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NWRI Contribution No. 91-15

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MANAGEMENT PERSPECTIVE

Cootes Paradise is included in the Hamilton Harbour Remedial Action Plan (RAP) area. The RAP is reviewing past and present environmental conditions to determine environmental stresses and then, remedial actions. Cootes Paradise, a local wildlife sanctuary, was blessed with abundant stands of emergent and submergent vegetation prior to the 1940s. Several environmental stresses, most notable of which is high water turbidity which inhibits plant growth, have resulted in the loss of virtually all of the vegetation. High chlorophyll (algae) concentrations have been observed as a result of the sewage discharge from the town of Dundas and since the 1970s various improvements at the sewage treatment plant (STP) have been implemented to reduce the algal abundance and hopefully improve water clarity. In 1988, sand filters were installed at the STP to reduce the phosphorus and suspended solids loading. The other environmental stresses such as soil erosion on the Spencer Creek watershed, resuspension within Cootes Paradise and carp activity are either not controllable or in the case of soil erosion, only small reductions appear possible and will take 20-40 years to implement. Therefore, the 1988 incorporation of sand filters at the Dundas STP was the only action in the foreseeable future that held some promise to improve water clarity in Cootes Paradise.

Water clarity was not improved in 1990 compared to data collected from 1977 onward. Seston and chlorophyll concentrations were not reduced compared to previous years. Water clarity differences were probably due to differences in the Spencer Creek discharge, confirming the our earlier findings that water clarity in Cootes Paradise was dominated by silt originating from Spencer Creek and from resuspension activities of carp.

Restoration of vegetation in Cootes Paradise is unlikely to occur unless more direct measures are undertaken to decrease silt loads from Spencer Creek and eliminate the effects of resuspension by wind, waves and carp. If major reductions in soil erosion were accomplished in the watershed, then the Dundas STP discharge would then have to be dealt with because phosphorus loadings from the STP are presently above the allowable limit.

PERSPECTIVES DE LA DIRECTION

Cootes Paradise est compris dans la zone du plan de mesures correctives (PMC) pour le port de Hamilton. Le PMC étudie les conditions passées et présentes du milieu pour déterminer les stress environnementaux, puis les mesures correctives qui pourraient être prises. Avant les années 1940, la réserve de faune régionale de Cootes Paradise était dotée d'une végétation émergente et partiellement submergée abondante. Plusieurs stress environnementaux, dont notamment la turbidité élevée de l'eau qui inhibe la croissance des plantes, ont causé la perte de pratiquement toute la végétation. On a observé des concentrations élevées de chlorophylle (algues) provenant de l'évacuation des eaux usées de la ville de Dundas et, depuis les années 1970, diverses améliorations ont été apportées à l'usine de traitement des eaux usées (UTEE) dans le but de réduire la quantité d'algues et de rendre peut-être ainsi l'eau plus limpide. En 1988, on a installé des filtres de sable à l'UTEE qui ont réduit les charges de phosphore et de matières en suspension. On ne peut rien faire contre les autres stress environnementaux, comme l'érosion du sol dans le bassin hydrographique de Spencer Creek, la remise en suspension dans Cootes Paradise et l'activité des carpes, sauf peut-être contre l'érosion du sol qu'on pourra freiner un peu, mais sur une période de 20 à 40 ans. Par conséquent, l'installation de filtres de sable à l'UTEE de Dundas en 1988 a été la seule mesure prise qui puisse dans un avenir prévisible rendre l'eau de Cootes Paradise plus limpide.

D'après les données recueillies depuis 1977, l'eau n'est pas devenue plus limpide en 1990. Les concentrations de seston et de chlorophylle n'ont pas été réduites comparativement à celles des années précédentes. Les différences observées dans la limpidité de l'eau sont probablement dues aux rejets plus ou moins importants dans le bassin de Spencer Creek, ce qui confirme des données obtenues auparavant qui indiquent que la limpidité de l'eau dans Cootes Paradise est surtout influencée par la vase provenant de Spencer Creek et par la remise en suspension des sédiments par les carpes.

Il est improbable que la végétation revienne dans Cootes Paradise, à moins de prendre des mesures plus directes pour diminuer la quantité de vase provenant de Spencer Creek et d'éliminer les effets de remise en suspension par le vent, les vagues et les carpes. Si l'on parvenait à réduire considérablement l'érosion du sol dans le bassin hydrographique, il faudrait alors s'occuper du problème de l'UTTE de Dundas car les charges de phosphore qu'elle rejette sont présentement supérieures à la limite admissible.

ABSTRACT

Painter et al. (1989) examined the water clarity problem in Cootes Paradise and concluded that several actions would be necessary to improve water clarity and reduced loading from the Dundas STP was one of the recommendations. In 1988, the Dundas Sewage Treatment Plant (STP) reduced its phosphorus and suspended solids loading to Cootes Paradise by installing sand filters. Cootes Paradise was revisited in 1990 to determine if water clarity had improved. Secchi disc transparency, seston, and chlorophyll at the main open water station and at West Pond, the direct recipient of the STP effluent, were no different from past years. In fact, STP suspended solids and phosphorus loadings had increased slightly in 1990 compared to 1987. Water clarity appears to be more a function of incoming turbidity on Spencer Creek and resuspension processes in Cootes Paradise than algae stimulated by phosphorus loading from the STP.

RÉSUMÉ

Painter et coll. (1989) ont étudié le problème de turbidité de l'eau de Cootes Paradise et sont arrivés à la conclusion que plusieurs mesures seraient nécessaires pour rendre l'eau plus claire; ils ont recommandé, entre autres, la réduction des charges de l'usine de traitement des eaux usées (UTTE) de Dundas. En 1988, l'UTEE de Dundas a réduit les quantités de phosphore et de matières en suspension déversées dans Cootes Paradise en installant des filtres de sable. Les auteurs sont retournés à Cootes Paradise en 1990 pour vérifier si l'eau était devenue plus claire. La transparence mesurée au disque de Secchi, le seston et la chlorophylle à la station principale en zone d'eau libre et à West Pond, l'endroit où est rejeté directement l'effluent de l'UTEE, étaient du même ordre que les valeurs mesurées les années précédentes. En fait, les quantités de matières en suspension et de phosphore rejetées par l'UTTE ont augmenté légèrement en 1990 par rapport à 1987. La limpidité de l'eau semble dépendre davantage de la turbidité provenant de Spencer Creek et des processus de remise en suspension dans Cootes Paradise que de la stimulation de la croissance des algues par les charges élevées de phosphore provenant de l'UTEE.

INTRODUCTION

Cootes Paradise has lost approximately 85% of its marsh habitat (Painter et al., 1989). Poor water clarity is the major factor accountable for the loss of aquatic plants. Both urban and agricultural development and the discharge of the Dundas Sewage Treatment Plant (STP) contribute to the poor water clarity. The resuspension of sediment by carp, wind and wave action is also important. The Preferred Options Report of the Hamilton Harbour Remedial Action Plan has identified the restoration of marsh habitat in Cootes Paradise as a high priority. Corrective measures for achieving and maintaining submergent plant habitat have been recommended by Painter et al. (1989) and include:

- 50% seston and 60% phosphorus loading reductions from the watershed;
- elimination of sediment resuspension by wind and wave action to maintain seston concentrations at 10-15 mg/L;
- phosphorus loading reductions from the Dundas STP and Hamilton Harbour and combined sewer overflows sufficient to reduce phosphorus concentrations by 65%;
- carp control to reduce vegetative destruction and their effects on water clarity; and
- dredging of the nutrient-rich sediment.

Cootes Paradise receives two major inputs - the Dundas STP and Spencer Creek. Semkin et al. (1976) determined that the Dundas STP was the more significant source of total and soluble phosphorus, whereas Spencer Creek was the predominant source of suspended solids. Phosphorus and suspended solids loading from the Dundas STP in the early 1970s was 45 kg/day and 500 kg/day, respectively (Semkin et al., 1976). The Dundas STP installed sand filters in July 1988 which reduced its phosphorus loading into Cootes Paradise from 5.7 kg/day in 1987 to 4.1 kg/day in 1989 and its suspended solids loading from 57.8 kg/day to 20.6 kg/day. However the STP phosphorus loading for 1990 was 5.9 kg/day and the suspended solids loading was 62.9 kg/day. Both loadings were higher than those of 1987. This report examines data collected between 1977 and 1990 to determine if any improvements in water clarity occurred, and attempts to determine the reason for any such improvements.

METHODS

Water samples were collected at weekly intervals between April 8 and November 3, 1987; at bi-weekly intervals between May 2 and October 19, 1988; at weekly intervals between May 4 and September 28, 1989, and at weekly intervals between June 15 and September 27, 1990. The sampling locations, the Dundas STP and Spencer Creek, are illustrated in Figure 1. The sampling locations were chosen to elucidate the factors responsible for the spatial variability in water clarity and the effect of inputs from the Dundas STP and Spencer Creek.

Composite water samples for chlorophyll a (Chla) analyses were collected through a depth equal to twice the Secchi disc transparency to approximate the depth of the euphotic zone. Aliquots (0.2-1.0 L) were filtered through GF/F glass-fibre filters (Whatman Co.), frozen, and analyzed later using the methods of the Water Quality Branch, Environment Canada (see Environment Canada, 1979). The Chla concentration uncorrected for phaeopigments was related to Secchi disc transparency because it takes into account that living as well as dead or decaying algal cells contribute to the water clarity. Seston and mineral concentrations were measured by filtering known volumes of water through Whatman GF/C filter papers. The mineral content was determined by combusting the organic matter at 550°C for two hours.

Nutrient and Secchi disc transparency data from 1977 to 1990 has been collected bi-weekly by the Royal Botanical Gardens (RBG) staff biologist, Mr. Len Simser, at our six main stations. The water samples were submitted to the Regional Municipality of Hamilton Laboratory for analysis.

RESULTS

Station CP1 is located in the open water area of Cootes Paradise. Another station (CP2) is also located in the open water area but for the purposes of this report and to simplify the discussion, CP1 observations only will be used to determine the response of the open water area of Cootes Paradise to the Dundas STP loading reductions. Station CP5 is located in West Pond and is the direct recipient of the Dundas STP effluent and therefore water quality conditions within West Pond may be influenced more directly by the Dundas STP improvements.

Stations CP1 and CP5 RBG nutrient and Secchi disc transparency means gathered from 1977 to 1990 have been summarized in Table 1. No discernable improvement in phosphorus and Chla at these two stations is apparent. Figures 2 and 3 illustrate the four-year seasonal trend for total and soluble phosphorus at CP1 and CP5 and again there is no obvious reduction in nutrient concentrations.

Secchi disc transparency measurements have been collected at CP1 and CP5 on an annual basis since 1977 (Table 1). At both stations water clarity in 1990 was similar to previous years when nutrient loading from the Dundas STP was much higher (45 kg/day). With 14 years of data available it is difficult to infer that the STP reduced loadings have improved water clarity in Cootes Paradise. Our field data also suggests that the STP changes have had little effect on water clarity in Cootes Paradise. At CP1 we observed a summer average secchi disc transparency of 19 cm in 1987, 34 cm in 1989 and 32 cm in 1990. The 1987 to 1990 difference in water clarity occurred even though the 1990 STP loadings were higher than the 1987 loadings, a year prior to the incorporation of sand filters. At CP5 we observed a summer average Secchi disc transparency of 15 cm in 1987, 24 cm in 1989 and 20 cm in 1990. Again, the difference in water clarity occurred from 1987 to 1990 even though STP loadings have actually risen. The water clarity differences between 1987 and 1990 seem more likely a result of seasonal and year to year variability due to other factors rather than the Dundas STP.

When examining seasonal variability in water clarity between 1987 and 1990 (Figure 4), 1990 Secchi disc transparency closely resembled that of 1987 from mid-June to mid-July. For the remainder of the 1990 sampling period, an increase of approximately 20 cm over the 1987 Secchi was observed. Seston concentrations at CP1 decreased 25 mg/L on average between the two years (Figure 5). Seston fluctuations closely resembled those exhibited by Secchi disc transparency. On average, chlorophyll concentrations were 20 μg/L lower in 1990 than in 1987 (Figure 6). Consistently lower chlorophyll concentrations were noticed from mid-July to the end of the sampling period. On July 18, 1990 a season low Secchi disc transparency of 10 cm occurred, which coincided with a season high seston concentration of 199 mg/L, and an elevated chlorophyll concentration of 165 μg/L. Both precipitation and Spencer Creek discharge were negligible on and prior to this day.

CP5 1990 Secchi disc transparency was approximately 5 cm greater than that observed in 1987 (Figure 7). Seston concentrations were similar in 1987 and 1990 except during June (Figure 8). Peak concentrations of seston (279 mg/L) occurred on July 18, 1990. The 1990 chlorophyll concentrations were similar to those of 1987 except during early July (Figure 9). This station is the direct recipient of the Dundas STP and receives no other input. The high seston concentrations in West Pond are not due to high seston concentrations in the STP effluent. The seston concentrations in the effluent are approximately 1 mg/L compared to the 134 mg/L average seston concentration at CP5. The high seston concentrations are probably due to resuspension of sediments by carp, wind, or wave action and the high algal biomass.

It is impossible to infer that the Dundas STP sand filter addition has improved 1990 water clarity when the 1990 loadings were higher than those of 1987. Painter et al. (1989), concluded that silt rather than algae was the predominant contributor to the high water turbidity in Cootes Paradise. Spencer Creek is the dominant source of suspended solids, and year to year and seasonal differences in the suspended solids loading are probably more important than the Dundas STP in determining the water clarity of Cootes Paradise.

During the summer period, 305 mm of rain fell in 1987, whereas 239 mm of rain fell in 1990. Spencer Creek discharge for this period averaged 0.948 m^3/s in 1987 and 0.461 m^3/sec in 1990. Seston concentrations taken at the upstream Spencer Creek station averaged 27 mg/L in 1987 and 48 mg/L in 1990. The decreased rainfall of 1990 has halved Spencer Creek flow, resulting in a lower seston loading into Cootes Paradise, even though seston concentration has nearly doubled. Using the average of 13 years of daily flow data from Spencer Creek and three years of weekly seston observations to determine an average seston concentration, the seston loading from Spencer Creek into Cootes Paradise averaged 3800 kg/day for the summer period (Table 2). A relationship was observed between summer Secchi depth and summer discharge from Spencer Creek (Figure 10). The trend indicates that wet summers result in more turbid water in Cootes Paradise than dry summers. The Dundas STP discharged a summer average of 43 kg/day of suspended solids over the last four years (Table 2). The Dundas STP suspended solids loading is minor when compared to the suspended solids loading of Spencer Creek. Even if seston loading reductions at the STP had occurred in 1990, their effect would be expected to have a minor or negligible impact on water clarity in Cootes Paradise.

Spencer Creek total phosphorus loading during the summer period was determined to be 6.1 kg/day, of which only 30% is biologically available (Painter et al, 1989), thus the soluble phosphorus loading is 1.8 kg/day. The Dundas STP phosphorus loading was found to be 6.0 kg/day (Table 2). It is clear that the Dundas STP loading of biologically available phosphorus into Cootes Paradise is about 3 times more significant than that of Spencer Creek. However, because the silt loading from Spencer Creek is so dominant, any phosphorus loading reduction at the STP would have little or no effect upon water clarity.

Figure 11 shows the effect of varied chlorophyll and seston concentrations upon secchi disc transparency (Painter et al, 1989). When seston concentrations are greater than 25 mg/L, significant reductions in chlorophyll concentrations will have little effect on secchi disc transparency. The 1990 average seston concentration of 55 mg/L is still too high to allow for significant secchi improvements due to reductions in chlorophyll as a result of phosphorus loading reductions at the Dundas STP. Painter et al. (1989) determined that the target seston and chlorophyll concentration for Cootes Paradise should be 10-15 mg/L and 10 μg/L, respectively. If these concentrations are obtained, secchi disc transparency could reach 75 to 110 cm.

A relationship between total phosphorus and Chl<u>a</u> developed by Chapra and Dobson (1981), predicted that a total phosphorus concentration of 40 μg/L would produce an algal population with a Chl<u>a</u> concentration of 10 μg/L. By taking into account the volume of Cootes Paradise, as well as the average flows of Spencer Creek and the Dundas STP, calculation of an allowable phosphorus loading is possible. An allowable phosphorus loading of 2.79 kg/day was calculated for the summer period. Semkin et al. (1976) determined an allowable summer phosphorus loading of 2.82 kg/day, agreeing extremely well with our calculation. Presently the summer phosphorus loading from all sources is 7.8 kg/day, nearly 3 times the allowable loading, with the Dundas STP contributing 77% to this total loading. It is apparent that the Dundas STP phosphorus loading requires a serious reduction if the allowable phosphorus loading is to be achieved. Spencer Creek biologically available phosphorus loading alone is 1.8 kg/day.

Our present observations confirm our earlier recommendations. Restoration of habitat in Cootes Paradise requires a Secchi disc transparency of 75-100 cm (Painter, In press). This water clarity will only be achieved when Spencer Creek seston concentrations are reduced by 75%. If such reductions could be achieved, the Dundas STP phosphorus loading would be significant because it currently exceeds the allowable phosphorus loading target. Phosphorus loading from the Dundas STP would have to be reduced considerably to achieve the allowable phosphorus loading target.

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Table 1: Cootes Paradise 1977-1990 CP1 and CP5 Summer Means

Stn	Year	Secchi (cm)	Chl (µg/L)	Tot Ph (µg/L)	Sol Ph (µg/L)
CP1	1977	17.4	82.78	239.00	25.20
CP1	1978	26.8	110.25	153.82	8.86
CP1	1979	23.8	90.16	187.73	13.91
CP1	1980	26.4	134.57	124.73	8.15
CP1	1981	16.7	80.52	165.00	28.22
CP1	1982	19.4	116.19	120.73	59.00
CP1	1983	21.1	105.48	144.45	17.73
CP1	1984	25.5	68.08		
CP1	1985		71.60		
CP1	1986	18.5	33.28	157.14	32.86
CP1	1987	18.6	87.19	170.00	30.00
CP1	1988	20.5	22.21	260.83	65.83
CP1	1989	22.1	67.30	220.00	50.00
CP1	1990	26.2	49.63	151.00	53.00
CP5	1977		103.86	268.00	162.30
CP5	1978		162.27	131.18	35.31
CP5	1979	19.0	230.76	400.27	47.40
CP5	1980	17.8	212.29	357.18	20.69
CP5	1981	15.6	187.57	158.20	22.20
CP5	1982	14.8	192.93	105.55	60.09
CP5	1983	15.4	241.16	536.27	30.73
CP5	1984	26.8	123.87		
CP5	1985		150.38		
CP5	1986	17.2	93.53	318.57	65.71
CP5	1987	15.4	127.83	414.29	74.29
CP5	1988	17.1	43.83	690.83	154.17
CP5	1989	17.4	102.92	422.50	111.25
CP5	1990	18.6	74.96	356.00	185.00

Table 2: Historical Spencer Creek Discharge and a comparison between Spencer Creek and Dundas STP phosphorus and seston loadings

Spencer Crk @ Dundas Crossing (1977-1990) Avg Monthly Flows (m3/s)

	1977	1978	1979	1980	1981	1982	1983	1985	1986	1987	1988	1989	1990	Avg
Jan	0.530	1.739	1.240	2.200	0.298	0.774	2.050	1.760	1.550	1.970	1.070	1.180	2.370	1.441
Feb	0.833	1.357	1.060	0.582	3.750	0.715	2.860	3.540	1.070	1.120	1.290	0.674	4.000	1.758
Mar	8.300	5.126	7.580	3.540	1.800	6.220	3.360	9.260	6.760	4.130	3.240	2.510	5.780	5.200
Apr	3.711	7.873	6.660	5.260	1.840	6.010	3.440	4.990	2.500	5.300	3.210	2.840	2.520	4.320
May	0.858	2.104	1.800	1.750	0.760	1.010	3.310	0.667	1.430	0.400	0.861	1.180	2.180	1.409
Jun	0.368	0.439	0.622	0.603	0.450	1.870	1.120	0.354	0.652	0.718	0.086	1.690	0.669	0.742
Jul	0.595	0.187	0.339	0.319	0.373	0.442	0.320	0.442	0.690	1.220	0.137	0.587	0.373	0.463
Aug	0.391	0.193	0.290	0.257	0.536	0.991	0.546	0.364	0.702	1.030	0.402	0.252	0.353	0.485
Sep	1.895	0.943	0.366	0.282	1.670	1.220	0.419	0.738	1.800	0.823	0.780	0.303	0.449	0.899
Oct	3.229	1.141	0.919	0.878	2.160	1.620	0.608	1.330	3.760	1.100	1.550	0.679		1.581
Nov	2.402	1.070	1.620	0.532	2.070	2.690	1.180	7.350	2.500	1.360	2.610	1.680		2.255
Dec	4.618	1.467	3.730	0.781	1.210	3.600	2.110	2.070	4.020	2.420	1.310	0.505		2.320
TD(m3)	73334753	56900000	69200000	44800000	43800000	71600000	55800000	86000000	72600000	56900000	43500000	37000000		

Spencer Crk & Dundas STP Suspended Solids and Phosphorus Loadings

	Spencer SS Load (kg/day)	Spencer Ph Load (kg/day)	Spencer 30%Ph (kg/day)	Dundas 4YR avg SS Conc	Dundas SS Load (kg/day)	Dundas 4YR avg Ph Conc	Dundas Ph Load (kg/day)
Jan	8475	13.27	3.98	3.6	44	0.29	3.55
Feb	10339	16.19	4.86	4.9	61	0.37	4.57
Mar	30590	47.89	14.37	5.4	66	0.28	3.46
Apr	25408	39.78	11.93	2.6	32	0.30	3.64
May	8285	12.97	3.89	3.8	46	0.56	6.92
Jun	4362	6.83	2.05	3.6	44	0.51	6.24
Jul	2726	4.27	1.28	5.4	67	0.58	7.17
Aug	2854	4.47	1.34	2.7	33	0.51	6.33
Sep	5289	8.28	2.48	2.4	29	0.33	4.12
Oct	9301	14.56	4.37	3.0	37	0.29	3.62
Nov	13266	20.77	6.23	2.7	34	0.35	4.32
Dec	13647	21.36	6.41	2.3	29	0.30	3.71

***Spencer Creek SS mean 68.08mg/L; Total Phosphorus mean 0.106584mg/L; Dundas STP flow mean 0.143 m3/s

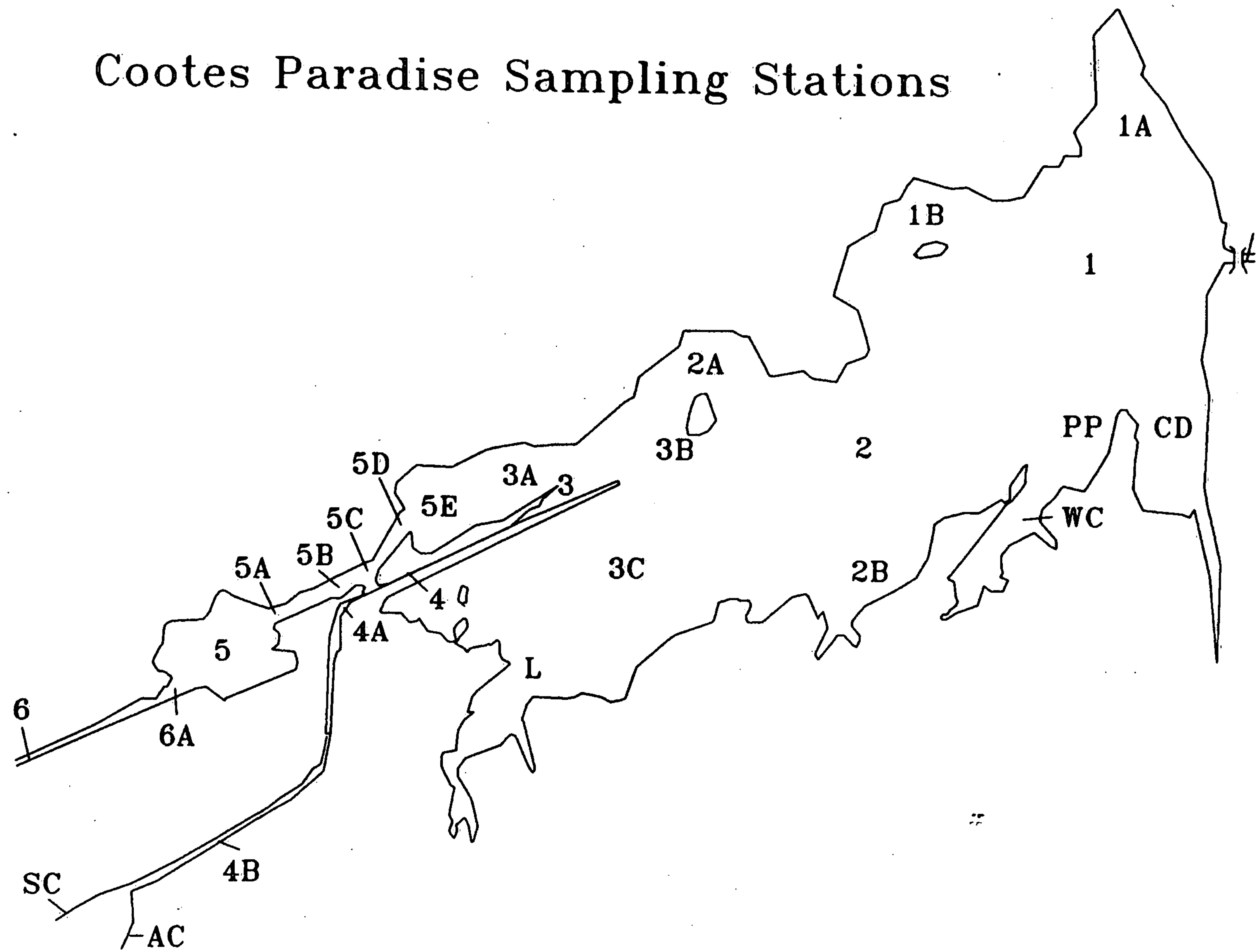

Figure 1: Cootes Paradise Study Area

1987, 1988, 1989 and 1990 CP1
Total and Soluble Phosphorus $\mu g \cdot L^{-1}$

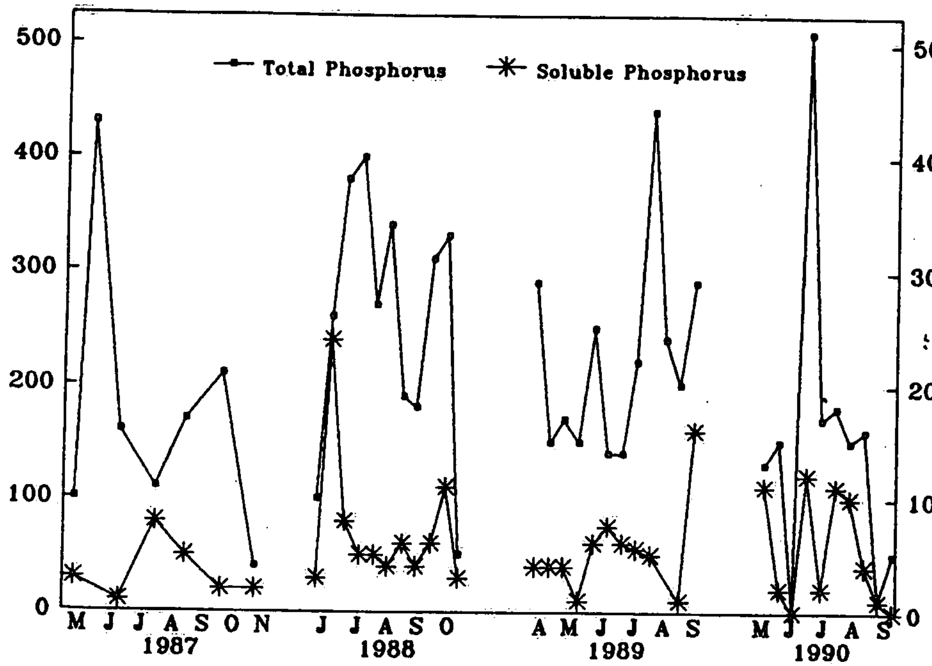

Figure 2: 1987 to 1990 Total and Soluble Phosphorus at CP1

1987, 1988, 1989 and 1990 CP5
Total & Soluble Phosphorus $\mu g \cdot L^{-1}$

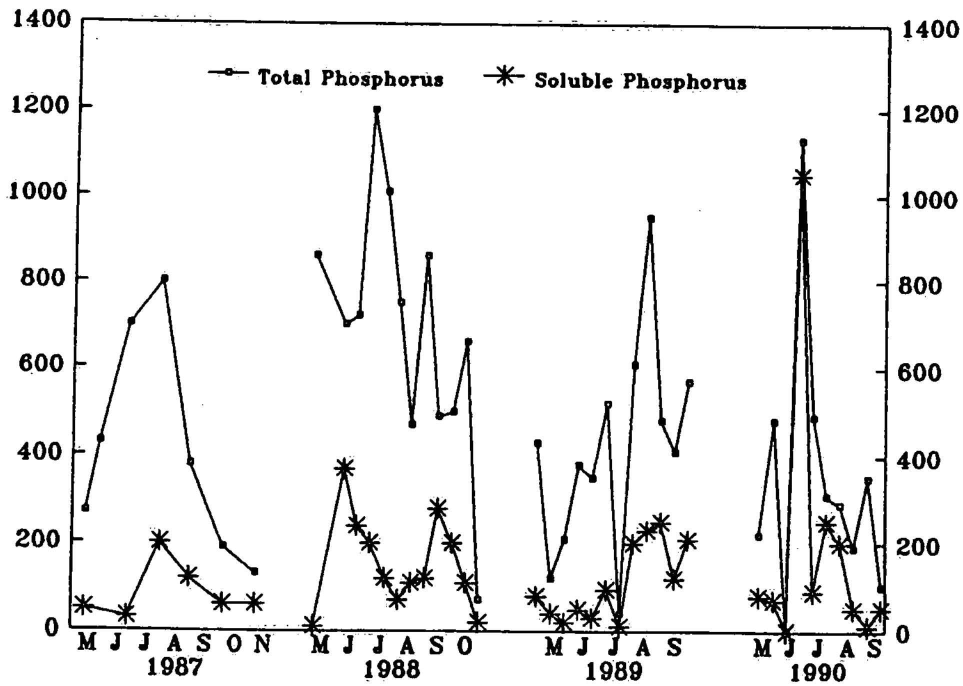

Figure 3: 1987 to 1990 Total and Soluble Phosphorus at CP5

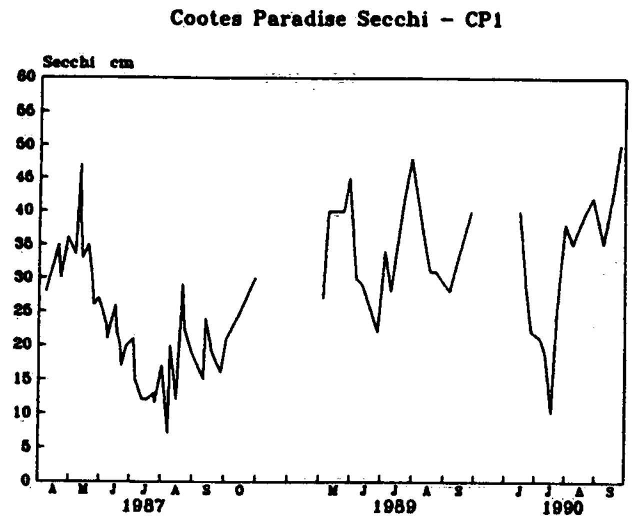

Figure 4: 1987, 1989 and 1990 Secchi Depth at CP1

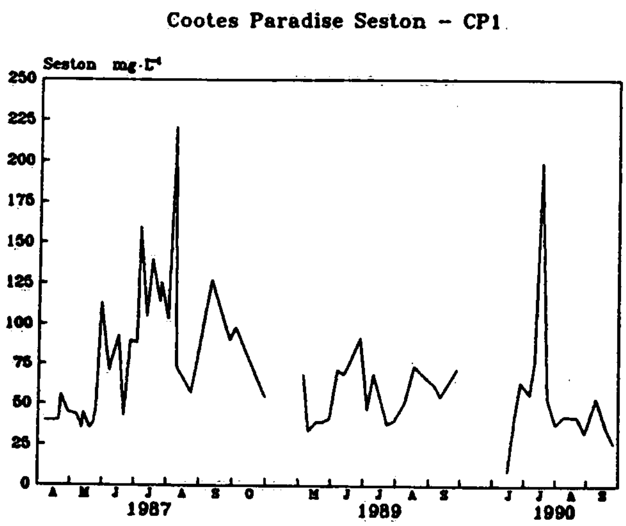

Figure 5: 1987, 1989 and 1990 Seston Concentration at CP1

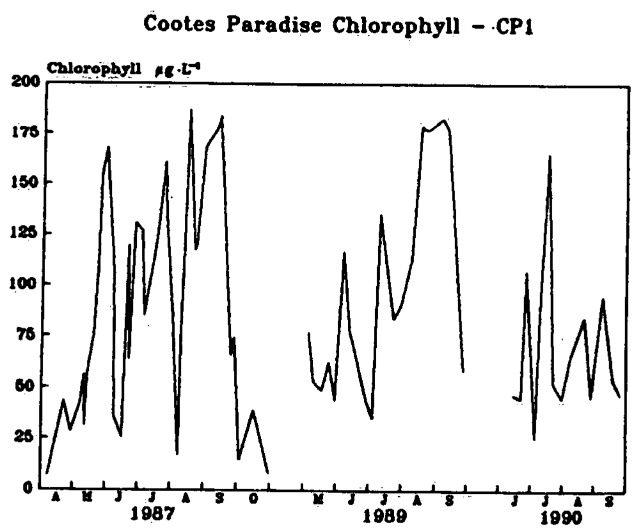

Figure 6: 1987, 1989 and 1990 Chlorophyll Concentration at CP1

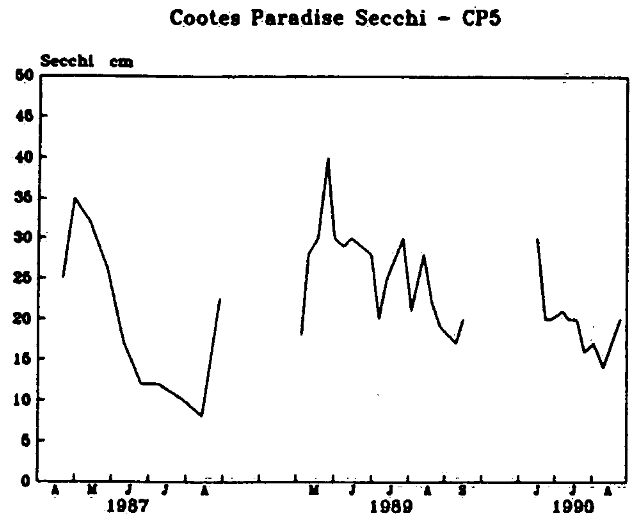

Figure 7: 1987, 1989 and 1990 Secchi Depth at CP5

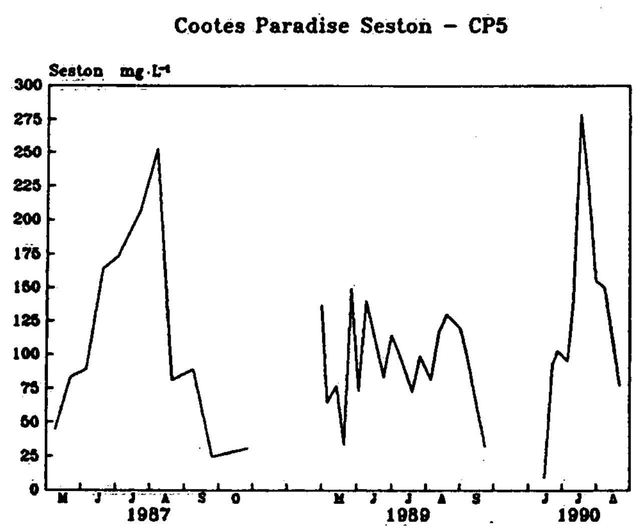

Figure 8: 1987, 1989 and 1990 Seston Concentration at CP5

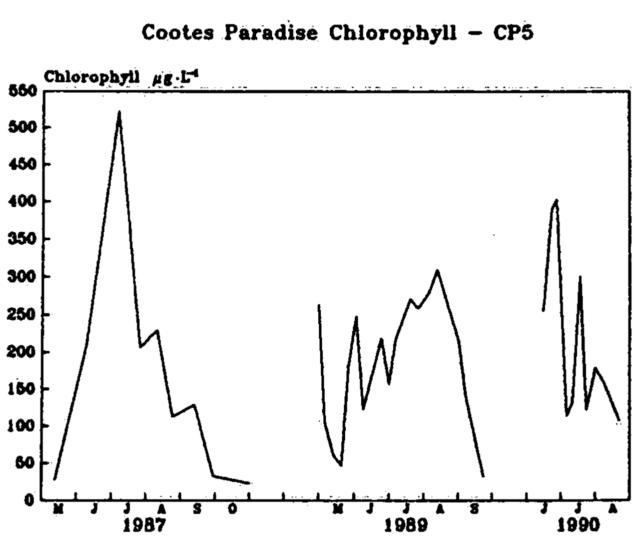

Figure 9: 1987, 1989 and 1990 Chlorophyll Concentration at CP5

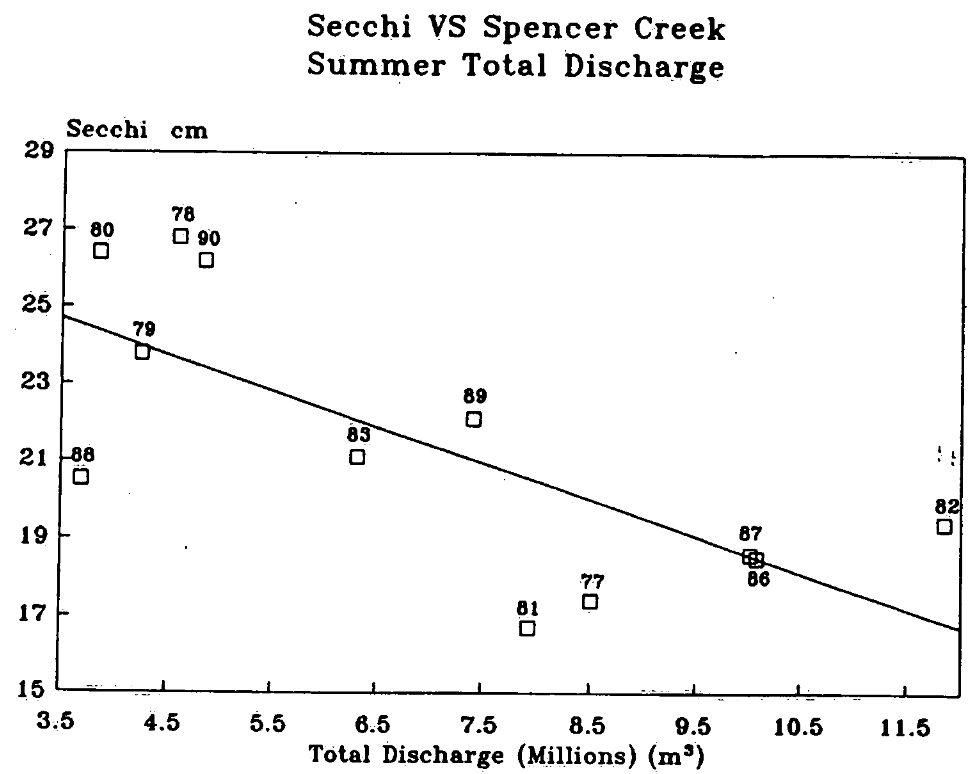

Figure 10: 1977 to 1990 Secchi VS Spencer Creek Summer Total Discharge

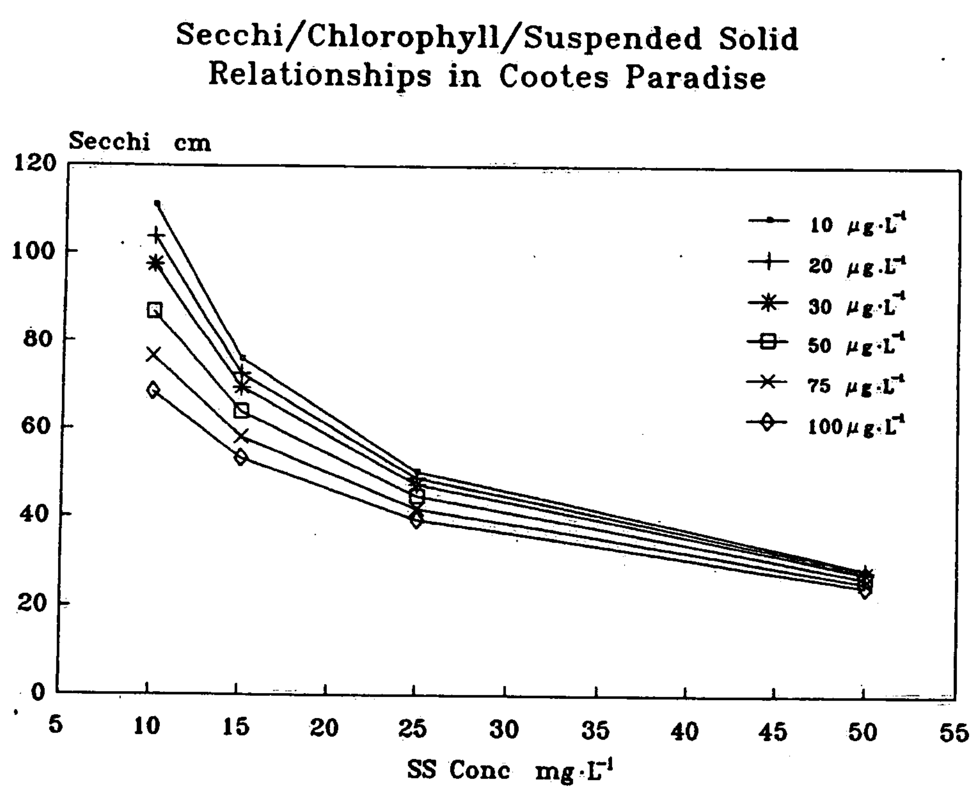

Figure 11: Secchi/Chlorophyll/Suspended Solid Relationships in Cootes Paradise

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