Five lakes (Diamond, Dubay, Fish, Jubert and Weaver) were sampled by the Commission in 1989 (figure 2). Lake morphometry, watershed area and land use data are summarized for each lake in Table 1. Land uses with potentially adverse effects on water quality include, row crops, commercial, industrial and medium and high density residential uses. These land uses are classified as deleterious uses in the Elm Creek watershed plan. Land uses with potentially positive effects on water quality include grasslands, wetlands, woods and parks. These uses are classified as sustaining uses. The percentages of deleterious and sustaining use were determined from 1980 aerial photos.

Water quality parameters monitored in 1989 are summarized in Table 2. Fish, Jubert and Weaver were sampled monthly from May through September. Analyses of lake samples for nitrogen compounds were conducted in May and September. Alkalinity and chloride analyses were conducted in May. All other parameters were monitored or analyzed monthly. Diamond Lake was sampled monthly from June through September. Alkalinity, chloride and nitrogen analyses were done once in June. All other parameters were monitored or analyzed monthly. Dubay Lake was sampled monthly from July through September. Dubay Lake was not sampled for alkalinity, chloride and nitrogen. All other parameters were monitored or analyzed monthly.

Water quality data for Lakes Diamond, Dubay, Fish, Jubert and Weaver are summarized in tables 3-7. Data from Diamond Lake was excluded from figures 6,8,10 and 12 so that the data from the remaining lakes could be viewed on a more appropriate scale.

Secchi disk transparency is a measure of water clarity. Higher Secchi disk transparency indicates greater water clarity. The maximum Secchi disk transparency occurred in May in Weaver Lake and Jubert Lake and in June for Fish Lake. The maximum Secchi disk transparency occurred in July in Dubay Lake and in September for Diamond Lake. Minimum transparency occurred in May in Fish Lake and in July in Diamond Lake. Dubay, Jubert and Weaver Lakes had their lowest transparencies in September (figure 3). Fish and Dubay Lakes had similar mean and median Secchi disk transparencies (figure 4). The two lakes had average and median values in excess of 5 feet. Weaver Lake had the highest median value (8.0 feet). Jubert Lake and Diamond Lake had the lowest mean and median values for transparency. Jubert and Diamond Lakes had mean and median values less than 2.3 feet.

Chlorophyll is a photosynthetic pigment found in all green plants. The concentration of chlorophyll a is a measure of algal abundance. The concentration of chlorophyll a in Fish Lake peaked in May and was lowest in June. Jubert Lake also had its lowest concentration in June but the peak concentration occurred in August. Diamond and Dubay Lakes had their lowest concentrations in September. Diamond Lake had its peak concentration in July and Dubay Lake had its highest concentration of chlorophyll a in August. (figure 5,6). Weaver Lake also had its highest concentration of chlorophyll a in August but had its lowest concentration in May. Diamond Lake had the highest and Weaver Lake the lowest mean and median concentrations of chlorophyll (figure 7,8).

Phosphorus is a chemical element that is essential for plant growth. Concentrations of total phosphorus indicate the maximum growth potential for algae in a lake and may be used to classify a lake's trophic status. Jubert and Fish Lakes had their maximum concentrations of total phosphorus in June. Jubert and Fish Lakes also had their lowest concentrations of total phosphorus in August. Diamond Lake had its highest concentration of total phosphorus in August and its lowest concentration in June. Dubay and Weaver Lakes had their minimum concentrations of total phosphorus in July. Weaver Lake had its maximum concentration of total phosphorus in May but Dubay Lake had its lowest concentration in September (figure 9,10). Diamond Lake had the highest mean and median concentrations of total phosphorus. Dubay and Jubert Lakes had mean and median concentrations of total phosphorus under 0.17 mg/l. Weaver Lake had the lowest median concentration and Fish Lake the lowest mean concentration (figure 11, 12). The relationships between concentrations of total phosphorus and chlorophyll trophic state and lake use are presented for comparison in table 8.

Temperature profiles show that Fish and Weaver Lakes were stratified on May 16 with well defined epilimnions. Jubert Lake was also stratified on this date but did not have a well defined epilimnion. Temperatures declined rapidly from the surface to a depth of nine feet. The lake surface was essentially the exposed top of the thermocline. Fish Lake was virtually isothermal by September 18 but Weaver and Jubert Lakes were still stratified (figures 13-15). Profiles for Dubay and Diamond Lakes are not shown due to their lack of depth. pH and dissolved oxygen profiles reflect the pattern of thermal stratification in the individual lakes (figures 16-21). pH was uniform throughout the epilimnion or tended to peak deep in the epilimnion due to photosynthesis. Dissolved oxygen concentrations mirrored temperature profiles with a rapid decrease in dissolved oxygen below the thermocline during stratification and nearly uniform dissolved oxygen concentrations during isothermal conditions. In Weaver and Jubert Lakes, pronounced peaks occurred in the lower epilimnion, upper metalimnion in May due to photosynthesis. Specific conductance varied seasonally in all lakes but did not demonstrate a consistent variation with depth (figures 22-24).

There are three categories of lakes in the Elm Creek watershed. Category I lakes have water quality suitable for body contact recreation and fishing. Category II lakes are less suitable for swimming, water skiing, and other body contact recreation due to extensive weed growth, algal blooms and/or their size. Category III lakes are marginal fishing lakes and generally are unsuitable for body contact recreation. Marginal fishing lakes can support a limited recreational fishery but have fishery problems, such as frequent winter kill and large rough fish populations. Fish and Weaver Lakes are Category I lakes, Jubert Lake is a Category II lake, and Diamond and Dubay Lakes are Category III lakes. Water quality goals for Elm Creek lakes were established in the Elm Creek Watershed Management Plan. Category I lake goals are .035 mg/l total phosphorus, 30 mg/m3 chlorophyll a and a Secchi disk transparency of 4.9 feet. Category II lake goals are .050 mg/I total phosphorus, 40 mg/m3 chlorophyll a and 3.3 feet Secchi disk transparency. Category III lake goals are .100 mg/1 total phosphorus, 80 mg/m3 chlorophyll a and 1.6 feet Secchi disk transparency. These values represent mean summer concentrations of total phosphorus and chlorophyll a and mean summer Secchi disk transparency.

Mean Secchi disk transparency in Diamond Lake declined in 1989 compared to 1986 (figure 25). Mean concentrations of chlorophyll a increased over seven times from approximately 80 to 581 mg m-3 (figure 26) and mean concentrations of total phosphorus increased by approximately 85% (figure 27). Diamond Lake has failed to meet the Secchi disk transparency, chlorophyll a, and total phosphorus goals for all three years it has been monitored.

Mean Secchi disk transparency in Dubay Lake increased in 1989 compared to 1986 (figure 28). Mean concentrations of chlorophyll a decreased over five times from approximately 62 to 12 mg m-3 (figure 29) and mean concentrations of total phosphorus increased by approximately 50% (figure 30). Dubay Lake met the Secchi disk transparency and chlorophyll a concentration goals for 1986 and 1989. Dubay Lake met the total phosphorus goal for 1986 but failed to meet the goal in 1989.

Mean Secchi disk transparency in Fish Lake also declined in 1989 compared to transparencies in 1986 and 1988 (figure 31). The 1986 transparency is the highest on record. The difference between 1988 and 1989 is not significant. The 1989 mean Secchi disk transparency is near the median of all mean values since 1980. The mean concentration of chlorophyll a and total phosphorus also declined in 1989 (figures 32,33). The decline in mean concentrations of chlorophyll a was more pronounced than the decline in the mean concentration of total phosphorus. The 1989 mean concentration of chlorophyll a is below the median mean concentration observed since 1980. The 1989 mean concentration of total phosphorus is near the median (1980-89) value. Fish Lake has met the Commission's Secchi disk transparency and chlorophyll a goal for the past four years. Fish Lake met the total phosphorus goal in 1989 but failed to meet the total phosphorus goal in 1987 and 1988.

Mean Secchi disk transparency in Jubert Lake increased in 1989 compared to 1987 (figure 34). Mean concentrations of chlorophyll a and total phosphorus were lower in 1989 than 1987 (figure 35, 36). The decline in mean concentration of chlorophyll a was more pronounced than the decline in the mean concentration of total phosphorus. Jubert Lake has failed to meet the Commission's Secchi disk transparency, chlorophyll a, and total phosphorus goals since monitoring began in 1985.

Mean Secchi disk transparency in Weaver Lake increased in 1989 .compared to 1988 and is the highest average Secchi disk transparency on record (figure 37). The mean concentration of chlorophyll decreased in 1989 compared to 1988 (figure 38). 1989 had the lowest mean concentration of chlorophyll a on record. Mean total phosphorus was significantly higher in 1989 than in 1988 and is the highest observed average concentration (figure 39). Mean concentration of total phosphorus increased in 1989 even though chlorophyll a had decreased. Weaver Lake has met the Secchi disk goal since 1983 and has met the chlorophyll a goal since 1981. Weaver Lake failed to meet the total phosphorus goal in 1989 but met the goal in all previous monitoring years.

Weaver Lake had the best overall water quality in 1989 but the water quality in Fish and Dubay Lakes was similar to Weaver Lake. Mean Secchi disk transparencies in Fish and Dubay differed by 1.0 foot although mean transparency was 3.5 feet higher in Weaver Lake. Dubay Lake had a higher mean concentration of total phosphorus (150 mg/1) than either Weaver (37 mg/1) or Fish (35 mg/1) but all three lakes had similar concentrations of chlorophyll a. Weaver Lake had the lowest mean concentration of chlorophyll a (7 mg $m^{-3}$) while mean chlorophyll a in Dubay and Fish was not much higher (12 and 11 mg m-3 ). Diamond Lake had the poorest water quality of the lakes monitored in 1989.

The decline in transparency from 1986 .to 1989 in Diamond Lake was accompanied by an increase in algal abundance as indicated by concentrations of chlorophyll a. The increase in chlorophyll . concentrations was accompanied by an increase in total phosphorus

concentrations. An increased transparency from 1987 .to 1989 in Jubert Lake was accompanied by a decrease in concentrations of chlorophyll a and total phosphorus. The decreases in total phosphorus and chlorophyll a concentrations indicate decreased algal abundance which resulted in increased transparency. Fish Lake had essentially similar transparency levels in 1988 and 1989

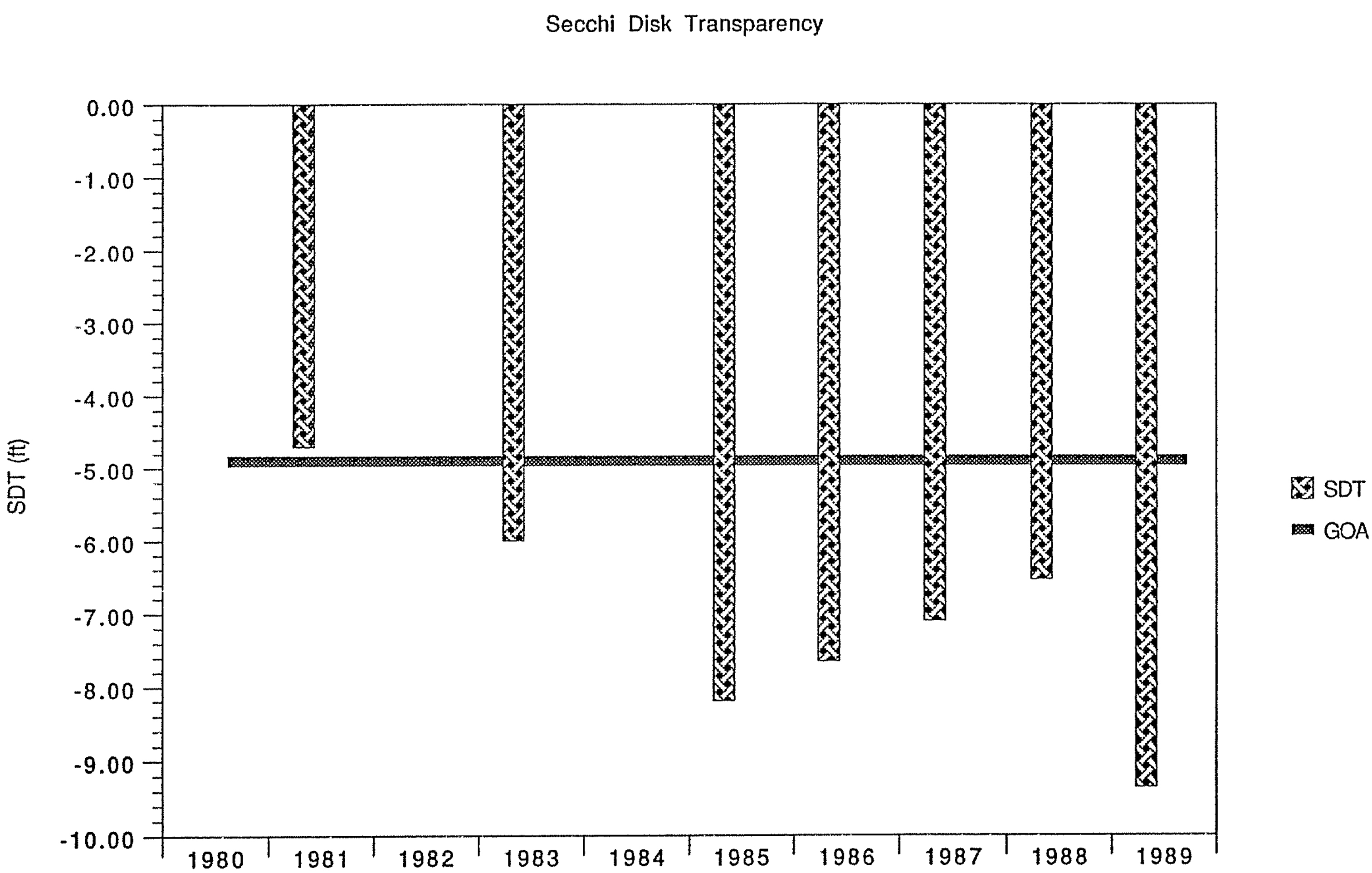
.and decreased concentrations of chlorophyll a and total phosphorus. The decreases in chlorophyll a and total phosphorus concentrations did not result in increased transparency in Fish Lake. Non-algal turbidity could be one explanation for the lack of improvement in transparency. The increase in transparency from 1986 to 1989 in Dubay Lake was accompanied by a decline in algal abundance as indicated by concentrations of chlorophyll a. An increase in total phosphorus concentrations accompanied the decrease in chlorophyll a which is unusual. The increase in total phosphorus can be explained if the percentage of total phosphorus attributed to algae was lower in Dubay Lake in 1989 than in 1986. Transparency also increased in Weaver Lake from 1988 to 1989. This increased transparency was accompanied by a decrease in chlorophyll a concentrations and an increase in total phosphorus concentrations. A decrease in chlorophyll a usually is accompanied by a decrease in total phosphorus. Weaver Lake has been chemically treated to reduce the algal growth in previous years. The dying and decaying algae resulting from chemical treatment could explain the increase in total phosphorus accompanied by the decrease in chlorophyll concentrations.

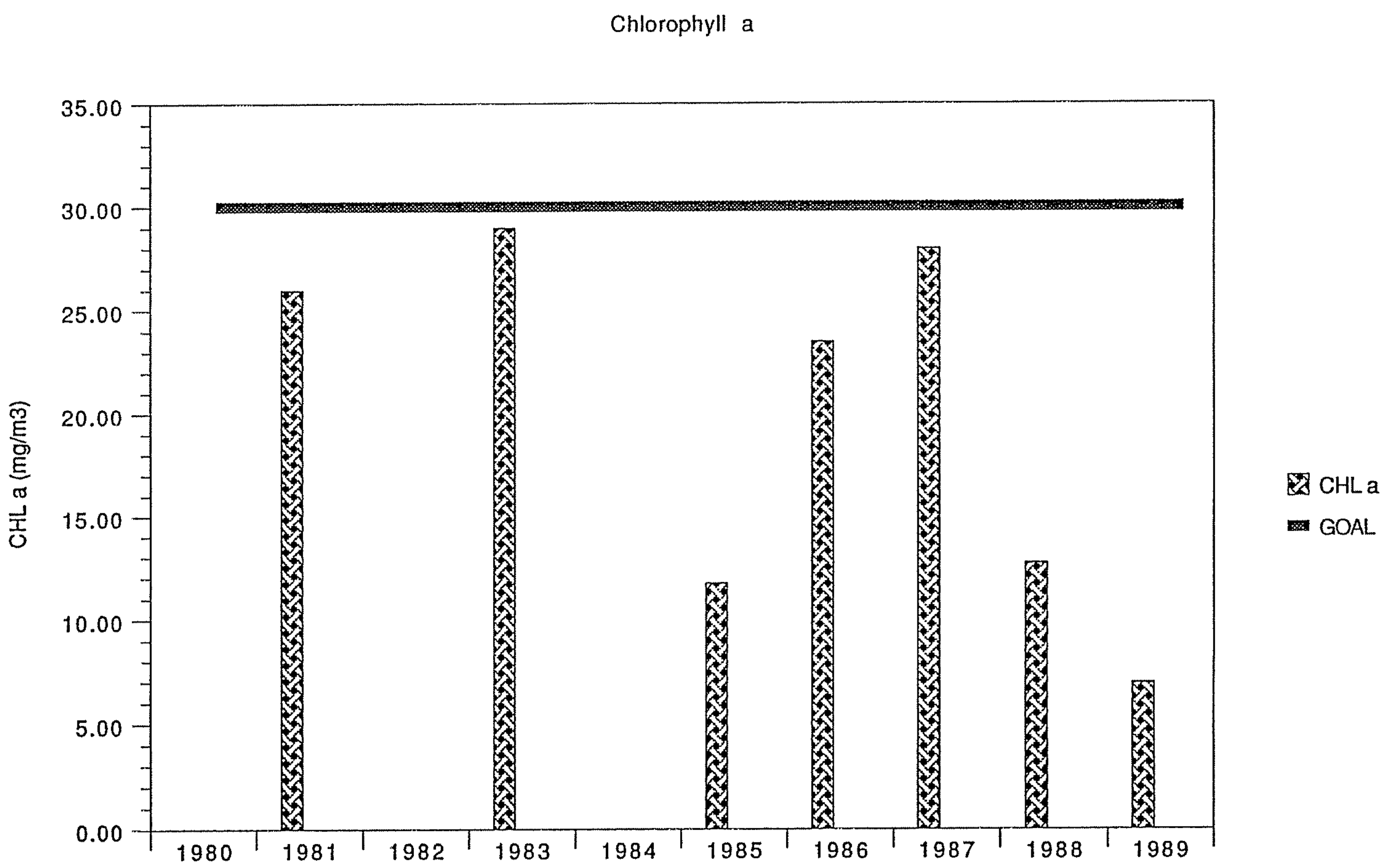
The distribution of biologically important substances in lakes is affected by differences in water density that can impede mixing of surface and bottom waters. Water density varies with temperature. Temperature profiles in lakes indicate the degree of thermal stratification or layering present at the time of sampling. Profiles of temperature (density), pH, specific conductivity and dissolved oxygen in Jubert, Fish and Weaver Lakes showed variability seasonally and with depth. Specific conductance was least affected by changes in depth. All lakes demonstrated reduced concentrations of dissolved oxygen in deeper waters during summer. Low concentrations of dissolved oxygen in deep waters are typical of eutrophic lakes. Insufficient data was collected at Diamond and Dubay Lakes to draw any significant conclusions on the temperature, pH, dissolved oxygen and specific conductance profiles.

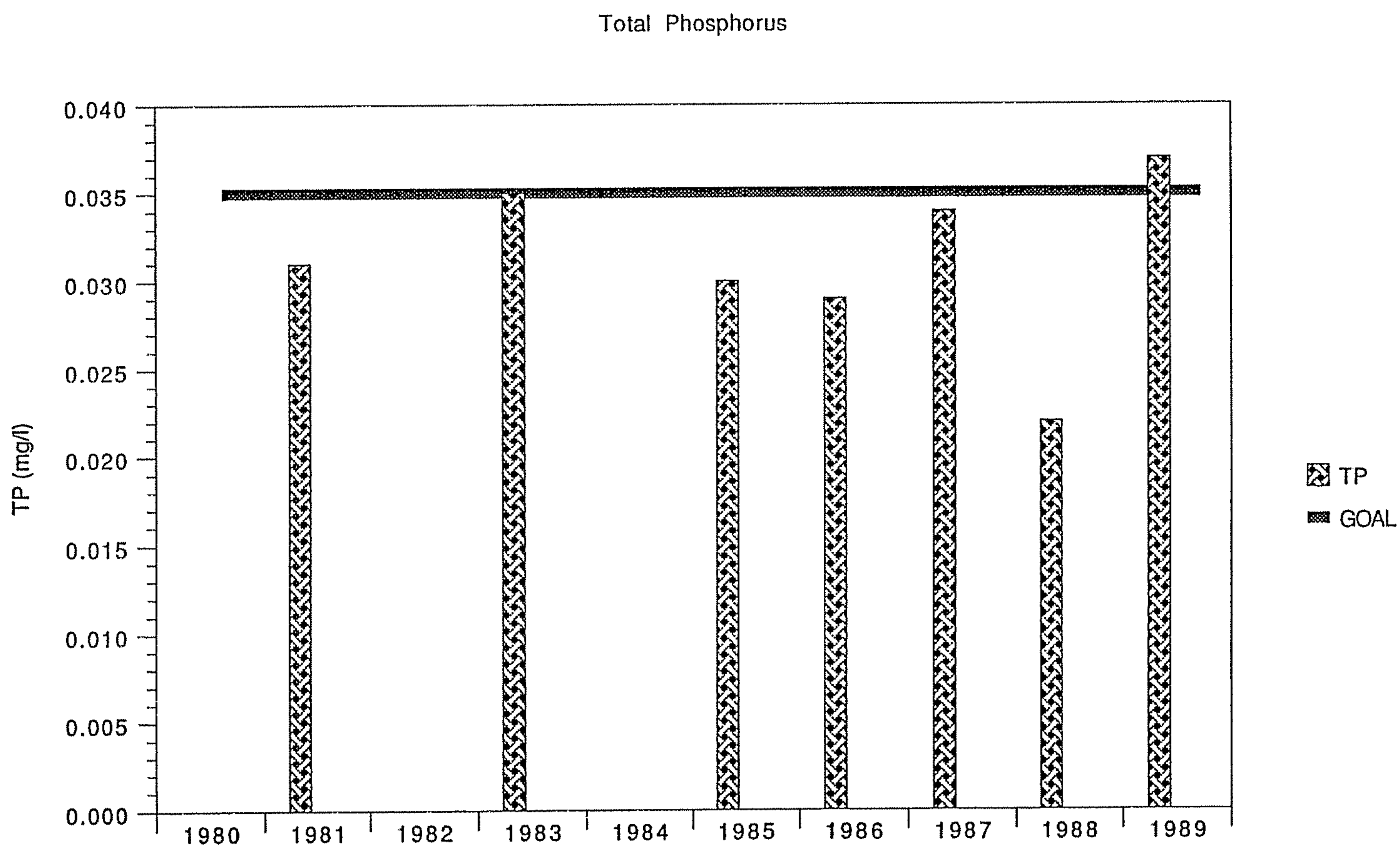
LAKE: WEAVER LAKE

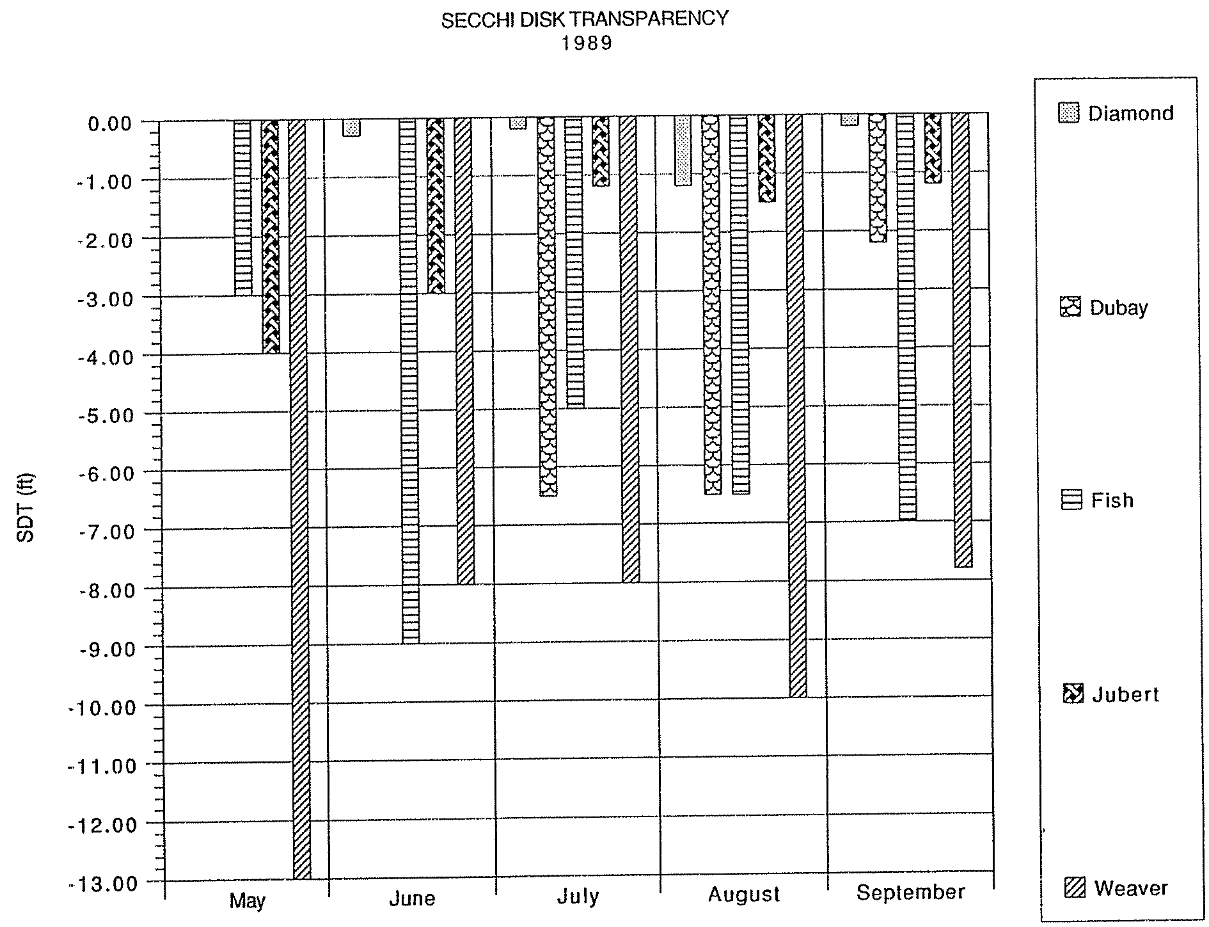
| PARAMETERS | SDT (ft) | CHL (mg/m3) | TP (mg/l) | NO3 (mg/l) | NO2 (mg/l) |
|---|---|---|---|---|---|
| MEAN (May-September) Epilimnetic | 9.36 | 6.96 | 0.037 | 0.18 | 0.011 |
| STANDARD DEVIATION | 2.00 | 2.90 | 0.016 | 0.13 | 0.006 |
| MEAN (May-September) Hypolimnetic | * | * | 0.055 | 0.06 | 0.014 |
| STANDARD DEVIATION | * | * | 0.030 | 0.01 | 0.009 |

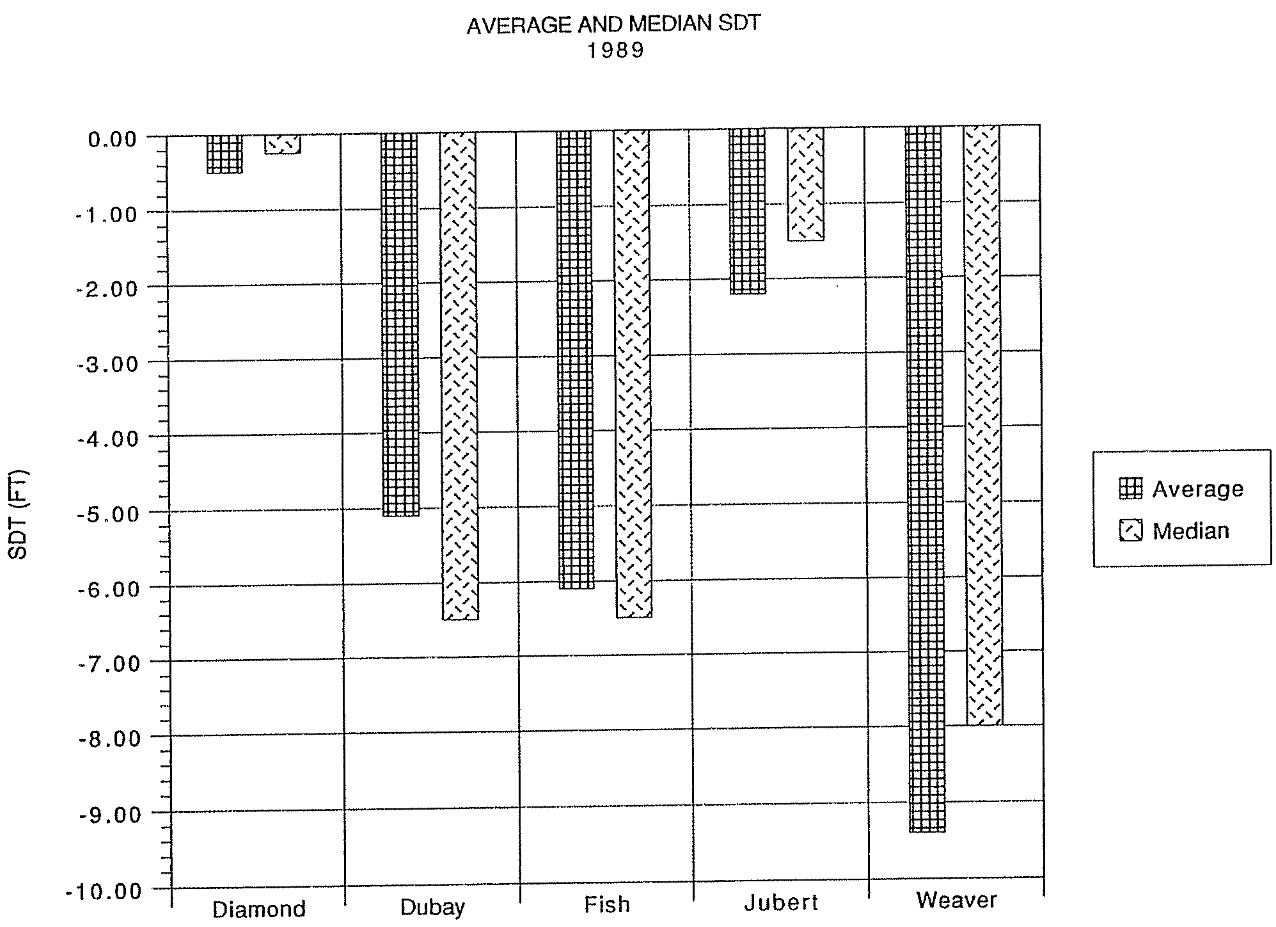
| PARAMETERS | NH3 (mg/l) | TKN (mg/l) | ALK (mg/l) | CL (mg/l) |
|---|---|---|---|---|
| MEAN (May-September) Epilimnetic | 0.534 | 1.420 | 120 | 44.60 |
| STANDARD DEVIATION | 0.219 | 0.920 | * | * |
| MEAN (May-September) Hypolimnetic | 1.203 | 2.880 | 130 | 45.20 |
| STANDARD DEVIATION | 0.286 | 1.210 | * | * |



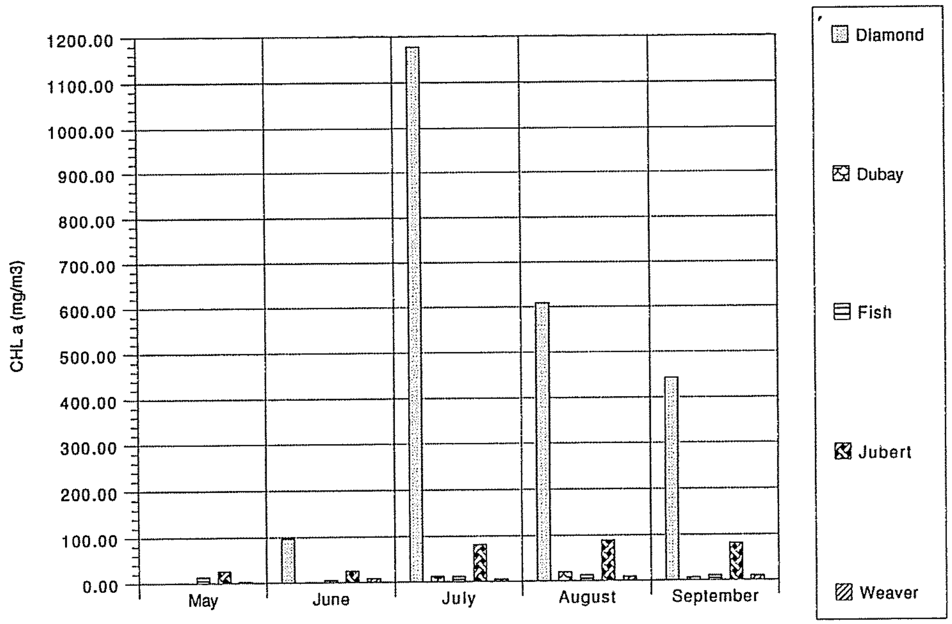

Chlorophyll a
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
CHL a (mg/m3)
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
CHL a
GOAL


Total Phosphorus
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
TP (mg/l)
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
TP
GOAL

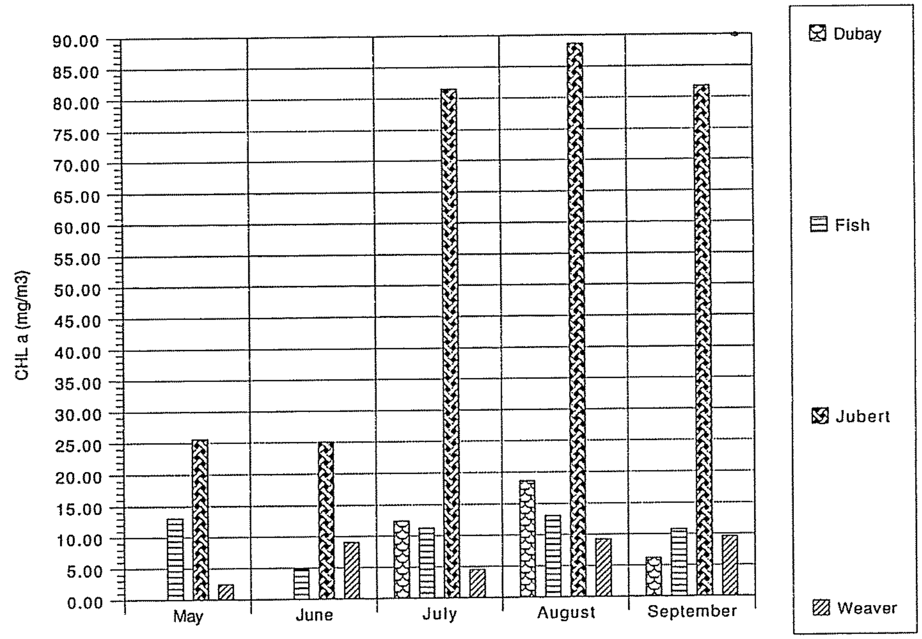

SECCHI DISK TRANSPARENCY
1989
SDT (ft)
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-11.00
-12.00
-13.00
May
June
July
August
September
Diamond
Dubay
Fish
Jubert
Weaver


AVERAGE AND MEDIAN SDT
1989
SDT (FT)
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
Diamond
Dubay
Fish
Jubert
Weaver
Average
Median

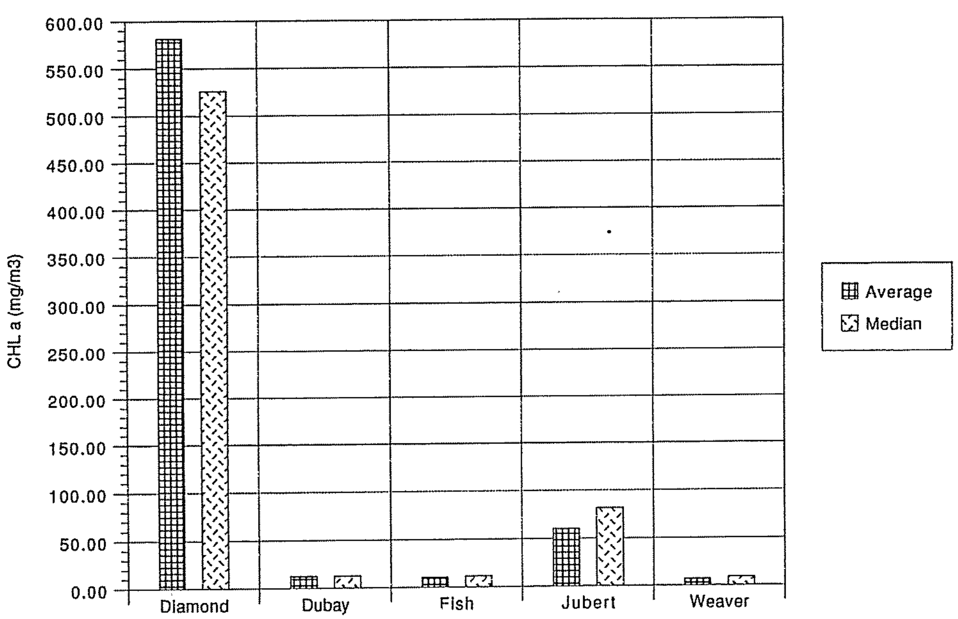
CHLOROPHYLL a
1989



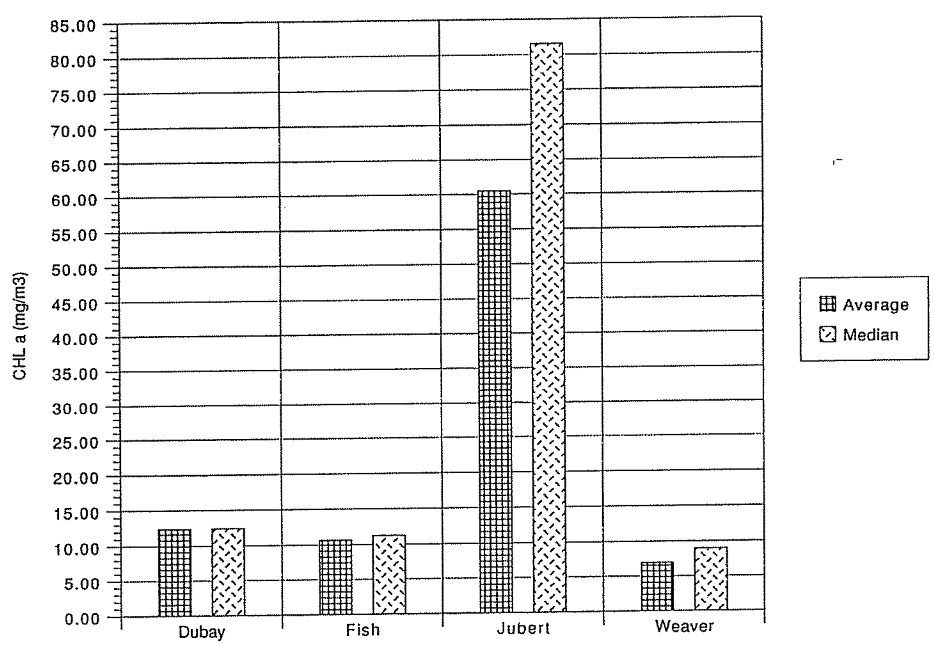

CHLOROPHYLL a
1989



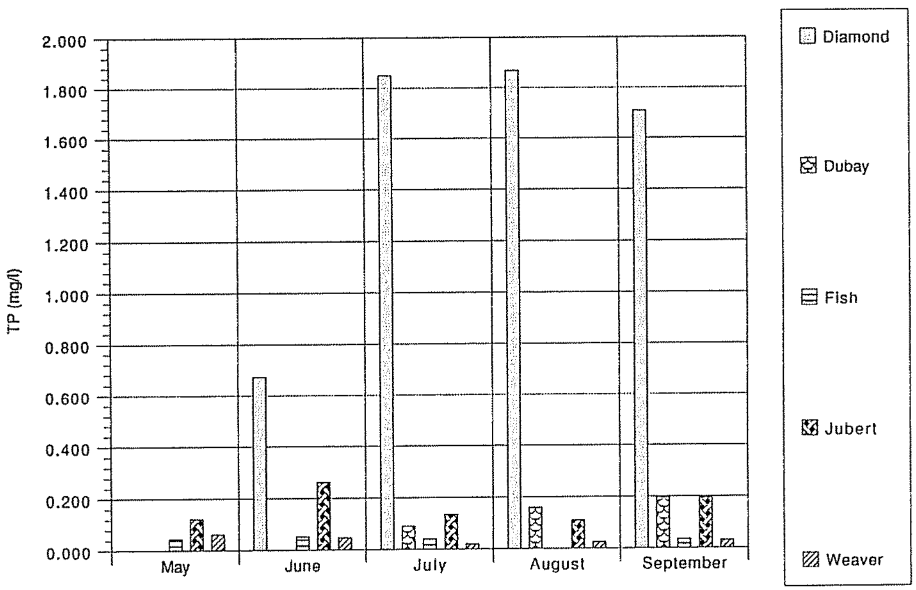

AVERAGE and MEDIAN CHL a
1989



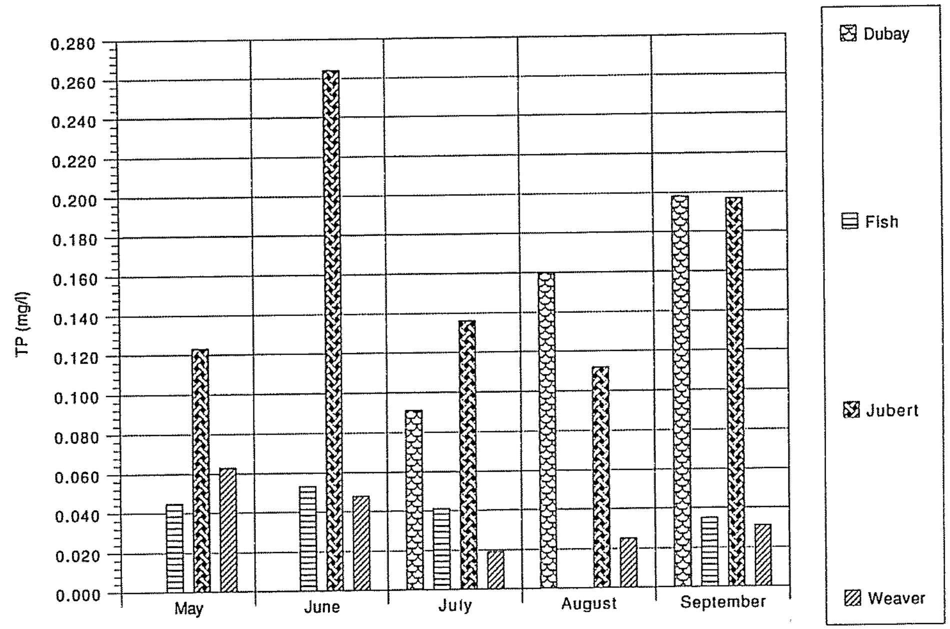

AVERAGE and MEDIAN CHL a
1989



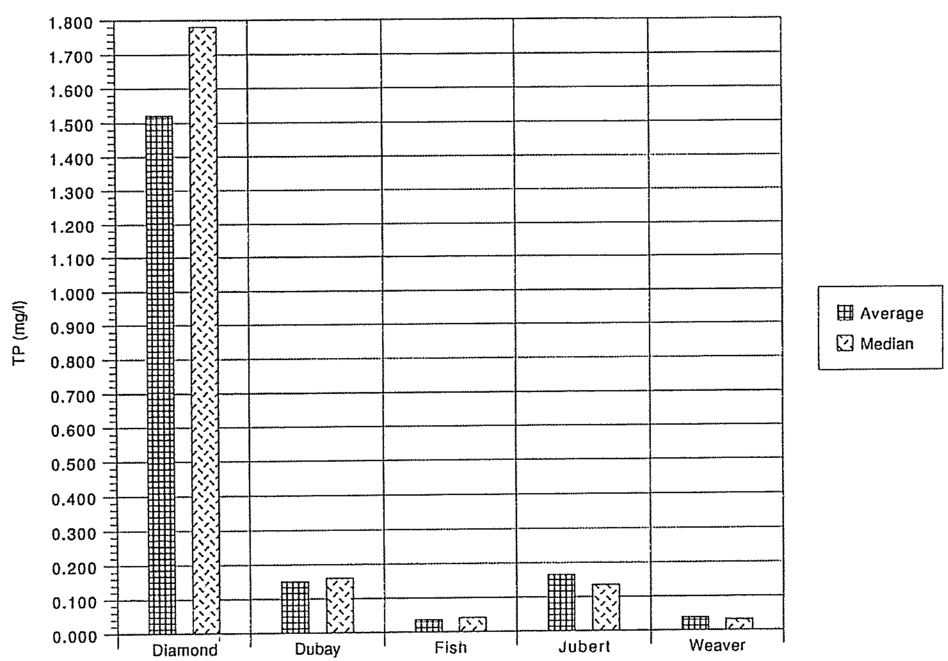
TOTAL PHOSPHORUS
1989



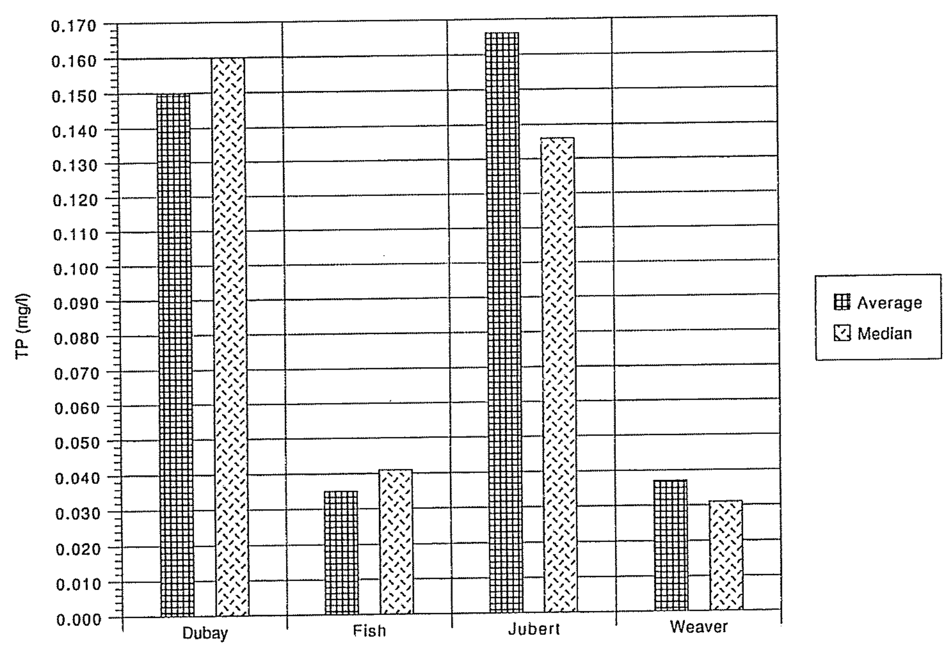

TOTAL PHOSPHORUS
1989

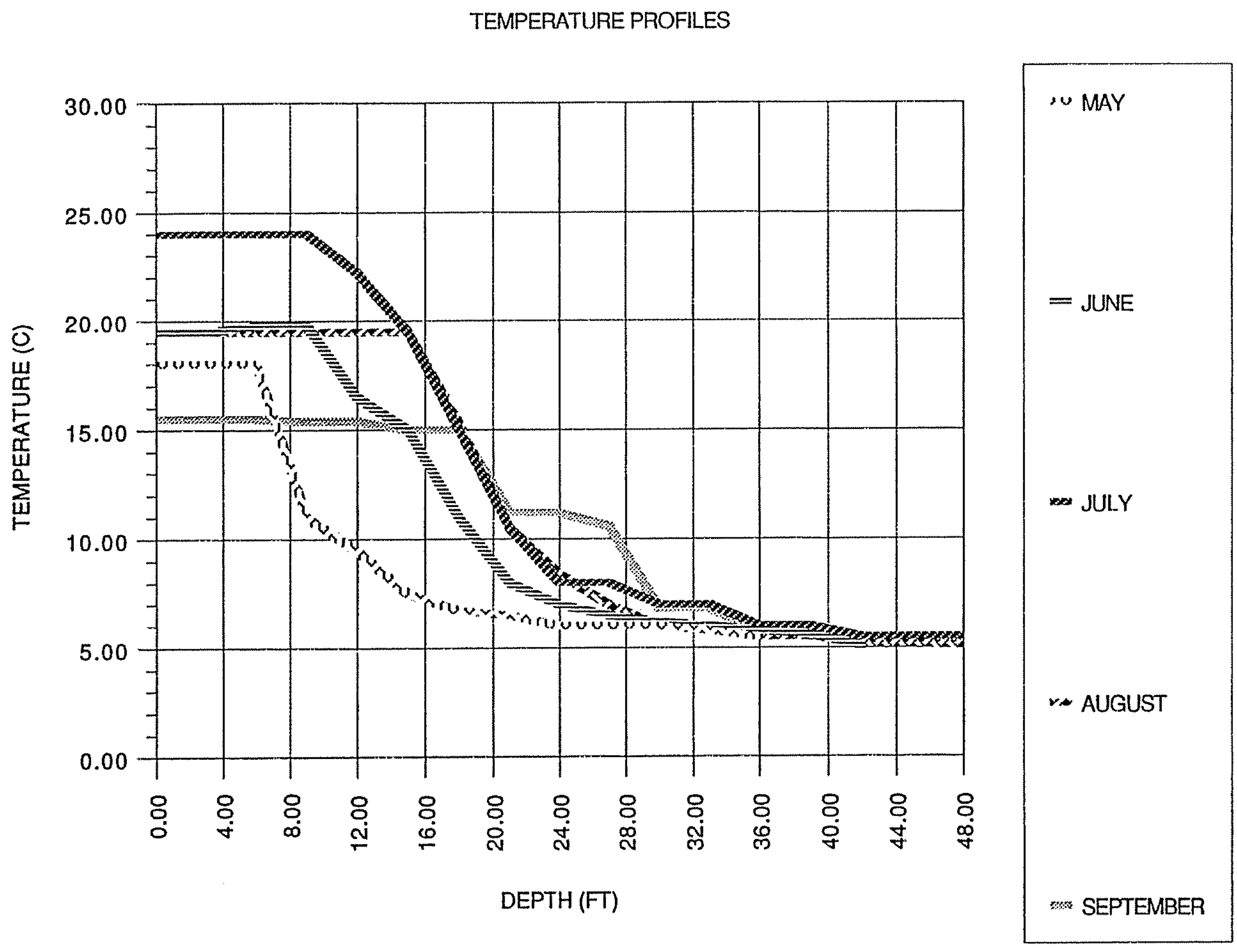


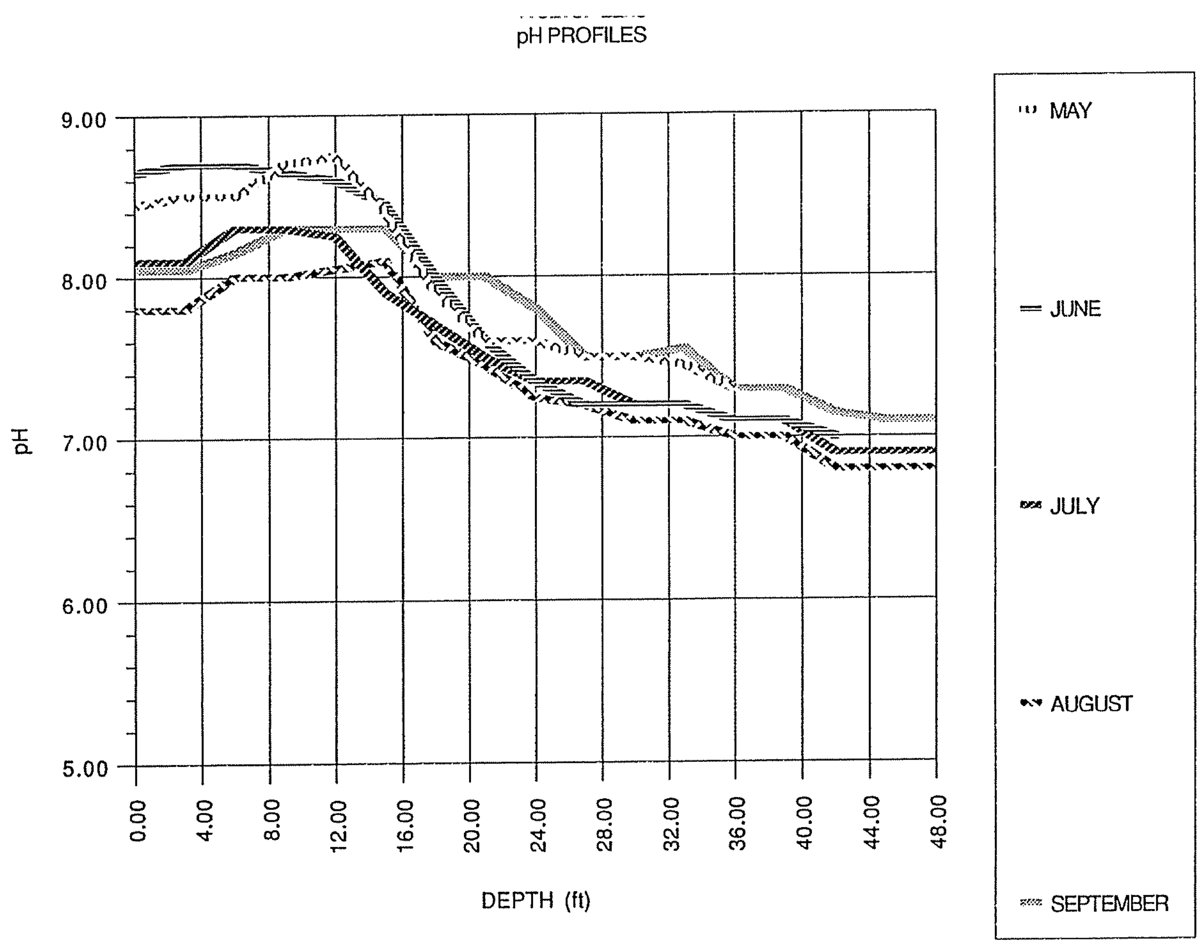

AVERAGE and MEDIAN TP
1989

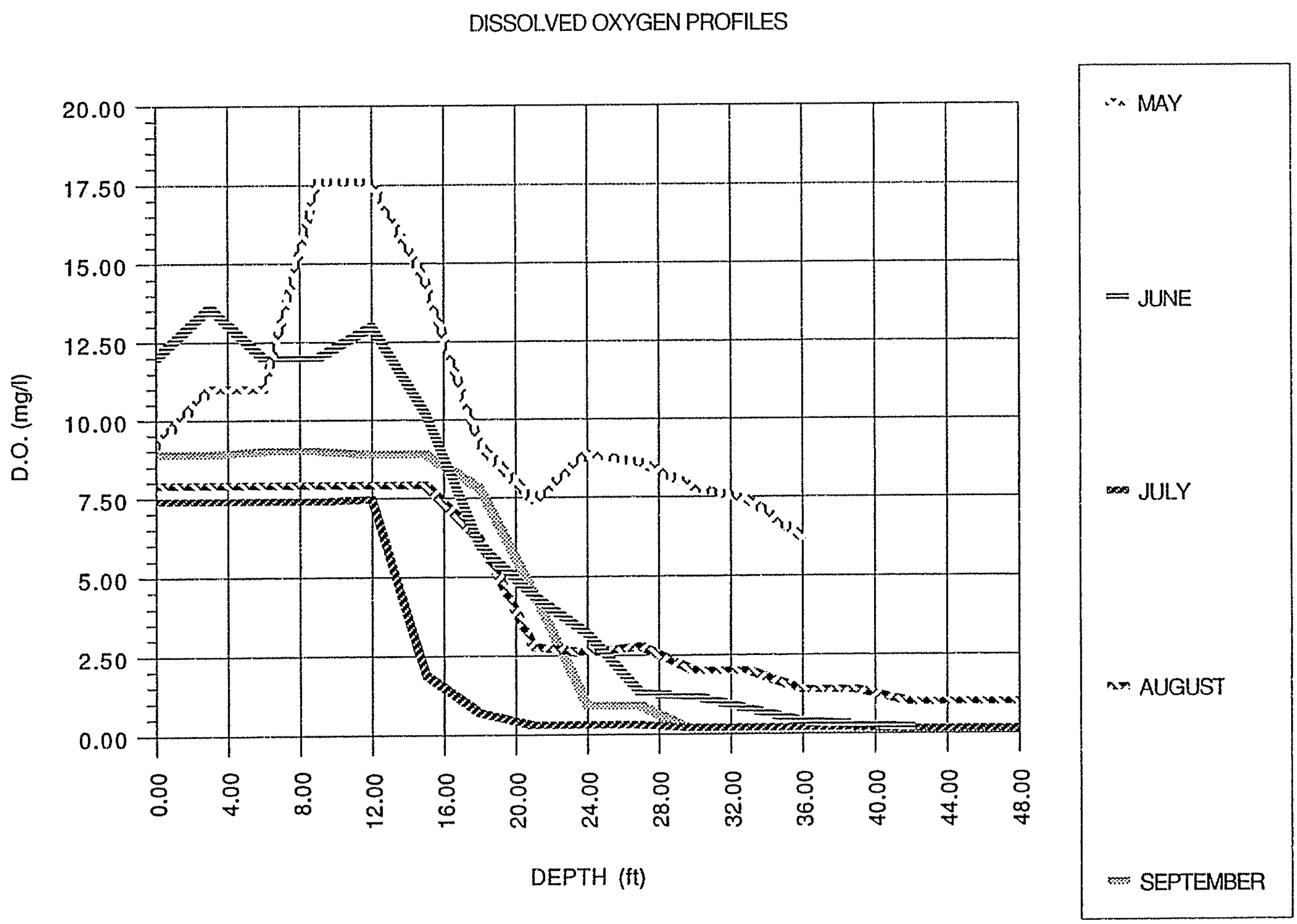


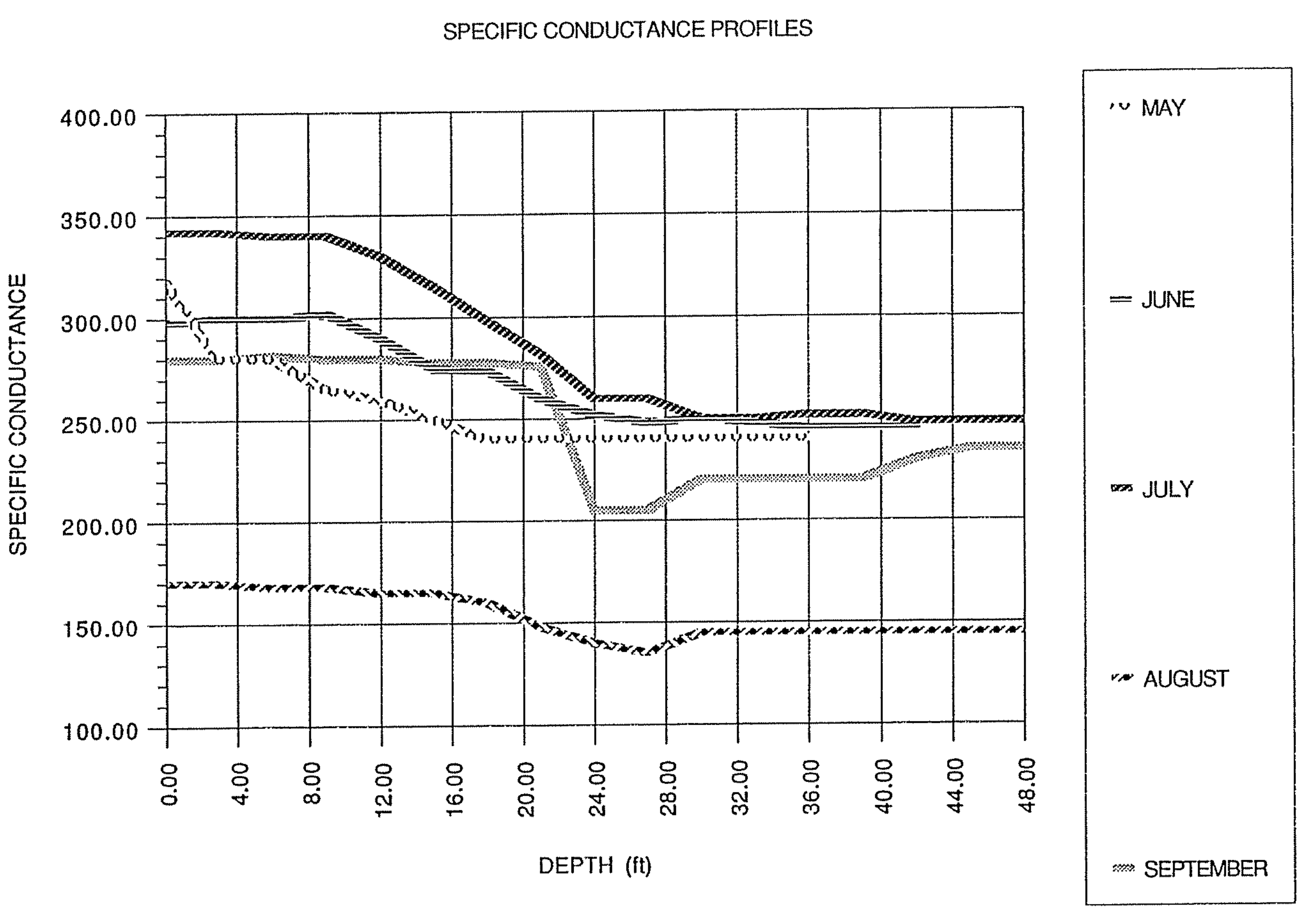

AVERAGE and MEDIAN TP
1989




TEMPERATURE PROFILES
TEMPERATURE (C)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
DEPTH (FT)
MAY
JUNE
JULY
AUGUST
SEPTEMBER


pH PROFILES
pH
9.00
8.00
7.00
6.00
5.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
DEPTH (ft)
MAY
JUNE
JULY
AUGUST
SEPTEMBER


DISSOLVED OXYGEN PROFILES
D.O. (mg/l)
20.00
17.50
15.00
12.50
10.00
7.50
5.00
2.50
0.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
DEPTH (ft)
MAY
JUNE
JULY
AUGUST
SEPTEMBER


SPECIFIC CONDUCTANCE PROFILES
SPECIFIC CONDUCTANCE
400.00
350.00
300.00
250.00
200.00
150.00
100.00
0.00
4.00
8.00
12.00
16.00
20.00
24.00
28.00
32.00
36.00
40.00
44.00
48.00
DEPTH (ft)
MAY
JUNE
JULY
AUGUST
SEPTEMBER