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Results of the City of Tampa Surface Water Compliance Monitoring Program for the year 1994 and examination of long-term water quality and biological indicator trends in Hillsborough Bay

City of Tampa Department of Sanitary Sewers

RESULTS OF THE CITY OF TAMPA SURFACE WATER COMPLIANCE MONITORING PROGRAM FOR THE YEAR 1994 AND EXAMINATION OF LONG-TERM WATER QUALITY AND BIOLOGICAL INDICATOR TRENDS IN HILLSBOROUGH BAY

SUBMITTED TO

THE FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
SOUTHWEST DISTRICT

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BY

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RESULTS OF THE CITY OF TAMPA SURFACE WATER COMPLIANCE

MONITORING PROGRAM FOR THE YEAR 1994 AND EXAMINATION OF LONG-TERM WATER QUALITY AND BIOLOGICAL INDICATOR TRENDS IN HILLSBOROUGH BAY

INTRODUCTION

This report is submitted to the Florida Department of Environmental Protection (FDEP) to satisfy the requirements set forth in specific condition No. 14 of the Howard F. Curren WWTP permit No. D029-184532B. The report is based on data obtained by the City of Tampa (COT) compliance water quality monitoring program approved under construction permit DC29-152799. The report also includes examination of long-term trends for water quality parameters and biological indicators collected by the City of Tampa Bay Study Group and the Environmental Protection Commission of Hillsborough County (EPC). Results from these studies are discussed in four sections: 1) Compliance monitoring of Hillsborough Bay water quality by the COT, 2) long-term monitoring of Hillsborough Bay water quality by the EPC, 3) comparison between COT compliance monitoring stations and selected EPC stations in the upper portion of Hillsborough Bay and 4) long-term monitoring of Tampa Bay water quality and biological indicators by the COT.

Results from the compliance monitoring include data collected monthly at three stations in the upper portion of Hillsborough Bay (COT15, COT16 and COT17; Figure 1). Sampling of these stations started in January 1990. The EPC laboratory analyzes sub-samples for carbonaceous biological oxygen demand (5-day), total phosphorus, ortho-phosphate, total nitrogen, total Kjeldahl nitrogen, nitrite+nitrate-nitrogen and ammonia-nitrogen. In addition, the COT Bay Study Group laboratory measures chlorophyll-a, dissolved oxygen and several other field measured water quality parameters.

The long-term water quality data base maintained by the EPC is discussed as trends of annual averages for the parameters specified in the study plan. This discussion includes all 14 EPC stations in Hillsborough Bay (Figure 2) and the group of EPC stations close to the COT AWT outfall (EPC2, EPC6, EPC52 and EPC70; Figure 1).

The comparison between COT compliance monitoring stations (COT15, COT16 and COT17; Figure 1) and the group of EPC stations close to the Howard F. Curren WWTP discharge (EPC2, EPC6, EPC52 and EPC70; Figure 1) includes examination of averages for the year 1994 for the parameters specified in the study plan.

Examination of the COT, multi-disciplinary, long-term water quality and biological indicator monitoring program includes discussion of annual averages for parameters specified in the study plan. The first part of this section reports on results from the water quality and phytoplankton monitoring conducted at two stations located in Hillsborough Bay (COT4 and COT12; Figure 3) and one station located in Middle Tampa Bay (COT13; Figure 3). The second part presents results from the drift macro-algae monitoring conducted at five transects in Hillsborough Bay (Figure 4).

METHODS

Field and laboratory methods are described in the compliance monitoring study plan submitted to the FDER Tampa office on November 16, 1989 entitled "City of Tampa Surface Monitoring Plan of Hillsborough Bay." Modifications to the study occurred on January 1993, when a Hydrolab DataSonde 3 probe replaced equipment previously used for measurements of temperature, salinity and dissolved oxygen.

RESULTS

Compliance Water Quality Monitoring in Hillsborough Bay by the COT

Information collected of parameters specified by the study plan fot the COT compliance monitoring stations COT15, COT16 and COT17 (Figure 1) for 1994 are listed in the appendix. Information for all measured parameters from the years 1990 through 1994 is discussed and presented in the graphs below.

Temperature (Figure 5):
There is little variation in water temperatures (mid-depth) among the three stations. The expected seasonal variation is evident.

Salinity (Figure 6):
There is little variation in salinity (mid-depth) among the three stations. Salinity was reduced at all stations for the period July through October 1991and for Octofer 1994.

Secchi Depth (SD; Figure 7):
SD depths show considerable temporal variation. High values generally occur at all stations during the winter, and low values generally during the summer. Although some variation is noted among the three stations, the difference is small and the overall trend is the same for all stations. An extremely high SD accured most often at COT15 in January 1994.

Dissolved Oxygen (Figures 8-10):
Data for dissolved oxygen for August 1994 is missing due to equipment failure during that sampling trip.

Surface Dissolved Oxygen (SDO; Figure 8):
SDO concentrations are similar for the three stations. High concentrations are noted for all stations during the winter and low concentrations are seen during the summer and fall.

Middle Dissolved Oxygen (MDO; Figure 9):

Trends for MDO concentrations are similar to those for SDO, except for a large variation among stations in July 1991 and June 1992.

Bottom Dissolved Oxygen (BDO; Figure 10):
BDO concentrations are dependent on parameters such as depth and benthic conditions. A comparison between these stations is, therefore, not valid. In general, seasonal trends for the three stations are similar, with peaks during winter and lows during summer and fall.

Total Nitrogen (TN; Figure 11):
TN concentrations are similar for the three stations and no seasonal pattern is apparent.

Total Kjeldahl Nitrogen (TKN; Figure 12):
See the comments for TN.

Ammonia Nitrogen (NH3; Figure 13):
There is little variation in NH3 concentrations among the three stations. No seasonal pattern is apparent.

Nitrite + Nitrate Nitrogen (NO2+NO3; Figure 14):
There is little variation in NO2+NO3 concentrations among the three stations. No seasonal pattern is apparent.

Total Phosphorus (TP; Figure 15):
TP concentrations are similar at the three stations. There is no obvious seasonality at the three stations for this parameter. However, a trend towards lower concentrations is evident.

Ortho-Phosphorus (PO4; Figure 16):
PO4 concentrations are similar at all three stations and no seasonality is apparent. The trends seen in PO4 concentrations are similar to those seen in TP concentrations.

Carbonaceous Biological Oxygen Demand (CBOD5; Figure 17):
CBOD5 is similar for all stations although some sporatic variability among stations occurs. No seasonal or long term trends are evident.

Chlorophyll-a (CHLA; Figure 18:)
CHLA concentrations measured at mid-depth are generally similar for the three stations. However, in July 1991 concentrations at stations COT16 and COT17 were near 60 ug/l, while the level at station COT15 was about 20 ug/l. Also, COT15 had substantially higher concentrations than COT16 and COT17 in September 1994. Nevertheless, consistent differences between the stations are not apparent. A seasonal pattern is evident, with peaks coinciding with periods of highest temperatures (see Fig. 5).

Long-Term Trends of Hillsborough Bay Water Quality Parameters Sampled by the EPC

Long-term trends, shown as annual averages for the parameters specified in the study plan (DO, CBOD5, TP, PO4, TN, TKN and CHLA) for all 14 EPC stations in Hillsborough Bay (Figure 2) and for the group of EPC stations close to the Howard F. Curren WWTP outfall (EPC2, EPC6, EPC52 and EPC70; Figure 1) are discussed and presented in the graphs below.

TN (Figure 19):
There does not appear to be a long-term trend in TN concentrations. There is little difference between the two groups of stations. Nitrogen data generated by the EPC prior to 1980 has been deemed questionable by EPC.

TKN (Figure 20):
See the comments for TN.

TP(Figure 21):
TP concentrations have decreased from approximately 2mg/l in 1974 to current concentrations of less than 0.5mg/l. The "All Stations" group consistently has higher concentrations than the upper Hillsborough Bay station group, reflecting the influence of the Alafia River on the lower and mid portions of Hillsborough Bay. The Alafia River appears to be a major source of TP to the bay (see Figure 31).

PO4 (Figure 22):
See the comments for TP. In addition, PO4 information is based on a much smaller number of samples than TP.

CBOD5 (Figure 23):
CBOD5 peaked during the period 1975-1977 at 4.5 to 5mg/l. Values have declined to current levels of near 2mg/l. There is no consistent difference between groups of stations. However, the influence of the Howard F. Curren WWTP prior to the conversion to AWT in 1979 may be indicated by the higher values for the upper Hillsborough Bay station group during the period 1973 through 1977.

DO (Figures 24-26):
There are no consistent spatial or temporal trends for either SDO, MDO or BDO concentrations, with the exception that SDO was elevated for the "All Stations" group during the years 1976 through 1981.

CHLA (Figure 27):
Based on the corrected EPC CHLA record, Hillsborough Bay had highest CHLA concentrations during the mid-1970's. At that time, values ranged from approximately 25 to 32ug/l. CHLA concentrations decreased from 1982 through 1993 when values were close to 10ug/l. In 1994, CHLA concnetrations increased to about 17ug/l. There is no consistent difference between groups of stations, however, the influence of the Howard F. Curren WWTP, prior to conversion to AWT in 1979, may be indicated by the higher values for the upper Hillsborough Bay station group during the period 1973 through 1977.

Comparison Between COT Compliance Monitoring Stations and Selected EPC Stations in the

Upper Hillsborough Bay

Average values for year 1993 for the parameters specified in the study plan (DO, CBOD5, TP, PO4, TN, TKN and CHLA) for the group of EPC stations close to the Howard F. Curren WWTP outfall (EPC2, EPC6, EPC52 and EPC70; Figure 1) and from the COT compliance monitoring stations (COT15, COT16 and COT17; Figure 1) are discussed and presented in the graphs below. Summary statistics for each parameter by each station listed above is shown in Table 1.

TN (Figures 28):
The highest mean TN concentration for the two station groups was found at station EPC70, and the lowest concentration at station EPC6. All COT compliance stations had TN concentrations within one standard error of the mean (1 SE) of station EPC70. Therefore, no statistically significant impact from the Howard F. Curren WWTP discharge on the COT compliance stations is apparent for this parameter.

TKN (Figure 29):
See the comments for TN.

TP (Figures 30 and 31):
The highest mean TP concentration for the two station groups was found at station EPC70 and the lowest concentration at station EPC52 (Figure 30). All COT compliance stations had intermediate TP concentrations, therefore no statistically significant impact from the Howard F. Curren WWTP discharge on the COT compliance stations is apparent for this parameter. In addition, when comparing TP concentrations for the COT compliance monitoring stations and all EPC stations in Hillsborough Bay (Figure 31) it is evident that station EPC74, at the mouth of the Alafia River, has by far the greatest concentration, suggesting that the Alafia River is a major source of TP to Hillsborough Bay.

PO4 (Figure 32 and 33):
The highest mean PO4 concentrations for the two station groups were found at COT15 and the lowest concentration was found at EPC2 (Figure 32). All three compliance stations had concentrations within 1 SE of station EPC70. All COT compliance stations had intermediate TP concentrations, therefore no statistically significant impact from the Howard F. Curren WWTP discharge on the COT compliance stations is apparent for this parameter. In addition, when comparing PO4 concentrations for the COT compliance monitoring stations and all EPC stations in Hillsborough Bay (Figure 33) it is evident that EPC74, at the mouth of the Alafia River, has by far the greatest concentration, suggesting that the Alafia River is a major source of PO4 to Hillsborough Bay.

CBOD5 (Figure 34):
The highest mean CBOD5 concentration for the two station groups was found at station EPC70 and the lowest concentrations at stations COT15 and EPC2. Excluding station EPC2, all COT compliance stations had CBOD5 concentrations substantially lower than the selected EPC stations. Therefore, no statistically significant impact from the Howard F. Curren WWTP discharge is apparent for this parameter.

DO (Figures 35, 36 and 37):
The highest mean SDO concentration for the two station groups was found at station EPC52 and the lowest concentrations at station EPC2 (Figure 35). The COT compliance stations had intermediate SDO concentrations. Therefore, no statistically significant impact from the Howard F. Curren WWTP discharge is apparent for this parameter.

The comments for SDO also apply for MDO (Figure 36). BDO concentrations (Figure 37) are not only a function of possible discharges, but are also greatly dependant on water depth and benthic conditions. Therefore, no attempt is made to relate this parameter to the Howard F. Curren WWTP discharge.

CHLA (Figure 38):
The highest mean CHLA concentrations for the two station groups was found at station EPC70 and the lowest concentration at stations EPC2 and EPC52. All COT compliance stations had intermediate TP concentrations, therefore no statistically significant impact from the Howard F. Curren WWTP discharge on the COT compliance stations is apparent for this parameter.

Long-Term Trends of Tampa Bay Water Quality and Biological Indicators Sampled by the COT

Results from the long-term, multi-disciplinary, COT water quality and biological indicator monitoring program are discussed and presented in the graphs below. The parameters SD, DO, CHLA, phytoplankton production rates, Schizothrix calcicola *sensu* Drouet filament concentrations and total phytoplankton cell concentrations are presented as annual averages for the study period for two stations located in Hillsborough Bay (COT4 and COT12) and one station located in Middle Tampa Bay (COT13; see Figure 3). Drift macro-algae biomass is shown as the annual average biomass for each of the five transects in Hillsborough Bay (Figure 4). The growth of submerged seagrasses and the attached benthic alga Caulerpa prolifera in Hillsborough Bay was discussed in the COT report submitted to FDER on March 1, 1994.

SD (Figure 39):
SD depth generally increased gradually between 1982 and 1989. After 1989, however, there was a reduction in water transparency at the three stations. This reduction does not appear to be related to phytoplankton biomass (CHLA), which has remained relatively steady since 1989 (see Figure 41). The recent SD reduction may have been caused by an increase in sediment resuspension. Possible sources of this resuspension may include dredging, commercial fishing activities, and/or an increase in bottom-feeding fish populations.

DO (Figure 40):
SDO and BDO concentrations declined gradually between 1986 and 1990 and have remained relatively stable since then. Further, 1993 BDO and SDO values were very similar for all (except COT4 bottom) stations, suggesting an improved benthic oxygen climate in Hillsborough Bay.

CHLA (Figure 41):

Surface CHLA concentrations were relatively high from 1979 through 1982, however, concentrations decreased sharply in 1983 and 1984. This decline continued, although more gradual to1993 when average concentrations of approximately 15, 13 and 5ug/l for stations COT4, COT12 and COT13, respectively, were found. CHLA concentrations increased slightly in 1994 at stations COT4 and COT13 to the highest concentrations seen since 1987 and 1988. This increase was probably due to an increase in stormwater runoff, and an associated increase in nitrogen loading, caused by the higher than normal rainfall to the Tampa Bay area during the late summer of 1994. The 1994 CHLA concentrations are still very low in comparison to concentrations found during the late 1970's and early 1980's, indicating that eutrophic conditions in Tampa Bay have been greatly reduced or eliminated.

Phytoplankton Production (Figure 42):
Annual primary production has decreased almost steadily since 1985 at all three stations, indicating reduced eutrophication in these sections of Tampa Bay. In general, the Middle Tampa Bay station has slightly lower primary production rates than the Hillsborough Bay stations.

Schizothrix calcicola *sensu* Drouet (Figure 43):
The abundance of this blue-green alga has decreased substantially since 1983. Concentrations during the last eight years have been approximately one-third of the pre-1984 levels. The 1993 concentrations were the lowest recorded during the entire sampling program, however, in 1994 the alga became more abundant probably due to the increase in rainfall discussed above.

Total Phytoplankton (Figure 44):
Long-term trends of decreasing total phytoplankton cell concentration is evident for all three stations. The Hillsborough Bay stations consistently have higher cell concentrations than the middle Tampa Bay station. Peak concentrations of phytoplankton abundance for stations COT4 and COT12 occurred in 1987, the same year TN concentrations, measured by EPC, were high in Hillsborough Bay (see Figure 19). Further, the 1993 concentrations were the lowest recorded during the entire sampling program.

Macro-Algae (Figure 45):
Long-term spatial trends of drift macro-algae biomass show that two areas, Transect B in northeastern Hillsborough Bay, and Transect E in northwestern Hillsborough Bay, generally have higher average drift macro-algae accumulations than the other three transects. It is also apparent that the current macro-algae abundance is less than earlier years for most transects.

DISCUSSION

There are no indications, either from the compliance monitoring program or from the comparison between the COT compliance monitoring stations and the group of EPC stations close to the discharge site, that the discharge from the Howard F. Curren WWTP, during the year 1993, had a negative impact on water quality and biological indicators in Hillsborough Bay.

The only parameter identified in this study, which shows an impact potentially related to sources in the upper portion of Hillsborough Bay is PO4. Possible sources of the this parameter includes, among others, the fertilizer loading terminals in East Bay and the Howard F. Curren WWTP.

However, the elevated concentration of this parameter may be of no consequence to water quality or biological indicators in Hillsborough Bay. It is a well known fact that growth of the phytoplankton population in all sections of Tampa Bay is strongly limited by the supply of nitrogen. Therefore, it is unlikely that the elevated concentrations of PO4 found at the compliance stations COT15 and COT16 have had a negative impact on water quality parameters or biological indicators in Hillsborough Bay or any other section of Tampa Bay.

Long-term trends of water quality and biological indicators monitored in Hillsborough Bay by both the EPC and the COT programs have shown substantial improvements during the last decade. It is apparent that several important indicators of estuarine health, such as CHLA, blue-green alga abundance and seagrass growth (discussed in the report to FDER on March 1, 1994), have improved since the Howard F. Curren WWTP converted from primary treatment to AWT in 1979. These findings agree with the recently acquired understanding of the nutrient, specifically nitrogen, loading history of Hillsborough Bay (Johansson 1991).

Statistical relationships have been developed between external nitrogen loading to Hillsborough Bay and the response of phytoplankton biomass (CHLA). These relationships suggest that the reduction in external nitrogen loading to the bay that occurred when the Howard F. Curren WWTP converted from primary treatment to AWT caused a substantial reduction of phytoplankton biomass in Hillsborough Bay. Therefore, the conversion of the Howard F. Curren WWTP from primary treatment to AWT has without doubt had a substantial beneficial long-term effect on water quality and biological indicators in Hillsborough Bay. Further, it is not unreasonable to assume that the recent water quality improvements seen in other major sections of Tampa Bay (Boler 1992), such as Middle Tampa Bay and Lower Tampa Bay, are at least partly related to the conversion of the Howard F. Curren WWTP.

REFERENCES

Boler, R. 1992. Surface water quality, 1990-1991. Hillsborough County, Florida. Hillsborough County Environmental Protection Commission.

Johansson, J.O.R. 1991. Long-term trends of nitrogen loading, water quality and biological indicators in Hillsborough Bay, Florida. pp. 157-176. In: Treat, S.F. and P.A. Clark (eds.), Proceedings, Tampa Bay Area Scientific Information Symposium 2. 1991 Feb. 27 - March 1; Tampa, FL. Text, Tampa, Fl.

Table 1. Summary statistics for COT compliance monitoring stations and selected EPC monitoring

stations in the upper portion of Hillsborough Bay for the year 1993.

	TN	TKN	TP	PO4	SDO	MDO	BDO	CBOD5	CHLA		
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l		
COT15	N CASES		12	12	12	12	12	12	12	12	12
	MINIMUM		0.74	0.74	0.10	0.19	3.40	1.63	1.69	0.25	4.97
	MAXIMUM		2.85	2.82	0.57	0.42	8.89	8.02	7.62	4.20	96.16
	MEAN	1.27	1.26	0.36	0.30	5.64	5.36	4.63	1.45	20.82	
	ST DEV	0.55	0.54	0.13	0.08	1.63	1.73	2.05	0.97	25.70	
COT16	N CASES		12	12	12	12	12	12	12	12	12
	MINIMUM		0.70	0.99	0.15	0.17	4.37	3.99	0.51	0.30	5.15
	MAXIMUM		1.71	1.66	0.56	0.45	8.96	8.84	7.72	1.90	33.41
	MEAN	1.23	1.26	0.37	0.29	6.07	5.77	4.66	1.38	15.82	
	ST DEV	0.29	0.23	0.12	0.10	1.46	1.63	2.27	0.42	10.00	
COT17	N CASES		12	12	12	12	12	12	12	12	12
	MINIMUM		0.96	0.94	0.17	0.15	4.70	4.55	2.79	0.40	4.30
	MAXIMUM		1.85	1.82	0.53	0.41	8.70	8.62	8.38	3.40	35.02
	MEAN	1.26	1.25	0.37	0.28	6.46	6.38	5.46	1.44	15.93	
	ST DEV	0.29	0.28	0.11	0.09	1.34	1.37	1.64	0.75	10.11	
EPC2	N CASES		12	12	12	12	12	12	12	12	12
	MINIMUM		0.58	0.58	0.25	0.11	2.30	0.40	0.20	0.60	1.44
	MAXIMUM		2.04	1.97	0.54	0.46	8.60	8.10	7.60	2.30	48.57
	MEAN	1.18	1.15	0.36	0.27	5.03	4.46	4.08	1.37	12.69	
	ST DEV	0.36	0.34	0.09	0.10	2.02	2.20	2.27	0.47	11.99	
EPC6	N CASES		12	12	12	12	12	12	12	12	12
	MINIMUM		0.54	0.54	0.24	0.13	5.00	4.40	1.10	0.40	1.58
	MAXIMUM		1.06	1.53	0.54	0.42	8.20	7.90	7.70	3.20	40.18
	MEAN	0.86	1.07	0.40	0.28	6.76	6.45	5.20	1.86	16.38	
	ST DEV	0.28	0.31	0.09	0.10	1.06	1.16	2.24	0.77	12.16	
EPC52	N CASES		12	12	12	12	12	12	12	12	12
	MINIMUM		0.56	0.56	0.20	0.12	4.50	4.40	1.90	0.70	1.25
	MAXIMUM		1.40	1.37	0.49	0.43	11.40	9.20	8.30	4.00	27.37
	MEAN	0.94	0.94	0.35	0.27	7.74	7.08	5.58	1.91	12.75	
	ST DEV	0.24	0.24	0.11	0.09	1.92	1.47	2.03	0.83	9.17	
EPC70	N CASES		12	12	12	12	12	12	12	12	12
	MINIMUM		0.63	0.46	0.15	0.13	4.70	4.20	1.00	1.50	3.01
	MAXIMUM		4.14	4.13	0.71	0.45	8.50	8.50	8.20	3.40	192.14
	MEAN	1.40	1.40	0.42	0.29	6.86	6.48	5.03	1.94	32.73	
	ST DEV	0.90	0.90	0.14	0.11	0.85	1.09	2.33	0.87	53.32	