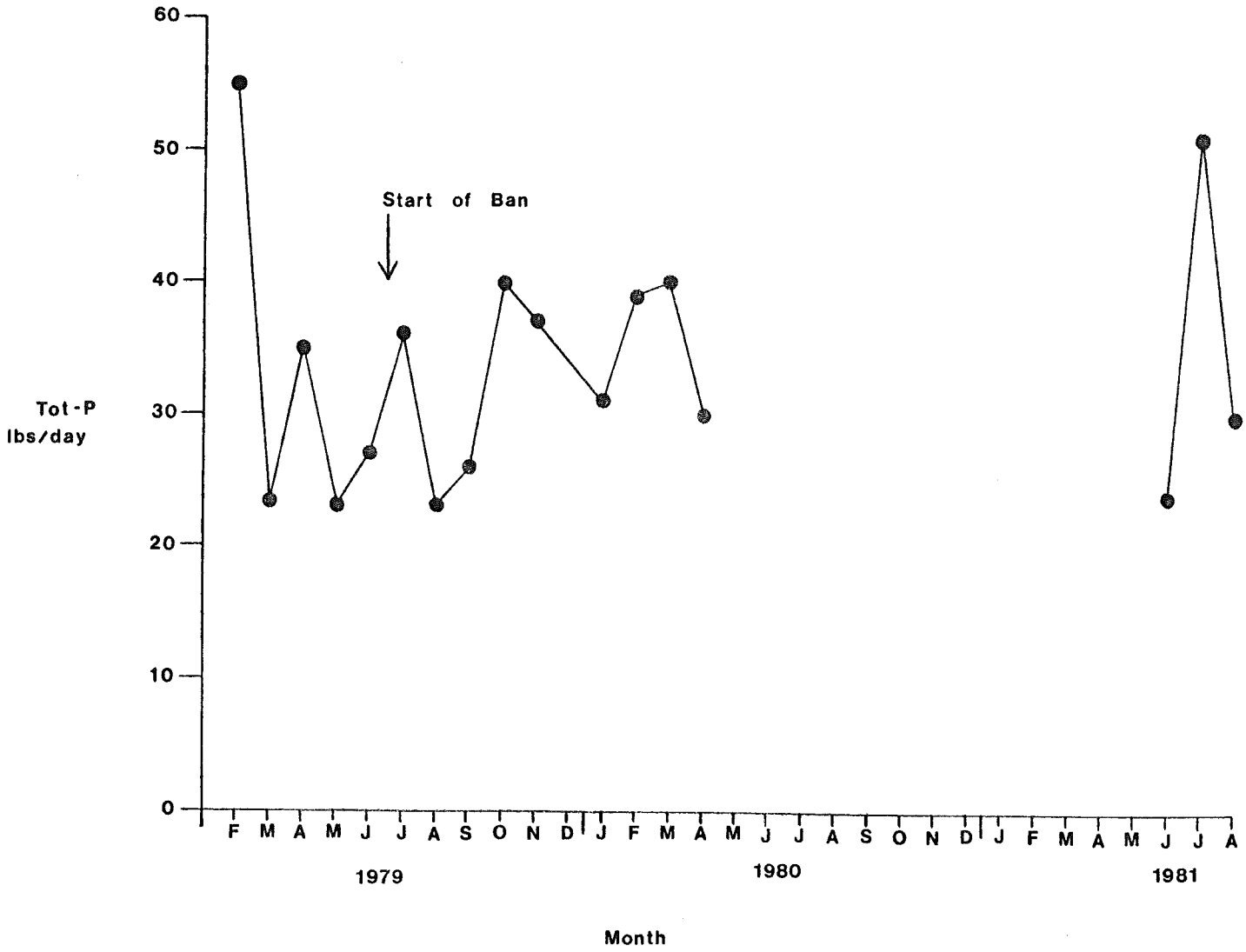
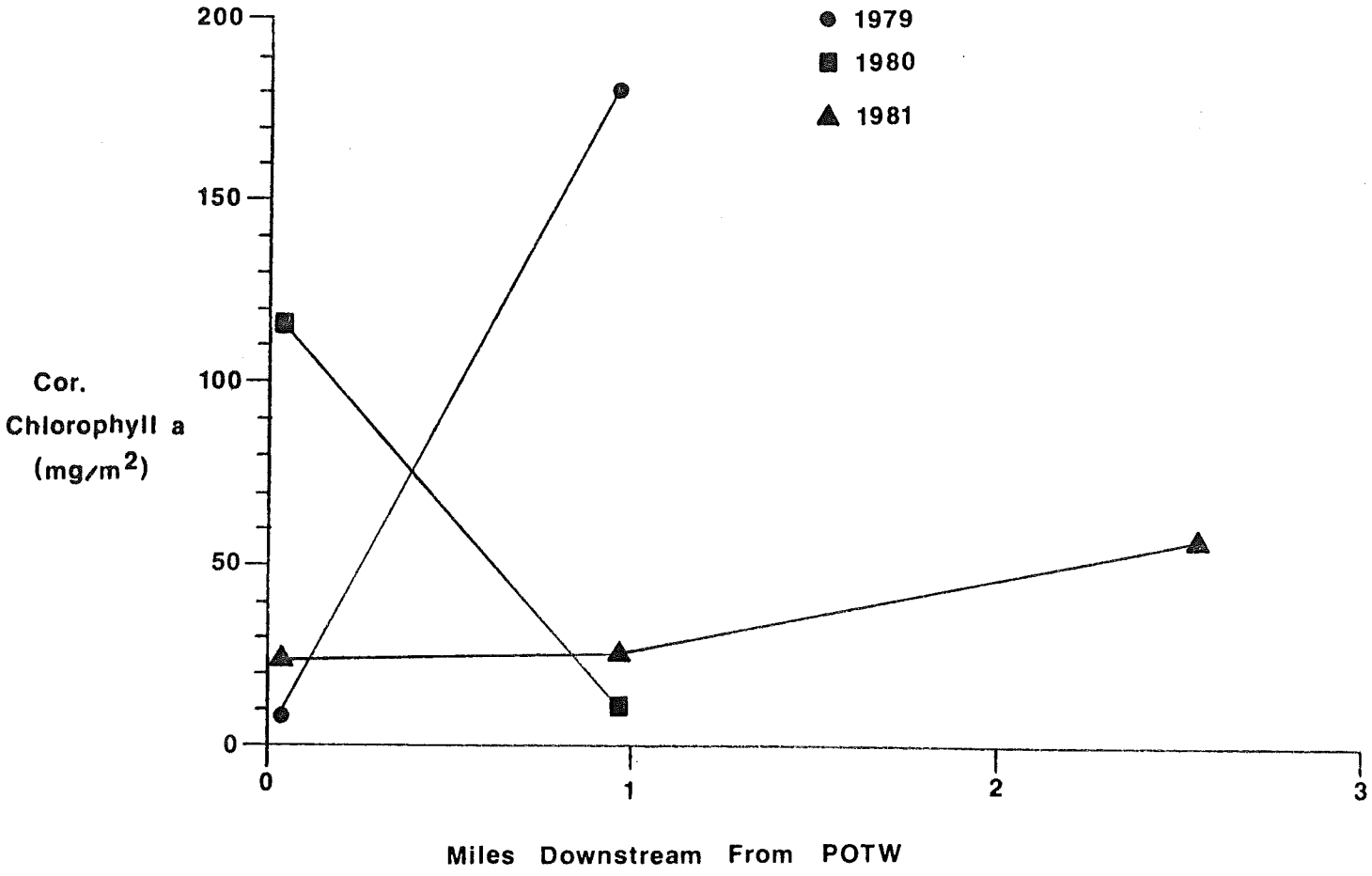


Figure 5. Corrected chlorophyll (mg/m^2) vs miles downstream from the POTW for the summers of 1979, 1980, and 1981.



APPENDIX A

Table A1. July 30-31, 1979 24-hour survey.

	Site B						Site C						Site D						Site E					
Parameter	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6
Time	10:18	14:25	18:35	22:40	02:15	06:03	10:30	14:35	18:40	22:45	02:22	06:05	10:45	14:40	18:20	22:20	02:40	06:25	11:00	14:50	18:10	22:10	03:00	06:35
Water Temp. (°C)	19	19	18	19	19	19	18	21	21	20	19	19	20	21	23	23	21	20	21	24	26	25	23	22
D.O. (mg/l)	5.0	5.5	5.0	5.4	5.4	5.2	1.5	2.6	0.4	1.0	0.8	0.7	3.1	8.2	5.3	0.9	0.9	0.9	5.1	6.8	8.4	7.9	6.4	4.3
Lab pH (s.u.)	8.2	8.4	8.4	8.6	8.3	8.3	8.3	8.5	8.2	8.6	8.3	8.3	7.9	8.6	8.6	8.6	8.3	8.4	7.9	8.0	8.6	8.4	8.4	8.5
Tot-P (mg/l)	5.8	5.4	5.8	5.6	5.4	5.4	5.4	3.4	4.4	4.8	5.0	5.2	3.8	3.5	3.6	3.5	4.2	3.7	0.46	0.44	0.48	0.86	0.58	0.51
Tot-P (lbs/day)	4.1	3.8	4.1	4.0	3.8	3.8	3.8	2.4	3.1	3.4	3.5	3.7	2.7	2.5	2.6	2.5	3.0	2.6	0.32	0.31	0.34	0.61	0.41	0.36
Dis-P (mg/l)	4.5	4.4	4.6	4.8	4.6	4.6	4.5	2.9	3.6	4.1	4.3	4.4	3.2	2.9	2.7	2.9	3.1	3.2	0.31	0.34	0.38	0.45	0.37	0.38
Dis-P (lbs/day)	3.2	3.1	3.3	3.4	3.3	3.3	3.2	2.1	2.6	2.9	3.0	3.1	2.3	2.1	1.9	2.1	2.2	2.3	0.22	0.24	0.27	0.32	0.26	0.27

Table A2. July 17-18, 1980 24-hour survey.

	Site B							Site C							Site D							Site E						
Parameter	T1	T2	T3	T4	T5	T6	T7	T1	T2	T3	T4	T5	T6	T7	T1	T2	T3	T4	T5	T6	T7	T1	T2	T3	T4	T5	T6	T7
Time	10:45	14:00	16:15	19:45	23:50	03:50	08:01	-	14:05	16:20	19:50	23:55	03:55	08:05	11:20	14:20	16:41	20:05	23:40	04:15	08:20	11:45	14:30	16:50	20:15	23:30	04:25	08:25
Water Temp. (°C)	21	21	21	21	20	19	21	22	23	25	23	21	20	22	24	25	28	26	25	21	22	25	28	30	27	25	22	22
D.O. (mg/l)	3.6	3.7	3.9	3.5	2.4	1.7	2.3	0.7	1.9	2.8	1.1	1.2	0.8	1.4	2.1	4.2	5.5	4.1	2.4	1.9	2.3	6.0	7.8	9.2	8.2	6.0	4.7	4.7
Lab pH (s.u.)	8.1	7.8	8.1	7.5	7.7	7.7	7.8	8.0	8.1	8.1	7.9	7.7	7.6	7.7	8.1	8.4	8.5	8.2	8.4	8.1	8.0	8.7	8.8	8.7	8.9	8.9	8.6	8.6
Tot-P (mg/l)	5.1	5.1	5.2	4.4	4.1	3.6	3.7	5.0	5.0	5.0	4.5	4.7	4.9	4.4	1.40	1.45	1.50	1.20	1.35	1.35	1.50	0.74	0.74	0.76	0.70	1.16	0.76	0.76
Tot-P (lbs/day)	4.2	4.2	4.3	3.6	3.4	2.9	3.0	4.1	4.1	4.1	3.7	3.8	4.0	3.6	1.14	1.19	1.23	0.98	1.10	1.10	1.23	0.60	0.60	0.62	0.57	0.95	0.62	0.62
Dis-P (mg/l)	4.5	3.8	3.7	1.7	2.3	2.1	1.99	3.9	3.3	3.3	2.5	2.7	2.8	2.5	1.10	1.06	0.87	0.72	0.80	0.82	0.83	0.44	0.42	0.43	0.41	0.37	0.38	0.41
Dis-P (lbs/day)	3.7	3.1	3.0	1.4	1.9	1.7	1.63	3.2	2.7	2.7	2.0	2.2	2.3	2.0	0.90	0.87	0.71	0.59	0.65	0.67	0.68	0.36	0.34	0.35	0.34	0.30	0.31	0.34

Table A3. July 22-23, 1981 24-hour survey.

	Site B						Site C						Site D						Site E					
Parameter	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6	T1	T2	T3	T4	T5	T6
Time	09:29	12:45	16:49	20:45	00:42	04:50	09:35	12:50	16:53	20:49	00:47	04:54	09:53	13:23	17:06	21:03	01:02	05:07	10:05	13:32	17:15	21:13	01:12	05:16
Water Temp. (°C)	17	17	17	17	17	17	16	19	20	18	15	14	16	22	24	19	15	16	19	25	27	21	17	17
D.O. (mg/l)	5.1	-	-	-	-	-	4.4	-	-	-	-	-	1.8	-	-	-	-	-	6.0	-	-	-	-	-
Lab pH (s.u.)	8.0	7.9	8.0	8.0	7.9	8.0	8.0	8.1	8.2	8.0	7.9	7.9	8.4	8.7	9.0	8.8	8.5	8.3	8.6	8.7	8.8	8.8	8.7	8.6
Tot-P (mg/l)	3.9	3.9	4.3	4.3	4.7	4.3	4.0	3.7	3.5	3.5	3.9	4.0	2.0	2.0	1.85	1.75	1.80	1.85	0.59	0.52	0.48	0.51	0.51	0.51
Tot-P (lbs/day)	3.3	3.3	3.6	3.6	4.0	3.6	3.4	3.1	3.0	3.0	3.3	3.4	1.7	1.7	1.56	1.48	1.52	1.56	0.50	0.44	0.41	0.43	0.43	0.43
Dis-P (mg/l)	3.3	3.6	3.5	3.5	3.6	3.6	3.4	3.1	2.9	3.0	3.3	3.4	1.58	1.52	1.34	1.41	1.52	1.55	0.36	0.33	0.31	0.32	0.32	0.32
Dis-P (lbs/day)	2.8	3.0	3.0	3.0	3.0	3.0	2.9	2.6	2.4	2.5	2.8	2.9	1.33	1.28	1.13	1.19	1.28	1.31	0.30	0.28	0.26	0.27	0.27	0.27

Table A4. Monthly 3-hour composite influent and effluent total phosphorus data for the Freedom POTW.

		Influent		Effluent	
Date	MGD Flow	Total-P mg/l	Total-P lbs/day	Total-P mg/l	Total-P lbs/day
2-21-79	0.0780	8.9	5.8	8.4	5.5
3-26-79	0.1450	10.6	12.8	2.35	2.8
4-17-79	0.1500	11.8	14.8	3.5	4.4
5-15-79	0.1100	21.2	19.4	2.5	2.3
6-19-79	0.0850	6.6	4.7	3.78	2.7
Implimentation of phosphorus ban.					
7-17-79	0.0734	5.6	3.4	5.9	3.6
8-14-79	0.1053	7.0	6.1	2.65	2.3
9-18-79	0.0865	9.2	6.6	3.65	2.6
10-16-79	0.0940	10.9	8.5	5.15	4.0
11-20-79	0.0944	11.5	9.1	4.75	3.7
1-16-80	0.1703	3.0	4.3	2.2	3.1
2-20-80	0.1136	24.5	23.2	4.15	3.9
3-19-80	0.1102	15	13.8	4.3	4.0
4-16-80	0.1305	8.3	9.0	2.8	3.0
5-21-80	0.1269	48	50.8		
6-24-81	0.0918	6.0	4.6	3.2	2.4
7-8-81	0.0804	7.8	5.2	7.6	5.1
8-12-81	0.1022	6.0	5.1	3.5	3.0

Table A5. Chlorophyll data for the 1979, 1980, and 1981 surveys.

	Site C			Site D			Site E
Parameter	1979	1980	1981	1979	1980	1981	1981
Uncor. Chl. a (mg/m^2)	10.7	126	26	198.7	13	27	71
Pheophytin a (mg/m^2)	3.6	16	3	31.5	3	2	19
Cor. Chl. a (mg/m^2)	8.5	115	24	180.6	11	26	59

Table A6. POTW and stream flow data for the 3 summer 24-hour surveys.

	POTW	Site C	Site D
1979 Flow (MGD)	0.085	0.116	0.239
1980 Flow (MGD)	0.098	-	-
1981 Flow (MGD)	0.121	0.124	0.053

APPENDIX B

Duck Creek looking upstream from Hwy 55. The reddish color of the water is probably due to clay from run-off.

All photographs were taken on September 3, 1981 rather than during the study.

Duck Creek looking downstream from HWY 55. The creek here and in the above photograph was dry during the 1981 study. The bottom is bedrock and looked like a very uneven surface of cement during the study.

Duck Creek looking upstream from Center Valley Road. (September 3, 1981).

Duck Creek looking downstream from Center Valley Road. (September 3, 1981).

Duck Creek looking upstream from Hwy J. The creek was very slow moving here and in the next photograph so flows were not taken here. (September 3, 1981).

Duck Creek looking downstream from Hwy J. (September 3, 1981).