DRAFT

This is an interim report covering some of the preliminary characterizations of the tinaja ecosystems of the Waterpocket fold in Capitol Reef National Park and assesseing the effect of cattle on the ecological variables of the aquatic environment considered to be sensitive to the presence of cattle. A final report will be submitted covering the Ecological Characterization of the Tinajas and biological assessment of the effect on cattle as adequate time for complete analysis of the data permits.

There were four watersheds selected as representative of the different types and locations in the Waterpocket Fold in the Park. The watersheds vary in total area and the maximum volume among the representative tinajas within each sample drainage varied by nearly ten-fold (Table 1). The relative elevation change and location of the tinajas in the drainage was slightly different among watersheds (Figure 1).

The watersheds and the tinajas also differed qualatively from one another in that Willow and Cottonwood drainages had a more open canyon type of relief, while the Fountain drainage was more of a narrow cliff-shaded rock defile. Miahayen, the largest watershed, was a mix of the two. In addition to volume (Table 1) the tinajas varied physically due to two forces shaping their formation. One type of tinaja was formed as a plunge pool at the foot of an intermittent waterfall or cascade. Its deepest point is where the water enters and shallows out in a radius from that

- Unpublished draft interim report by Dr. Terence Boyle, regarding study of "livestock effects on the tinajas of Capitol Reef National Park". 1987
- A final report was never completed.
- Comments on this draft attached at end, and annotated throughout. Comments by Norm Henderson, CARE Chief of R.M.

point forming a sand beach on the downstream side. At some tinajas this sand beach has been colonized and stabilized by various types of terrestrial vegetation resulting in an almost permanent berm of soil serving as a dike raising the level of the water in the tinaja. A second type of tinaja is formed primarily by dissolution of the calcium carbonate cementing the sand grains together by naturally occurring carbonic acid in the rain water. These dissolution pools are in bare slick-rock and are usually round or elliptical and have the classical tinaja (water jar) cross section. Some of this second type of tinaja may have sand bottoms, however some are practically empty except for the water. In spite of the fact that the Waterpocket Fold anticline is composed of at least five distinctly different layers of sandstone, the tinajas found occurred only in the Navajo formation.

The major cation-anion characterization of the tinajas from samples collected in May revealed the total ion concentration to be very low for surface waters. The differennce in patterns of chemical constituents were higher iron concentrations in the Willow and Cottonwood drainages, and higher calcium, magnesium, and bicarbonate in the Fountain and Miahayen drainages (Table 2a). This was reflected in a higher conductivity and pH in the Fountain and Miahayen tanks. Notable excursions from the background pattern of low chemical concentrations is the high potassium (6.8 mg/L) and high ammonia (2.7 mg/L) found in Willow 5 in the May sample (Table 2b). Both of these constituents were probably due to the presence of cattle which use that tinaja heavily during the winter grazing season.

There was a general increase in many chemical constituents in Willow #5 i.e., Ca, Mg, Na, K, HCO_3, Cl, SO_4 and conductivity; are all these associated w/ grazing? Willow 5 is small and could concentrate these anions/cations.

Iron concentrations were elevated in Fountain and Miahayen Tanks in a late September sample and low in Cottonwood and Willow Tanks (Table 3). A sample taken two weeks later in these tanks in October showed greatly reduced iron concentrations. A sample taken again in November in all drainages and tanks showed low levels of iron except in the five tinajas in the Willow drainage (Table 3).

Although there is scanty information on the toxicology of iron in the literature, iron is present in the tinajas at levels that may be toxic to some aquatic life. The U.S.E.P.A. criteria for maintaining freshwater life is concentrations of iron not to exceed 1.0 mg/l (U.S.E.P.A., 1976), however one study indicates that iron is toxic to algae at 0.45 mg/l (McLean, 1974). Settling iron flocs have also been reported to coat and precipitate planktonic diatoms (Olsen, 1941). Moreover, precipitated iron may complex with phosphorus rendering it unavailable as a nutrient for algae. Another study by Warnick and Bell (1969) found that concentrations of 0.32 mg/l killed half the populations of selected species of mayflies, stoneflies and caddisflies in 96 hour laboratory exposures. Iron is present in the tinajas of Capitol Reef at levels sufficiently high and may result in acute toxicity and death of selected species of aquatic organisms. The biological communities present in the tinajas may be restricted to those organisms that are tolerant to pulses of high iron concentration. Iron probably comes into the tinajas from the watershed dissolved in runoff water as ferric ($+Fe^{+2}$) state and probably precipitates as ferric hydroxide (Hem 1970). The chemistry of iron in natural waters is complex and at least in part, biologically controlled. To assess the effects of the high iron concentrations on the tinajas more needs to be known about its persistence and fate in the water column.

To determine biological differences among the four watersheds selected variables were analyzed using a split-plot in time analysis of variance (Steele and Torrie, 1960). To be considered statistically significant there had to be a significant (<.05) main effect among drainage and a non-significant (>.05) interaction with the time effect. Where this criteria was met on range tests it was applied to separate the means by watershed. This statistical procedure is conservative and robust. Of this variables tested by this procedure including density of larval amphibians, number of observed adult amphibians, benthic macroinvertebrates, census of invertebrate density of zooplankton, and the density of phytoplankton as indicated by chlorophyll a (Table 4). The pattern of analysis from the mean separation showed that Willow and Cottonwood had higher zooplankton densities than Fountain and Miahayen drainages. Phytoplankton density was significantly higher in Cottonwood Tanks than in Willow. Chlorophyll a (phytoplankton) was not measured in Fountain or Miahayen.

The final set of variables in this preliminary characterization considers the distribution of species of adult amphibians observed among the 20 tinajas (Table 6). In general the canyon treefrogs were distributed in those tinajas that were surrounded at least partly by rock walls as in the upper Willow Tanks but predominantly in Fountain and Miahayen. The toads had a less definitive distribution with the exception of *Bufo punctatus* which appeared to require tinajas with sandy beaches and the Cotonwood system in particular.

Effects of Cattle

The cattle were expected to have three sets of possible effects on the aquatic communities in the tinajas. First was alteration of the shoreline vegetation where it occurred and reduction of terrestrial habitat required by aerial or terrestrial life stages of aquatic organisms. Second is the effect of urea directly introduced into the tinajas as urine. Urea in aquatic systems quickly breaks down into two ammonia molecules. Un-ionized ammonia is highly toxic to aquatic organisms in general and to species of zooplankton in particular (U.S.E.P.A., 1985). Third is the effect of feces deposited directly into the tinajas by cattle. The feces and to some extent the ammonia from urea creates a biochemical oxygen demand due to their direct oxidation and due to the increased respiration of the microbial population using the reduced organic compounds in the cattle feces. The possible stress to the aquatic community results from lowering the dissolved oxygen to the point where sensitive species are eliminated. — What about the increase in population level due to increased nutrients. Couldn't that also be a possibility?

The cattle in the allotment containing the four drainages are stocked in October and removed in April. In 1986 this was true except for a single cow and her calf which lingered during the summer in the vicinity of Willow and Cottonwood tanks. A site visit in late April showed that the tinajas, Willow 5, Cottonwood 4 and 5, and Fountain 5 were heavily visited by cattle before their removal. Therefore, these tanks were compared with those not visited by cattle in these respective watersheds to determine if there were effects.

To determine whether the presence of cattle had a latent effect on the aquatic community several variables were examined over two periods of time: May to early July is the dry period when the volume of water in the tinajas decreased by evaporation and loss due to seepage. This is the time period when the residual effects of cattle should be most apparent. Late July to September is the time when the tinajas were affected by the precipitation from the summer monsoons. Because of the apparent differences in physical factor and water chemistry, the tinajas within the drainage are examined separately and compared for effects due to the presence of cattle. The Miahayen drainage was not in these comparisons because cattle did not appear to utilize the area.

Willow Tanks

The tinajas in the Willow Tank system showed a rapid reduction in volume from May to early June (Figure 2). All tinajas in the Willow drainage were dry [mostly dry] by early July. By mid-July precipitation had restored the maximum volume to all tinajas (Figure 2, 3). Tinajas 1, 2, 4 and 5 appear to lose water rapidly indicating that seepage into the bedrock is an important means of water loss. Comparison of dissolved oxygen (DO) profiles in two similar tinajas showed that low DO occurred in both bodies of water and were part of the variability of the natural system probably due to water loss on concentration of the respiring biological community (Figure 4). No effect due to cattle on DO could be inferred from the data. * what about statistics on DO? Compare between tinajas over time.

date of first data almost one month after cattle taken off!

The pH of the Willow tinajas ranged from [range] neutral to very slightly acidic (Figure 5). There was no important variation in pH among tanks. Conductivity in the Willow Tank Tinajas indicated a low concentration of dissolved solids (11-70 mg/L) except on June 26 in Willow 5 when the conductivity indicated a dissolved solid approaching 200 mg/L (APHA, 1975) (Figure 6). Turbidity appeared to be intermediate on most sample dates for most tinajas except for a very high value on June 26 in Willow 5 (Figure 7).

Total phosphorus measured in Willow Tanks was very low in all samples indicating oligotrophic conditions (Carlson, 1977) except in Willow 5 on June 26 when the phosphorus concentration increased by over two orders of magnitude and moved the Trophic Status Index into the highly eutrophic region (Figure 8).

Total nitrogen in the Willow Tanks indicated that again something was contributing to extraordinary high levels in Willow 5 on June 26 (Figure 9). Comparing the ratio of nitrogen to phosphorus indicated that only on two occasions was nitrogen the element limiting to primary production (NES, 1975). Total carbon showed no unusual levels in concentrations except for the June 26 sample in Willow 5 which was high relative to the other samples and beyond what would be normally expected in an unpolluted aquatic environment (Figure 10).

Chlorophyll a extract from algae is an estimate of phytoplankton density (U.S.E.P.A., 1973). Because phosphorus is the limiting nutrient in the tinajas there should be a general relationship between the concentration of phosphorus and cholrophyll a. In the case of Willow Tanks this relationship is out of bounds in that frequently phosphorus is indicating a low productivity, oligotrophic situation while cholrophyll a is indicating a eutrophic situation. This occurred four times in the sample season in Willow Tanks, in Tinajas 2, 3 and twice in Tinaja 5. In the first two cases the phosphorus to chlorophyll a ratio are beyond the expected range and could have come from benthic algae or periphyton suspended as plankton. The high levels of chlorophyll a in Willow 5 could be the result of the high level of nutrient stimulating the production of algae (Figure 11).

The pattern of zooplankton density did not appear to be associated with water quality or algal abundance but appeared to rise after reduction in volume indicating a concentrating effect (Figure 12). Species diversity of the zooplankton community was calculated as the Shannon formula and was low overall due to restricted number of species present (Figure 13).

how many species? What ones?

The zooplankton community was analyzed using a comparison of the similarity between cattle affected tinajas and those without cattle, and the similarity within the uneffected tinajas. The statistical inference is that if the "within" similarity is greater than the "between" then there is a significant effect due to the cattle (Boyle, et al, 1984). There were no significant differences among the zooplankton communities similarities in Willow Tanks that could be ascribed to the use by cattle (Table 7). what about species differences?

The species richness and diversity of the benthic macroinvertebrate community was even lower than the zooplankton. The benthic macroinvertebrate community was dominated by the family Chironomidae which characteristically have short life spans, high reproductive potential, are facile colonizers and are tolerant to a high degree of environmental stress, especially low

types etc.
what about other macroinvertebrates; i.e., boatman, backswimmer etc.?

dissolved oxygen. There were no differences in the benthic macroinvertebrates for diversity and similarity that could be ascribed to the use by cattle (Table 7).

Again, data collected over one month after cattle taken from range. How do you know there wasn't an influence when the cattle were there?

Cottonwood Tank

The tinajas in the Cottonwood system showed the same drying trend in the May through early July period as Willow Tanks (Figure 14). Tinajas 4 and 5 were available to cattle during the winter months, the greatest volume, and were nearly dry at the early July sample date. The tinajas volume increased with precipitation during the mid-July through September monsoon (Figure 15). Even during this rainy season the Cottonwood Tinajas show rapid loss of water unless maintained with frequent precipitation. Comparison of the pattern of dissolved oxygen in selected tanks showed the low DO conditions occurred during the time of low water regardless of the access by cattle (Figure 16).

Analysis of the pattern of conductivity shows a low concentration of dissolved solids ranging between 15-130 mg/L (Figure 17). In the dry period the conductance increases with reduction in volume as would be expected with loss due to evaporaton. During the monsoon there was less fluctuation due to the more constant freshwater input. Tinaja 4 and 5 did not show any pattern in conductivity change different than the rest of the tinajas that could be interpreted as impact from cattle. The pH fluctuated in Cottonwood during the May to July dry season from 5.9-7.9 pH units. Within individual tinajas increased pH's during this time were due to the denser algae and higher photosynthetic rate removing carbon dioxide from the water and raising the pH (Figure 18). The pH's during the July-September were lower reflecting the lower chlorophyll a concentrations during this period. Turbidities in Cottonwood tanks were within and expected unpolluted range and appeared to vary during the dry season with chlorophyll a (Figure 19). Total phosphorus concentration during the dry season appeared to vary inversely with volume indicating a concentration effect due to evaporation loss (Figure 20). Total phosphorus during the monsoon season showed a reduction in concentration due to dilution. The phosphorus concentration in the tinajas reflect a Trophic Status Index (Carlson, 1977) in the low nutrient or oligotrophic range. The nitrogen to phosphorus ratio indicated that phosphorus was the nutrient limiting to primary production (Figure 21). Comparisons of total carbon showed that the upper tanks in the Cottonwood drainage had the highest concentration indicating that they may be acting as a filter collecting and sequestering the detrital material in the watershed (Figure 22). The carbon concentrations did not show an influence due to the presence of cattle in the system.

Like Willow Tank, the chlorophyll a level in Cottonwood Tanks were much higher in the dry period May to early July than in the later mid-July to September monsoon seasons (Figure 23). The chlorophyll a values were higher than predicted by total phosphorus concentration and may have been due to suspension of attached algae from the bottom or sides of the tinajas. There was no pattern in the chlorophyll a concentrations that appeared to be due to nutrient enrichment associated with the presence of cattle.

The zooplankton community was analyzed for three parameters. The density of zooplankton varied greatly among the tinajas and over time within a single tinaja. This variation was primarily attributable to the rapid parthenogenic reproduction rate of the crustaceans: when high numbers of zooplankton were counted they were predominantly the nauplae larval form. During the dry season the zooplankton peak densities were in May and early June in Cottonwood 1, 2 3 and in late June and July in Cottonwood 4 and 5 (Figure 24). The summer monsoons appeared to trigger a synchronous increase in zooplankton in the August 5 sample. There was no pattern in the density of zooplankton that could be attributed to the presence of cattle. Diversity considered not only the number of taxa present but also how the number of individuals is distributed among them. Shannon's formula is the most commonly used metric of diversity and ranges from 0.5 units for low diversity to 4.5 for high diversity. Most natural communities range 2.5-4.5 units. The diversity of the zooplankton in Cottonwood Tanks is low, primarily due to a restricted number of taxa but also due to high dominance of individuals in a restricted number of taxa (Figure 25). There were no changes in diversity associated with cattle.

This figure only shows diversity index not # of taxa or the # of individuals of each taxa.

As in Willow Tanks the species richness and diversity were even lower than the zooplankton and comprise largely of the members of the family Chironomidae. The similarity analysis of the benthic macroinvertebrate communities and the invertebrate census were not significantly different or diagnostic of the presence of cattle (Table 7).

Fountain Tanks had a slightly different pattern of rainfall from Willow and Cottonwood drainages in that there was a rain in early June that sustained the volume of the tinajas into July (Figure 26). In late July increased precipitation brought the Fountain Tanks to their full capacity (Figure 27). The volume varied after that according to their retention capacity. The water in Fountain 1 and 5 were retained by sand berms and doubtless lost a great deal of water to ground water seepage. Fountain 2, 3, and 4 were in solid rock and ground water seepage was less of a factor. The dissolved oxygen varied as in Cottonwood and Willow Tanks (Figure 28).

The pH in Fountain Tanks was slightly alkaline, more so than Willow or Cottonwood (Figure 29). Moreover, the pH appeared to be higher generally in the dry season than during the monsoons. The conductivity also was overall higher by several fold than in Cottonwood and Willow Tanks (Figure 30). This indicated that the overall dissolved solids were between 44-161 and were primarily alkaline. The turbidity was much lower in the dry season and appear to rise drastically with large rainfall events during the monsoons (Figure 31). Total phosphorus was much lower in the Fountain Tank system than in Willow or Cottonwood and reflected low nutrient oligotrophic conditions (Figure 32). The total nitrogen to phosphorus ratio indicated that phosphorus was the nutrient limiting to primary production. Total nitrogen was in the range of the unpolluted Cottonwood and Willow Tanks (Figure 33).

Total carbon rose in Fountain Tank in the monsoons (Figure 34). This may be an indication of more detrital input from the watershed runoff than in Cottonwood or Willow systems.

The density of zooplankton was highest in Fountain 1 and 5 and peaked on July 6 and was substantially lower through the monsoon season (Figure 35). Analysis of the diversity of the zooplankton community shows low values compared to other communities found in surface waters due to a reduced species richness. There were no observable effects in the zooplankton due to the presence of cattle (Figure 36). Analysis of the similarity pattern of the zooplankton did show that Fountain 5 did have a community of zooplankton different from the other tanks in the drainage (Table 7). Whether this difference was due to cattle or to the fact that Fountain 5 was the only tank to go nearly dry during the season is not known.

Summary

Twenty tinajas were studied in four drainages in the Waterpocket Fold Capitol Reef National Park in Utah during the months of May to September 1986. All the tinajas were found in the Navajo sandstone and were formed either as plunge pools or from localized dissolution of the calcium carbonate cementing the sand grains. There was a tenfold difference in the areas of the watersheds and in the volumes of the different tinajas. The water chemistry among the watershed differed principally due to variation of calcium, magnesium, iron, and pH. Biological differences among watersheds were detected in density of zooplankton and phytoplankton, and the species composition of the adult amphibians.

The number of species and diversity found in the zooplankton and benthic macroinvertebrate community was low, possibly being limited by periodic desiccation, low dissolved oxygen concentrations and pulses of high iron.

Gross alterations of the water chemistry with high levels of total nitrogen, total phosphorus, potassium, conductivity, ammonia, and organic carbon were detected in one tinaja frequented by cattle. Differences could be detected in patterns of similarity in the zooplankton community in the tinaja used by cattle.

Table 1. Dimensions of four watersheds and their tinajas in Capitol Reef National Park.

	Tinaja Number	Volume (m^3)
Willow		
Watershed area (ha) 54	1	190
Elevation range (meters) 1818-1485	2	190
	3	130
	4	130
	5	63
Cottonwood		
Watershed area (ha) 110	1	87
Elevation range (meters) 1818-1470	2	24
	3	20
	4	160
	5	290
Fountain		
Watershed area (ha) 210	1	310
Elevation range (meters) 2136-1303	2	96
	3	147
	4	86
	5	330
Miah~~agen~~eyan		
Watershed area (ha) 458	1	too large to measure
Elevation range (meters) 2000-1273	2	47
	3	47
	4	29
	5	27*

If you abbreviate other measurements abbreviate this too! (m)

I assume you mean the elevation range for the entire watershed!

Many of these figures we related to & they don't make sense.

?

*Volume before flood destroyed vegetation dike in 1986.

Terry - These volume figures don't make any sense! Miaheyan 5 was much bigger than most of the other tinajas measured. For example, willow 5 is (when it has water in it at all) only a small pond maybe 3-4 m in width at the widest spot. Miaheyan 5 was probably 15-20 meters in diameter. Other tank comparisons in the table are likewise off - Please check your calculations

5/20

Table 2a. Major chemical constituents of water samples collected in May 1986.

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Tinaja	Al	Fe	Mn	Cu	Zn	Ni	Mo	Cd	Cr	Sr	B	Ba
	mg/l											
Willow 1	0.2	0.20	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Willow 2	0.1	0.48	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Willow 3	0.1	0.35	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Willow 4	0.1	0.24	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Willow 5	0.1	0.11	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.01
Cottonw. 1	0.1	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cottonw. 2	0.2	0.13	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cottonw. 3	0.2	0.13	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cottonw. 4	0.1	0.14	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cottonw. 5	0.1	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fountain 1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.05
Fountain 2	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.03
Fountain 3	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02
Fountain 4	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.03
Fountain 5	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.05
Miahayen 1	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Miahayen 2	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02
Miahayen 3	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Miahayen 4	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.02
Miahayen 5	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.03

Table 2b. Major chemical constituents of water samples collected in May 1986.

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Tinaja	pH	Cond. umhos/cm	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	P
			mg/l									
Willow 1	6.0	30	3.2	0.7	0.5	0.7	1	12	1.7	2.4	1	0.1
Willow 2	6.2	35	4.5	0.9	0.5	0.5	1	18	1.6	1.8	1	0.1
Willow 3	6.1	35	5.0	1.1	0.5	0.5	1	18	0.8	1.7	1	0.1
Willow 4	6.2	30	4.4	0.9	0.4	0.5	1	12	0.6	1.9	1	0.1
Willow 5	6.4	100	7.4	1.5	3.4	6.8	1	43	3.2	3.0	1	0.1
Cottonw. 1	5.8	20	2.2	0.5	0.4	1.0	1	6	3.0	1.8	1	0.1
Cottonw. 2	5.6	20	2.1	0.5	0.4	0.5	1	6	0.7	2.2	1	0.1
Cottonw. 3	5.9	25	3.0	0.7	0.4	0.6	1	6	0.9	2.0	1	0.1
Cottonw. 4	5.8	20	2.3	0.6	0.4	0.5	1	6	3.3	1.9	1	0.1
Cottonw. 5	5.8	20	2.5	0.6	0.4	0.5	1	6	1.1	1.9	1	0.1
Fountain 1	7.3	222	34.5	4.1	2.4	0.8	1	104	2.7	2	1	0.1
Fountain 2	7.4	124	18.0	3.0	0.9	0.3	1	48	0.8	4.8	1	0.1
Fountain 3	7.3	113	15.0	2.6	1.1	0.4	1	43	1.1	4.6	1	0.1
Fountain 4	7.3	118	17.3	2.8	1.1	0.7	1	46	1.1	3.9	1	0.1
Fountain 5	7.3	182	30.3	3.8	0.9	0.3	1	79	0.8	2.6	1	0.1
Miahayen 1	7.0	66	9.7	1.2	0.5	0.4	1	25	0.4	1.5	1	0.1
Miahayen 2	6.7	86	12.7	1.5	0.7	0.5	1	32	0.7	1.6	1	0.1
Miahayen 3	6.7	56	6.7	0.9	0.6	0.4	1	18	0.6	2.1	1	0.1
Miahayen 4	7.3	181	28.4	4.5	0.8	0.2	1	81	0.6	1.3	1	0.1
Miahayen 5	7.2	192	26.5	5.9	1.8	1.3	1	102	2.5	2.6	1	0.1

Table 3. Iron concentrations from tinajas in September, October and November

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Tinaja	Month	mg/l Fe
Cottonwood 1	September	0.11
Cottonwood 2	September	0.14
Cottonwood 3	September	0.05
Cottonwood 4	September	0.02
Cottonwood 5	September	0.11
Fountain 1	September	0.42
Fountain 2	September	1.06
Fountain 3	September	0.85
Fountain 4	September	0.96
Fountain 5	September	0.52
Miahayen 1	September	2.05
Miahayen 2	September	3.17
Miahayen 3	September	1.78
Miahayen 4	September	0.80
Miahayen 5	September	1.74
Willow 1	September	0.12
Willow 2	September	0.21
Willow 3	September	0.26
Willow 4	September	0.11
Willow 5	September	0.11
Fountain 1	October	0.02
Fountain 2	October	0.02
Fountain 3	October	0.02
Fountain 4	October	0.01
Fountain 5	October	0.02
Miahayen 1	October	0.20
Miahayen 2	October	0.22
Miahayen 3	October	0.07
Miahayen 4	October	0.14
Miahayen 5	October	0.01
Cottonwood 1	November	0.01
Cottonwood 2	November	0.01
Cottonwood 3	November	0.17
Cottonwood 4	November	0.01
Cottonwood 5	November	0.01
Fountain 1	November	0.01
Fountain 2	November	0.01
Fountain 3	November	0.01
Fountain 4	November	0.01
Fountain 5	November	0.01
Willow 1	November	0.39
Willow 2	November	1.48
Willow 3	November	0.40
Willow 4	November	0.21
Willow 5	November	0.59
Miahayen 1	November	0.01
Miahayen 2	November	0.01
Miahayen 3	November	0.01
Miahayen 4	November	0.01
Miahayen 5	November	0.01

Table 4. Results of split_plot in time analysis of variance for selected biological variables by drainage

	F	P
I. Density of larval amphibians		
Interaction with time	3.59	0.0001
Drainage effect	3.97	0.0273
Overall	Not statistically significant	
II. Density of adult amphibians		
Interaction with time	4.81	0.0001
Drainage effect	2.70	0.08
Overall	Not statistically significant	
III. Census of macroinvertebrate		
Interaction with time	1.31	0.2173
Drainage effect	0.52	0.6725
Overall	Not statistically significant	
IV. Density of zooplankton		
Interaction with time	1.11	0.3633
Drainage effect	6.58	0.0042
Overall	Highly significant difference	
V. Density of benthic macroinvertebrate		
Interaction with time	3.03	0.0303
Drainage effect	8.07	0.0040
Overall	Not statistically significant	
VI. Chlorophyll a		
Interaction with time	1.55	0.2131
Drainage effect	8.63	0.0188
Overall	Highly significant difference	

According to page 4 this was to be true for significance
drainage >.05
time <.05
These conditions are true only in II
I think you reversed the signs on page 4.

Table 5. Results of student-Newman-Keuls test following significant analysis of variance

Variable	Willow	Cottonwood	Fountain	Miahayen
	Mean (individual /L)			
Density of Zooplankton	28[a]	26[ab]	18[bc]	12[c]
	Mean (ug/L)			
Chlorophyll a	8.9[a]	29.5[b]		

*Superscripts indicate differences in means

Table 6. Total frequency of adult amphibians observed

Tinaja	*Hyla Arenicolor*	*Bufo woodhousei*	*Bufo punctatus*	*Bufo microscaphus*	*Bufo cognatus*	*Scaphiopus intermontanus*	*Rana pipens*
Willow							
1	5		3			1	
2	8	1	4		2		
3	18	2	1		6		
4							
5							
Cottonwood							
1		2	5		3		
2	1	2	13		3		
3		1	30				1
4		3	34	6		1	
5		1	61		10		
Fountain							
1	22		21		1	1	
2	26						
3	17						
4	32						
5			1			10	
Miahayen							
1	6						
2	28		2				
3							
4	225						
5	1	10	1				

Table 7. Comparison of Within: Between ~~pattern of~~ community similarities ← what is this?

Tank	Mean	S.D.	Significant
	Zooplankton		
Willow			
Between similarity	0.63	0.04	N.S.
Within similarity	0.64	0.26	N.S
Cottonwood			
Between similarity	0.62	0.13	N.S.
Within similarity	0.83	0.14	N.S.
Fountain			
Between similarity	0.26	0.08	Significant at
Within similarity	0.49	0.23	0.05 level
	Census Macroinvertebrates		
Willow			
Between similarity	0.68	0.03	N.S
Within similarity	0.67	0.09	N.S
Cottonwood			
Between similarity	0.78	0.10	N.S
Within similarity	0.81	0.07	N.S.
Fountain			
Between similarity	0.57	.11	N.S.
Within similarity	0.77	.07	N.S.
	Benthic Macroinvertebrates		
Willow			
Between similarity	0.71	0.18	N.S.
Within similarity	0.61	0.13	N.S.
Cottonwood			
Between similarity	0.61	0.14	N.S.
Within similarity	0.61	0.20	N.S.
Fountain	Insufficient data		

does this mean there were fewer species increase # of individuals

what is the difference here?

- what is the difference between Census Macroinvertebrate and Benthic Macroinvertebrates

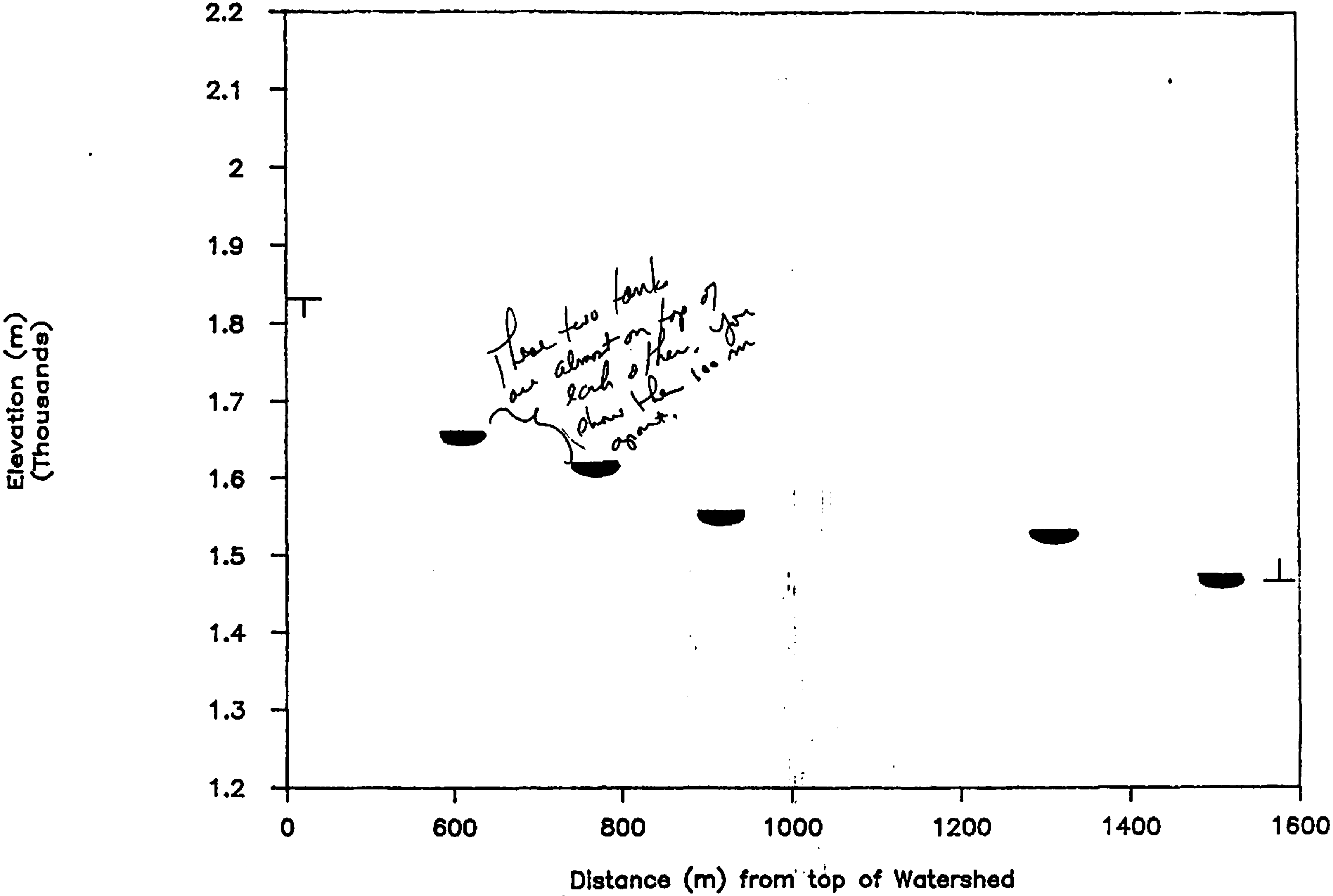
~~Zooplankton - what are them~~

- what is shown in these "similarity" indices. Do we assume it's are same species diversity is same. What does significance mean?

Figure 1a

Willow Tanks

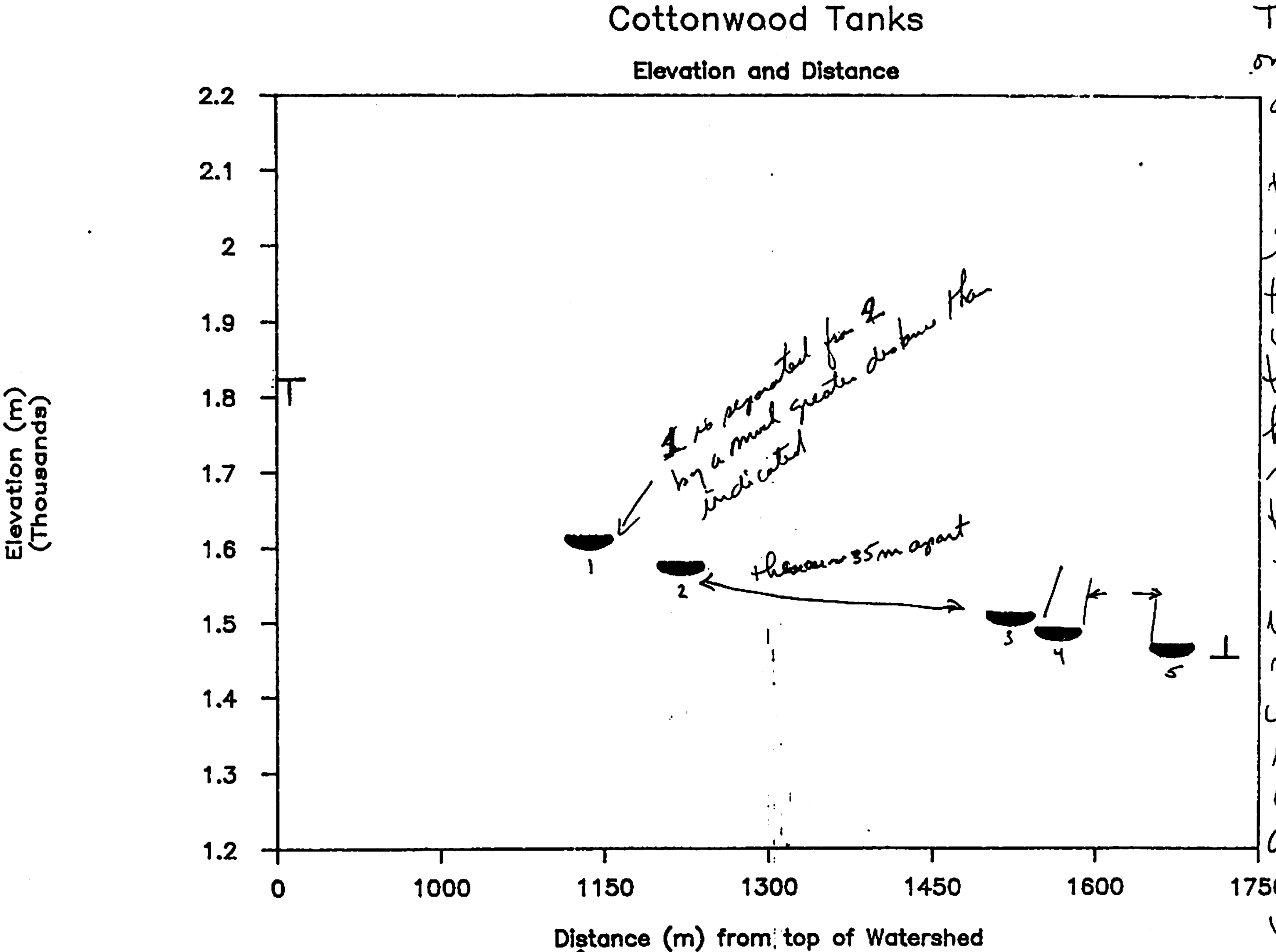
Elevation and Distance



The relationship between the tanks don't make any sense to me. How did you determine distance to tanks?

Horizontal distance?

Figure 1b



Horizontal distance?

I don't see how your figure indicates this.

The relationships on the diagram don't make sense to the folks who know the tanks well. What are you trying to show here? The relationship between tanks? The distances between tanks don't make sense for Cottonwood since it has two sub drainages within drainage. Cottonwood looks something like this from above

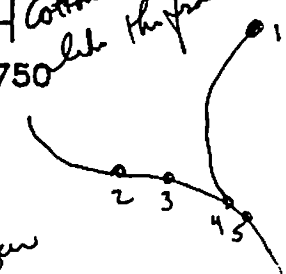


Figure 1c

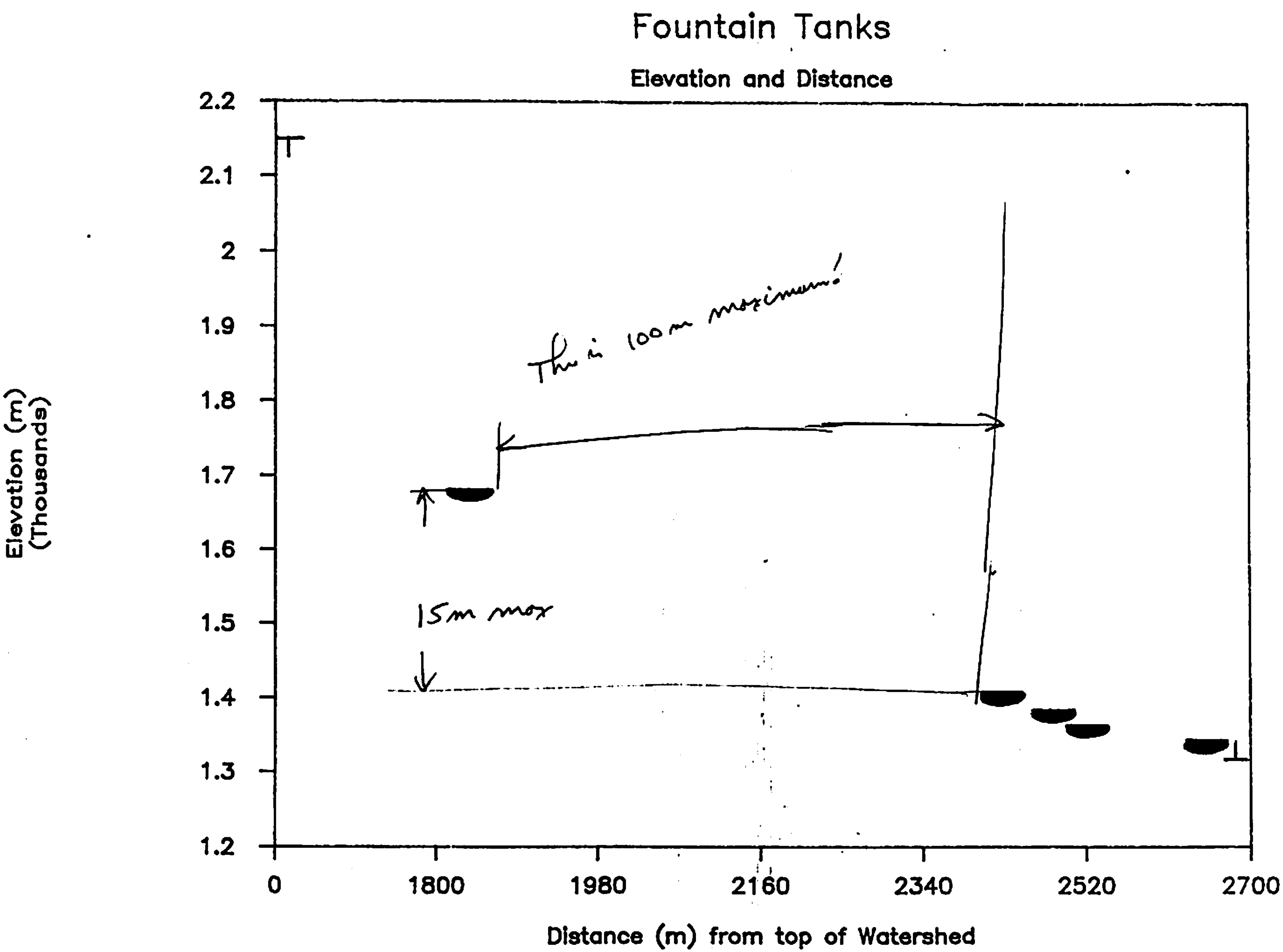
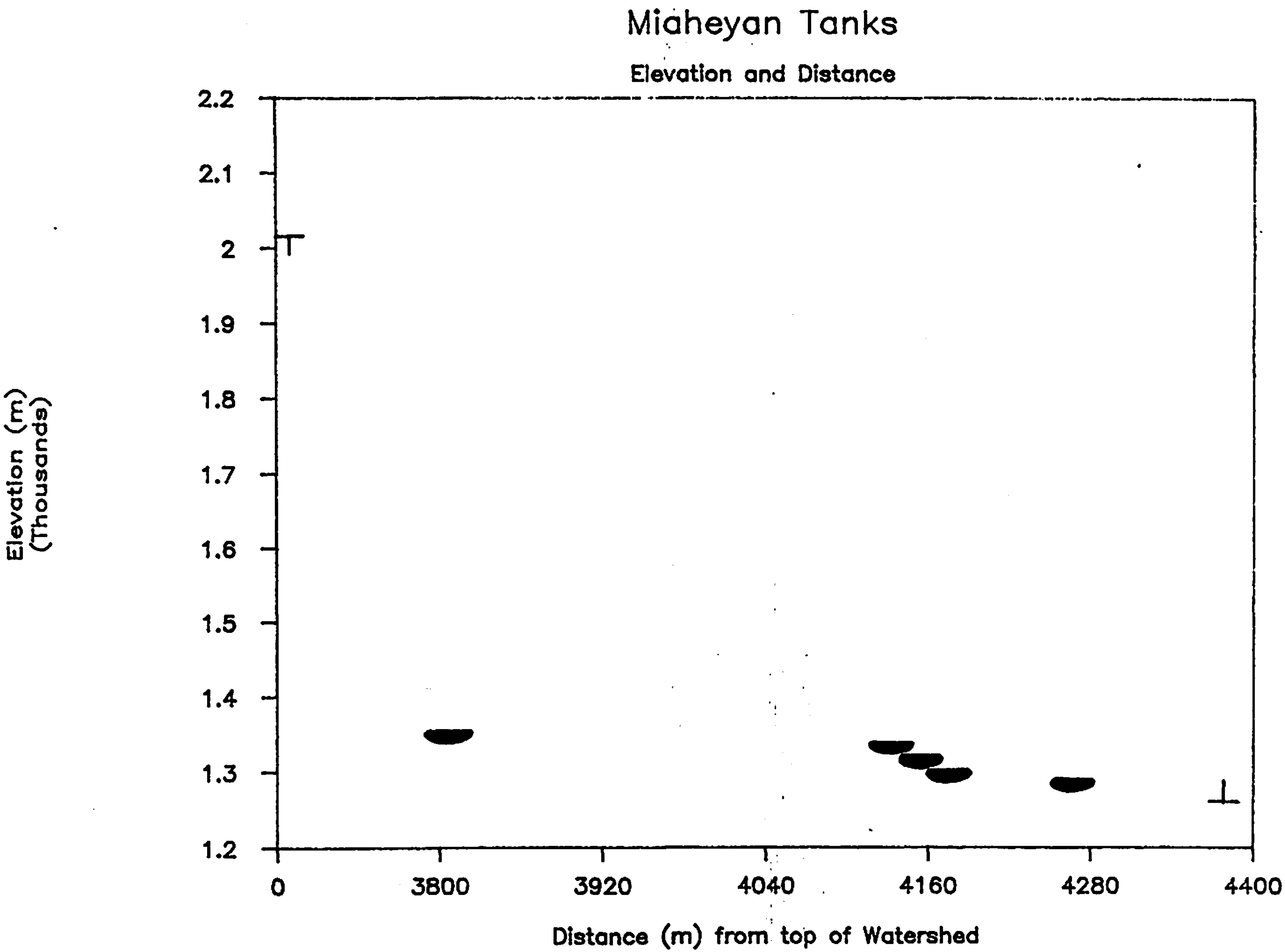
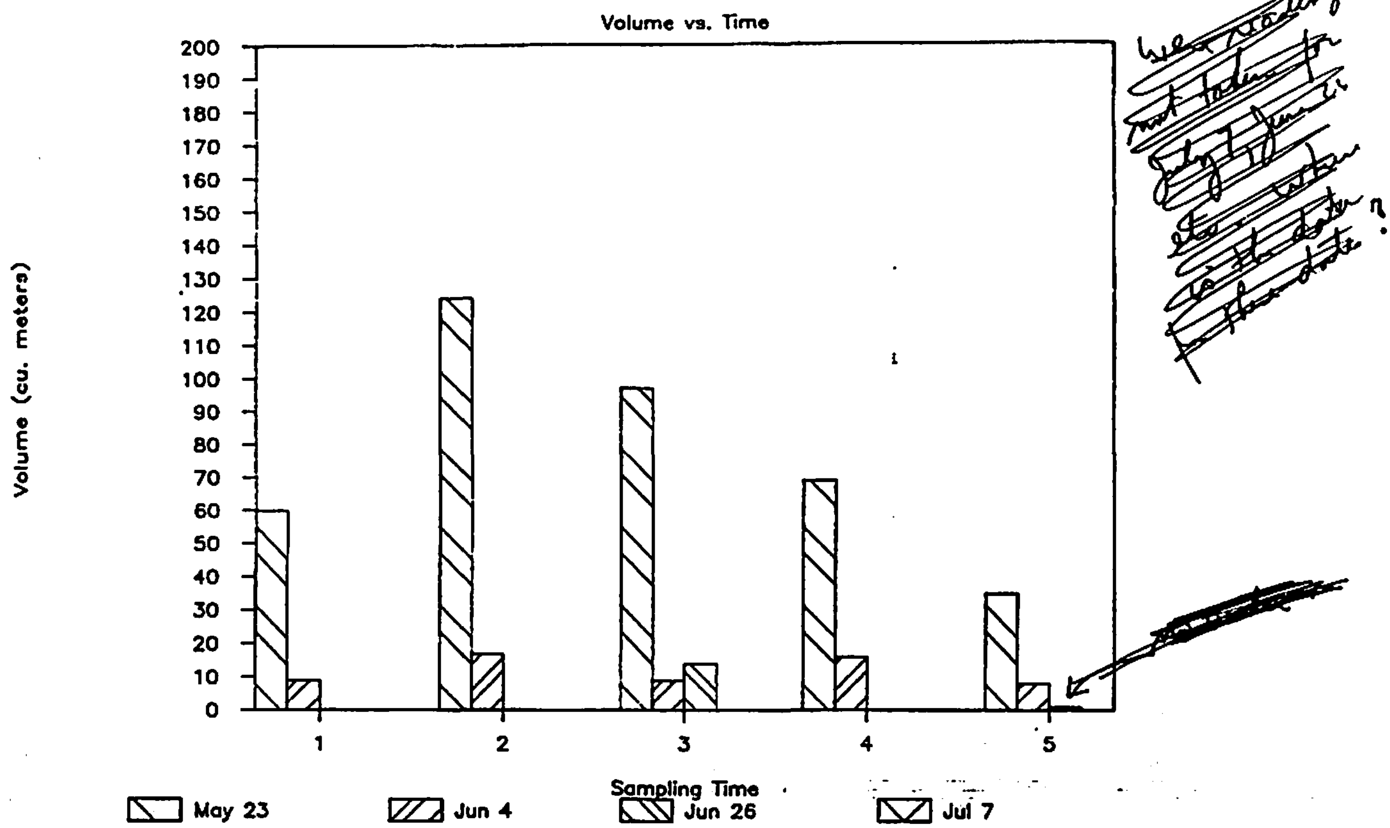

Fountain Tanks
Elevation and Distance
Elevation (m)
(Thousands)
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
0
1800
1980
2160
2340
2520
2700
Distance (m) from top of Watershed
This is 100m maximum!
15m max

Figure 1d


Miaheyan Tanks
Elevation and Distance
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
Elevation (m)
(Thousands)
0
3800
3920
4040
4160
4280
4400
Distance (m) from top of Watershed

Willow Tanks



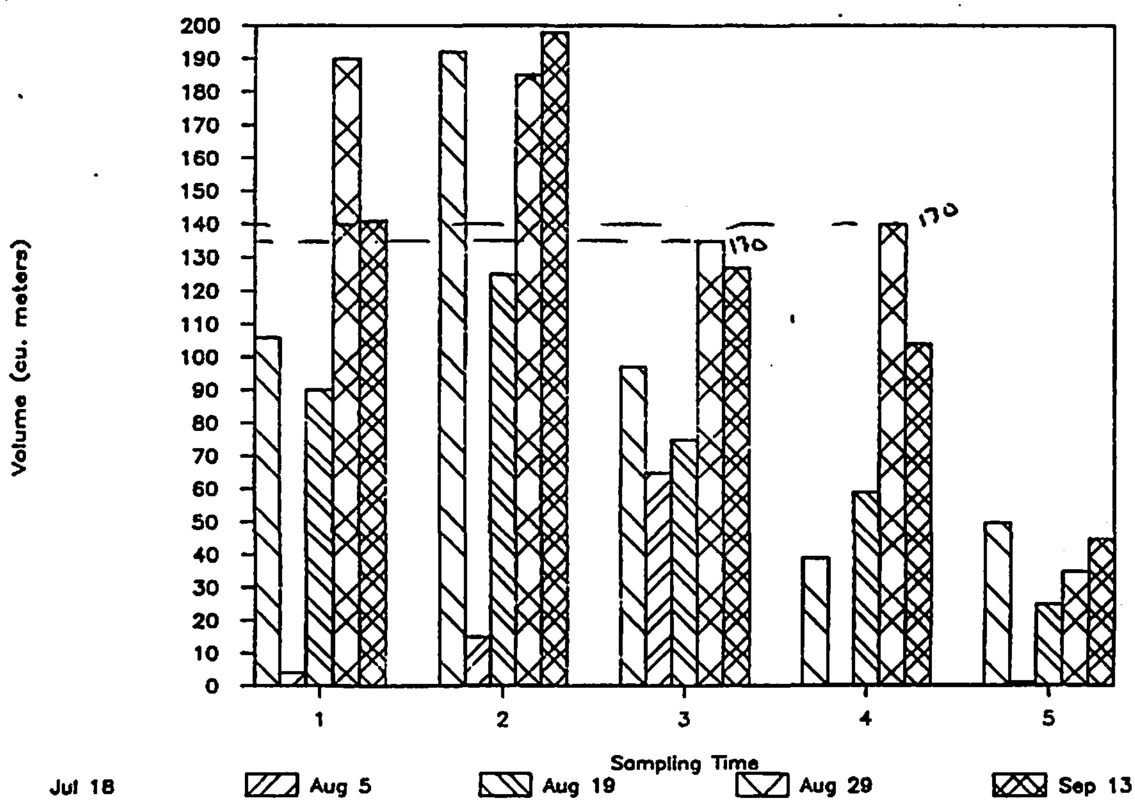


Figure 2

* I'm not sure what this graph means. Wouldn't just a line graph be easier to decipher.

Figure: 3

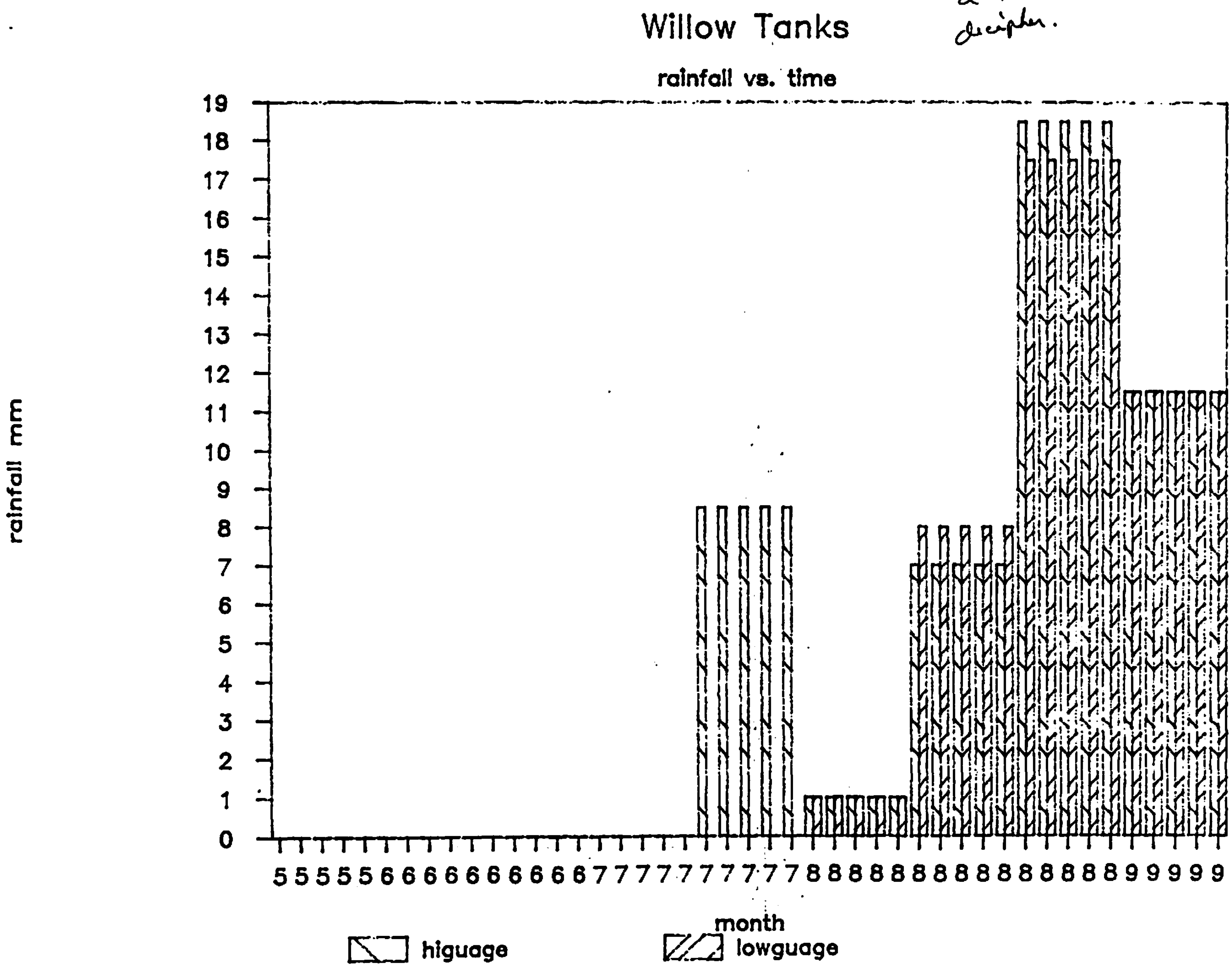
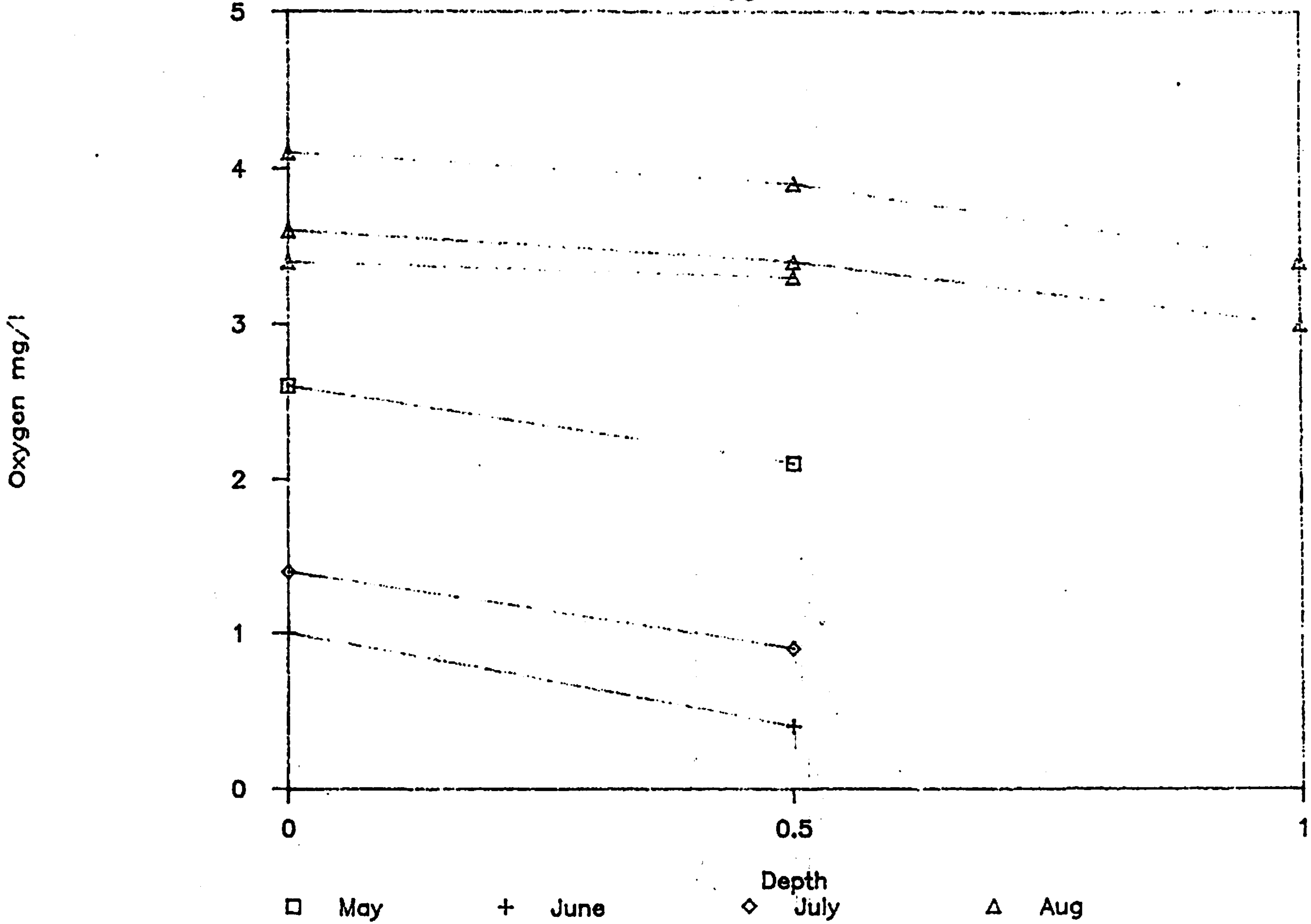


Figure 4a

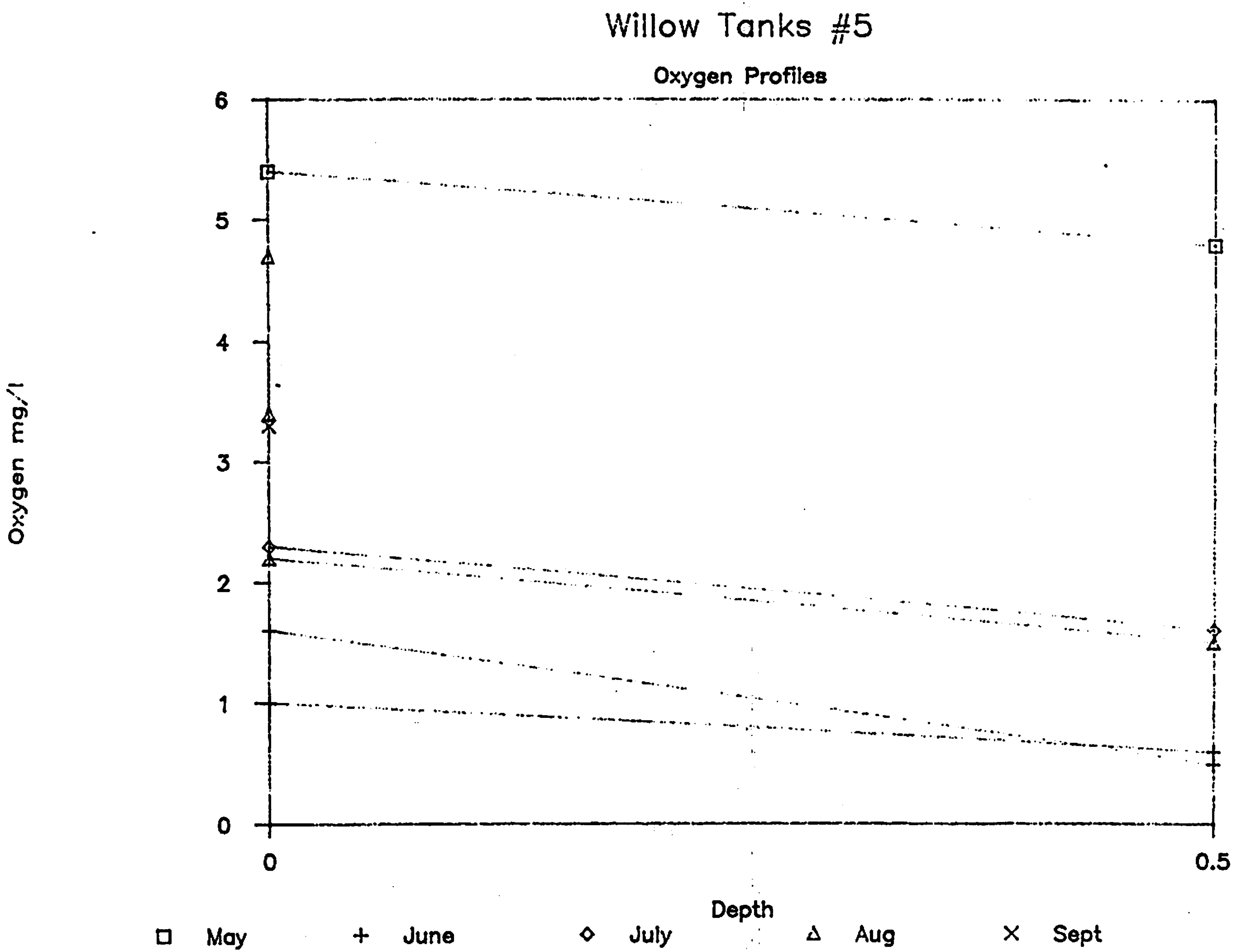
Willow Tanks #1

Oxygen Profiles



* where is the data for the other july ~~dates~~ sept, and june dates.

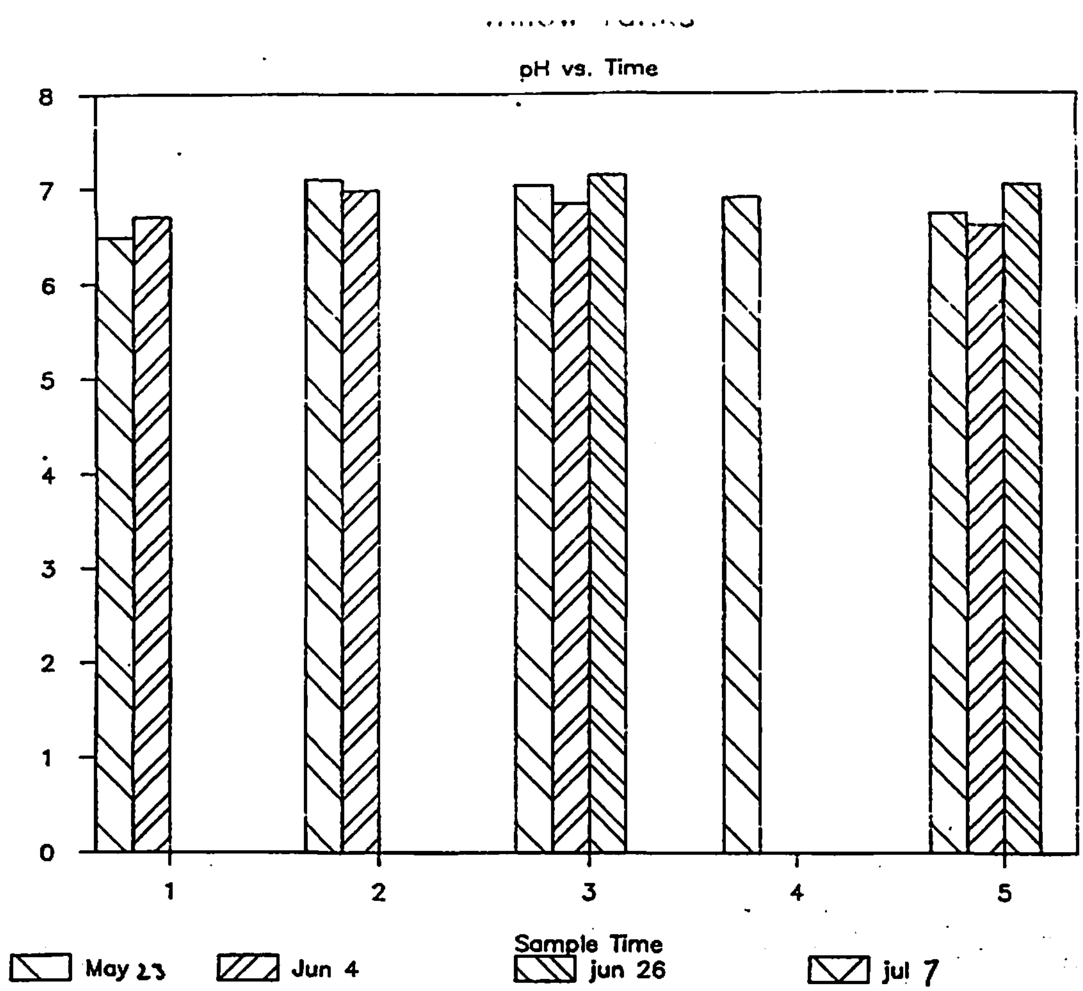
Figure 4b


Willow Tanks #5
Oxygen Profiles
6
5
4
3
2
1
0
Oxygen mg/l
0
0.5
Depth
May
June
July
Aug
Sept

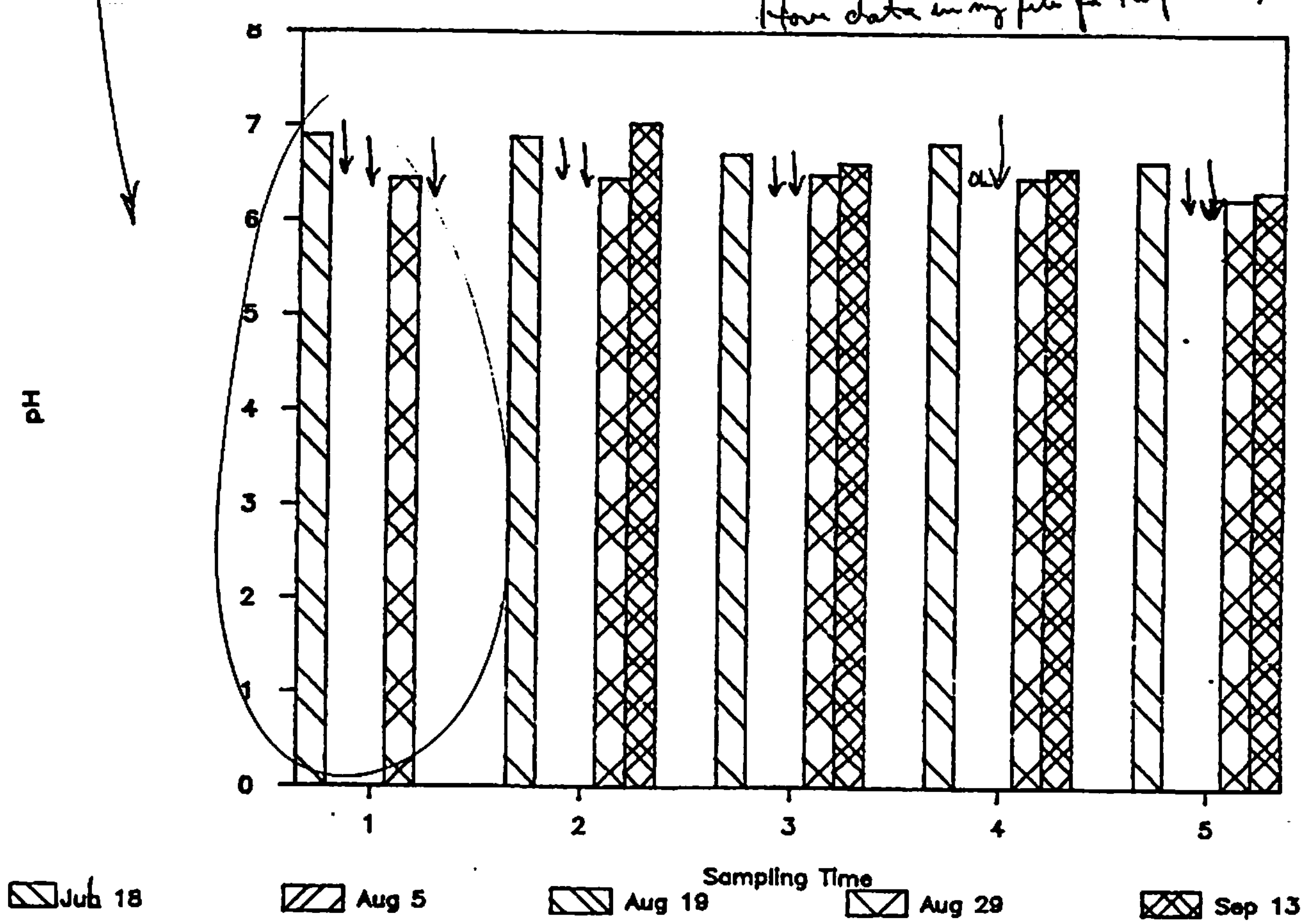
Again: are data missing for a reason? I have data for Time 1 for instance for Aug 5, 19, Sept 13, Sept 26, Dec 5.

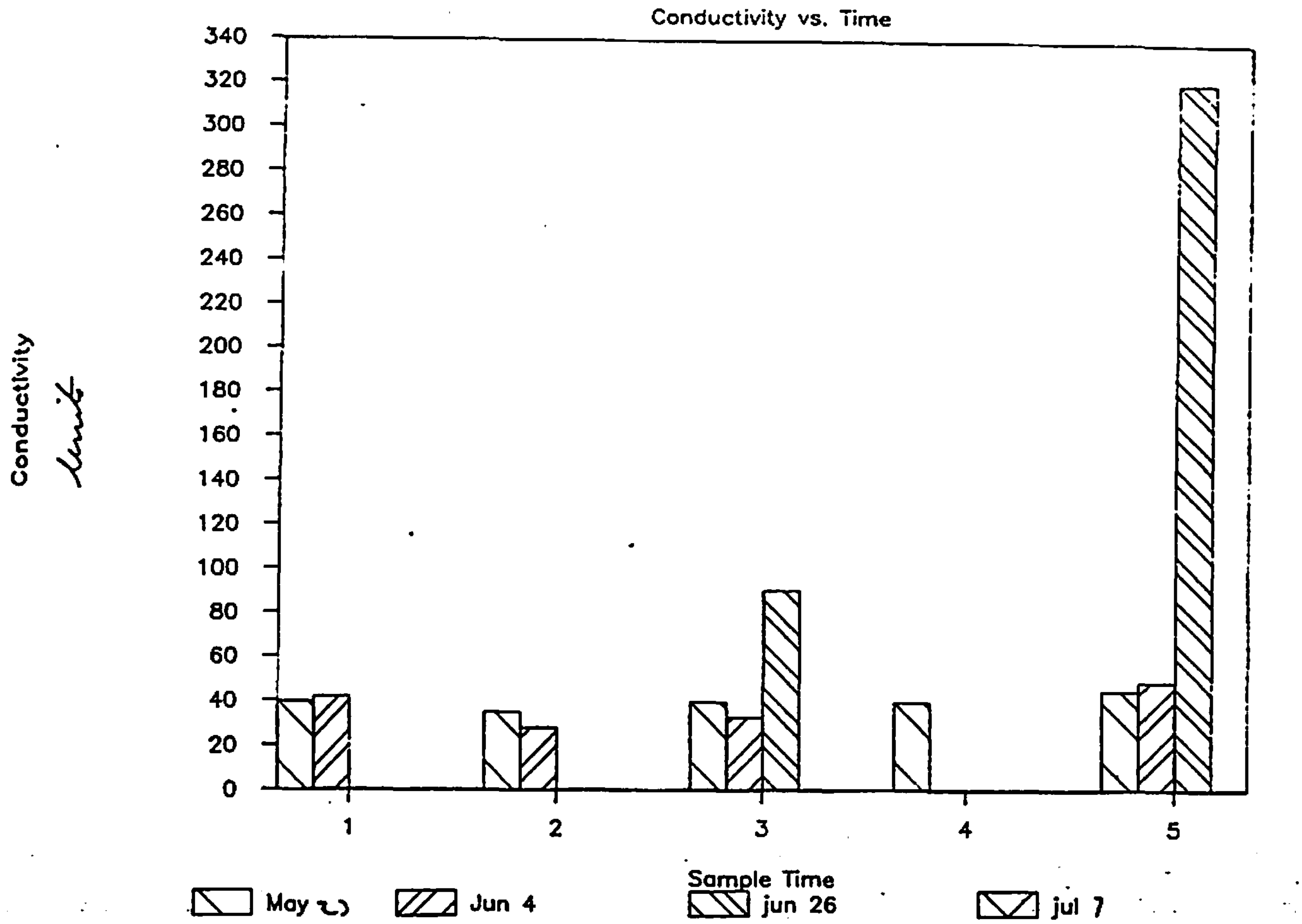
A table may be more appropriate for the data.

Figure 5



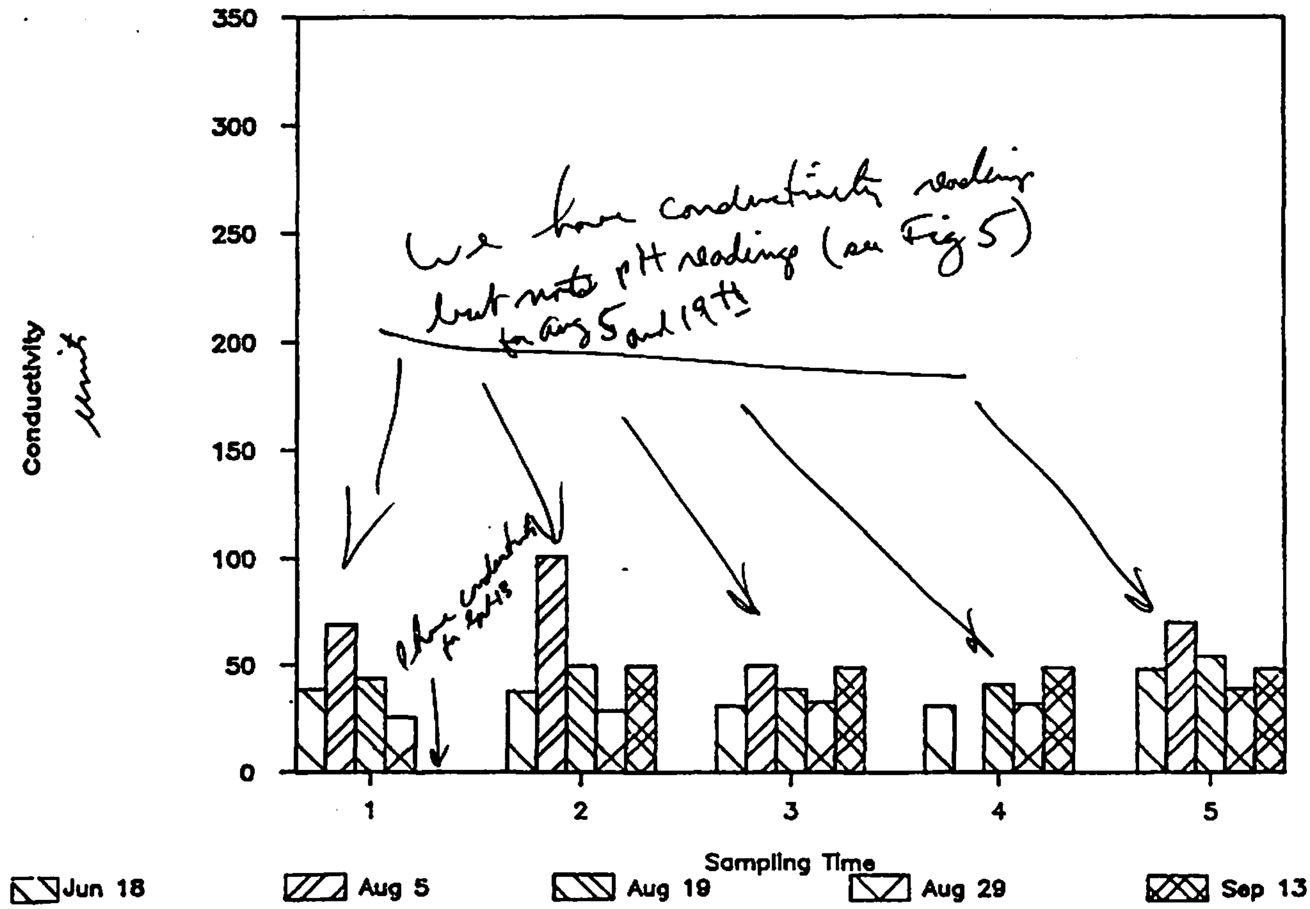
Have data in my file for the following





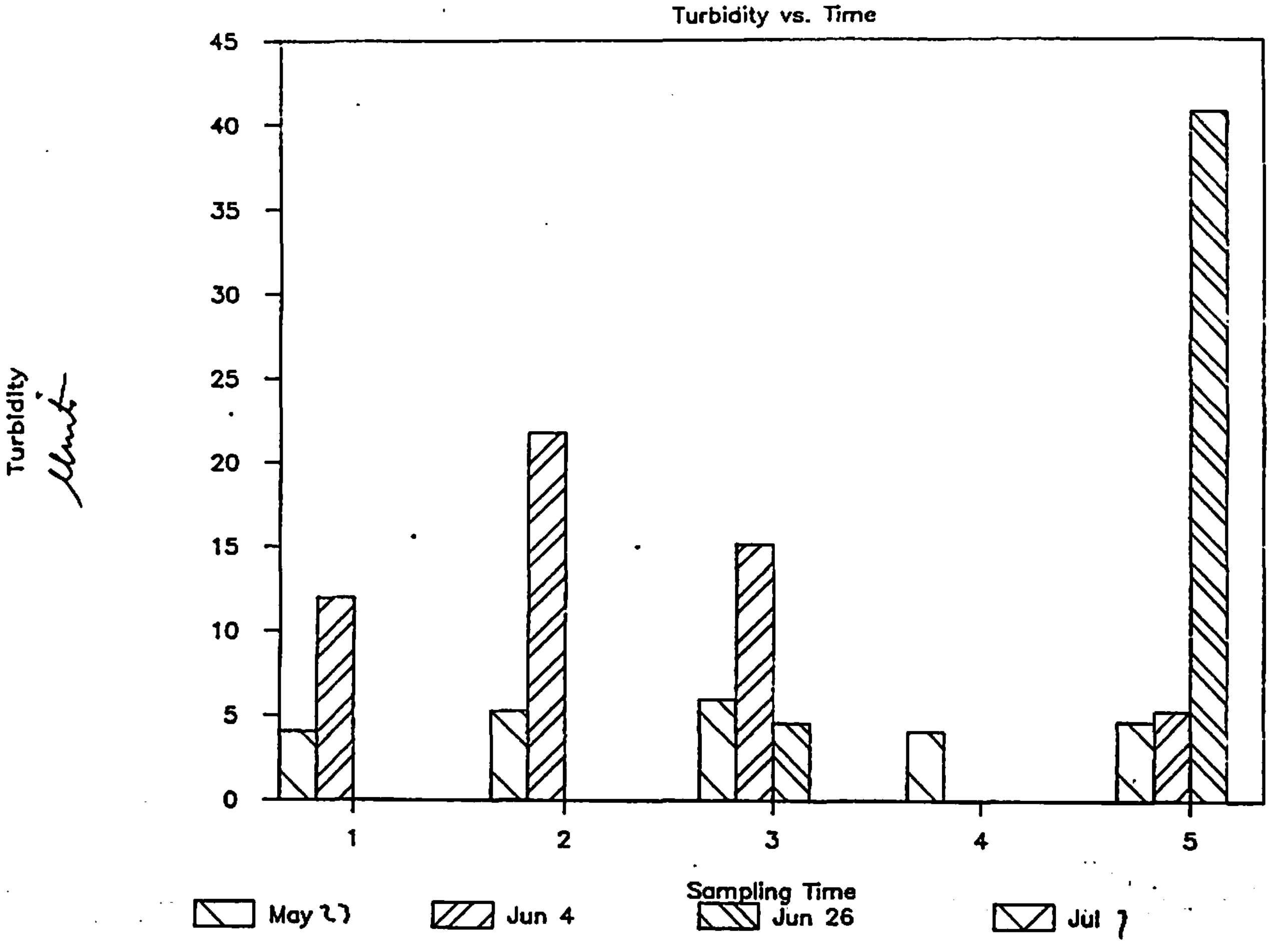
Conductivity vs. Time
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Conductivity
unit
1
2
3
4
5
Sample Time
May 23
Jun 4
jun 26
jul 7

Figure 6



350
300
250
200
150
100
50
0
Conductivity
unit
We have conductivity readings but not pH readings (see Fig 5) for Aug 5 and 19th
1
2
3
4
5
Sampling Time
Jun 18
Aug 5
Aug 19
Aug 29
Sep 13

Figure 7


Turbidity vs. Time
Turbidity
Unit
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
Sampling Time
May 27
Jun 4
Jun 26
Jul 7

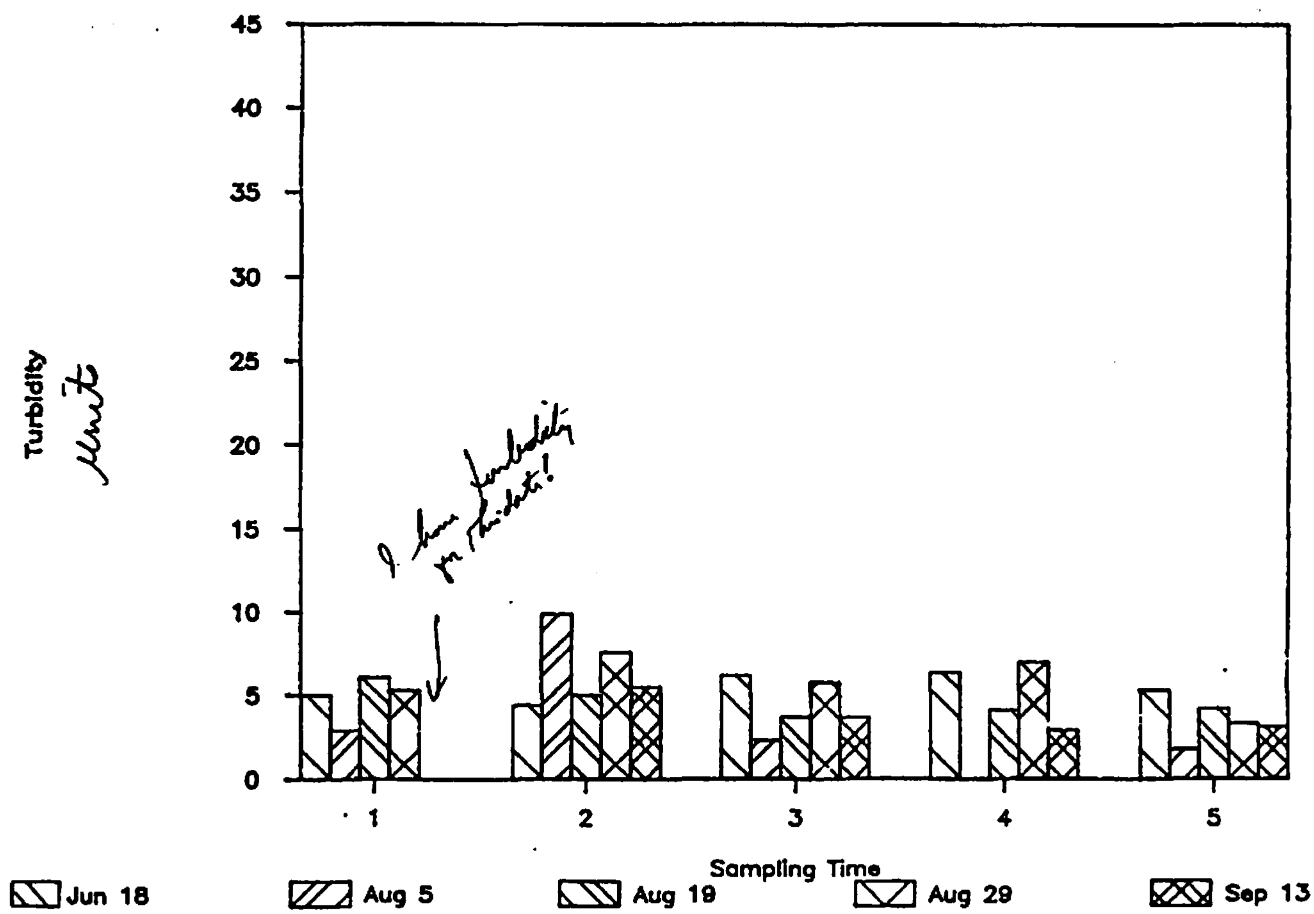
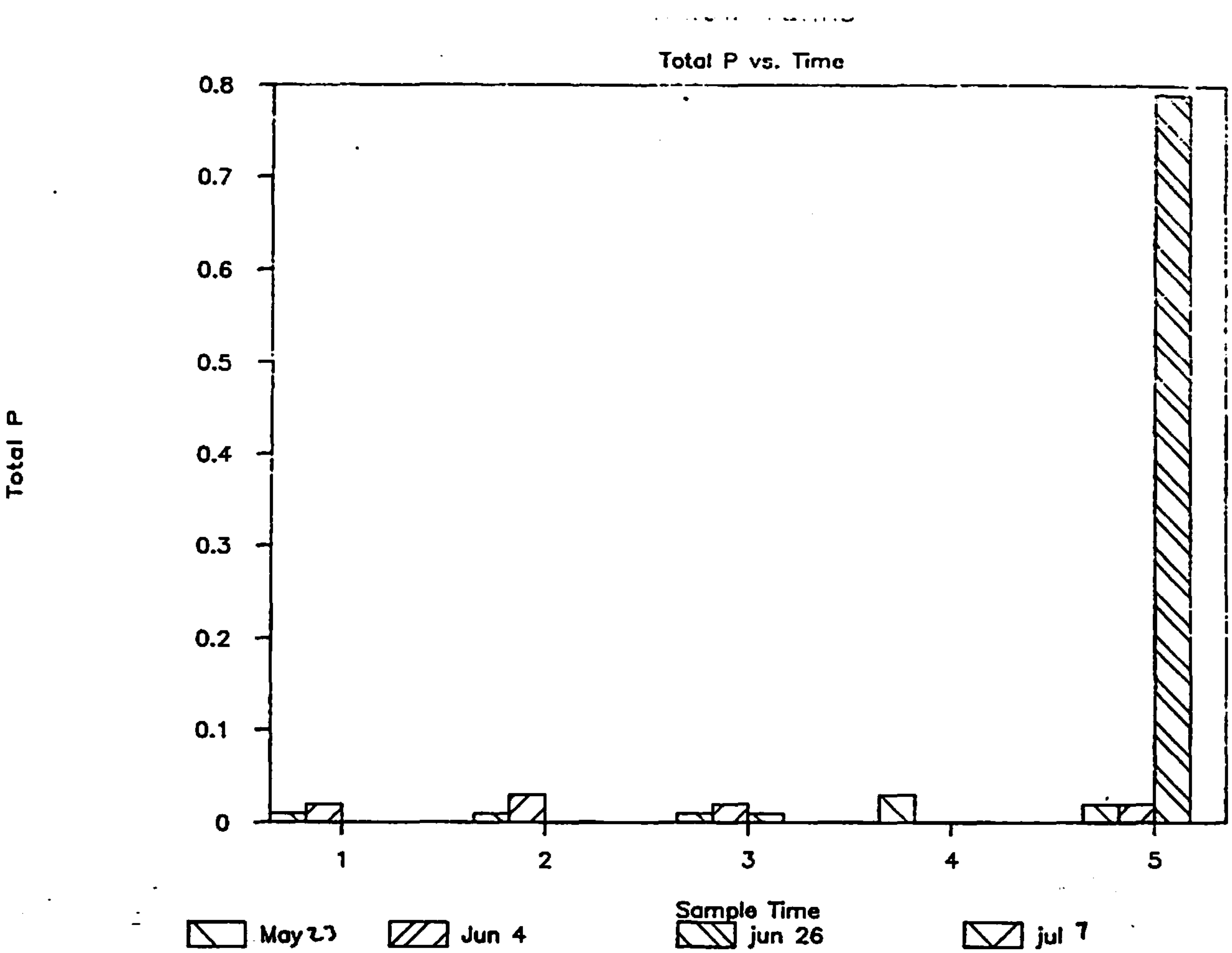

Turbidity
Unit
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
Sampling Time
Jun 18
Aug 5
Aug 19
Aug 29
Sep 13

Figure 8


Total P vs. Time
Total P
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Sample Time
May 23
Jun 4
jun 26
jul 7

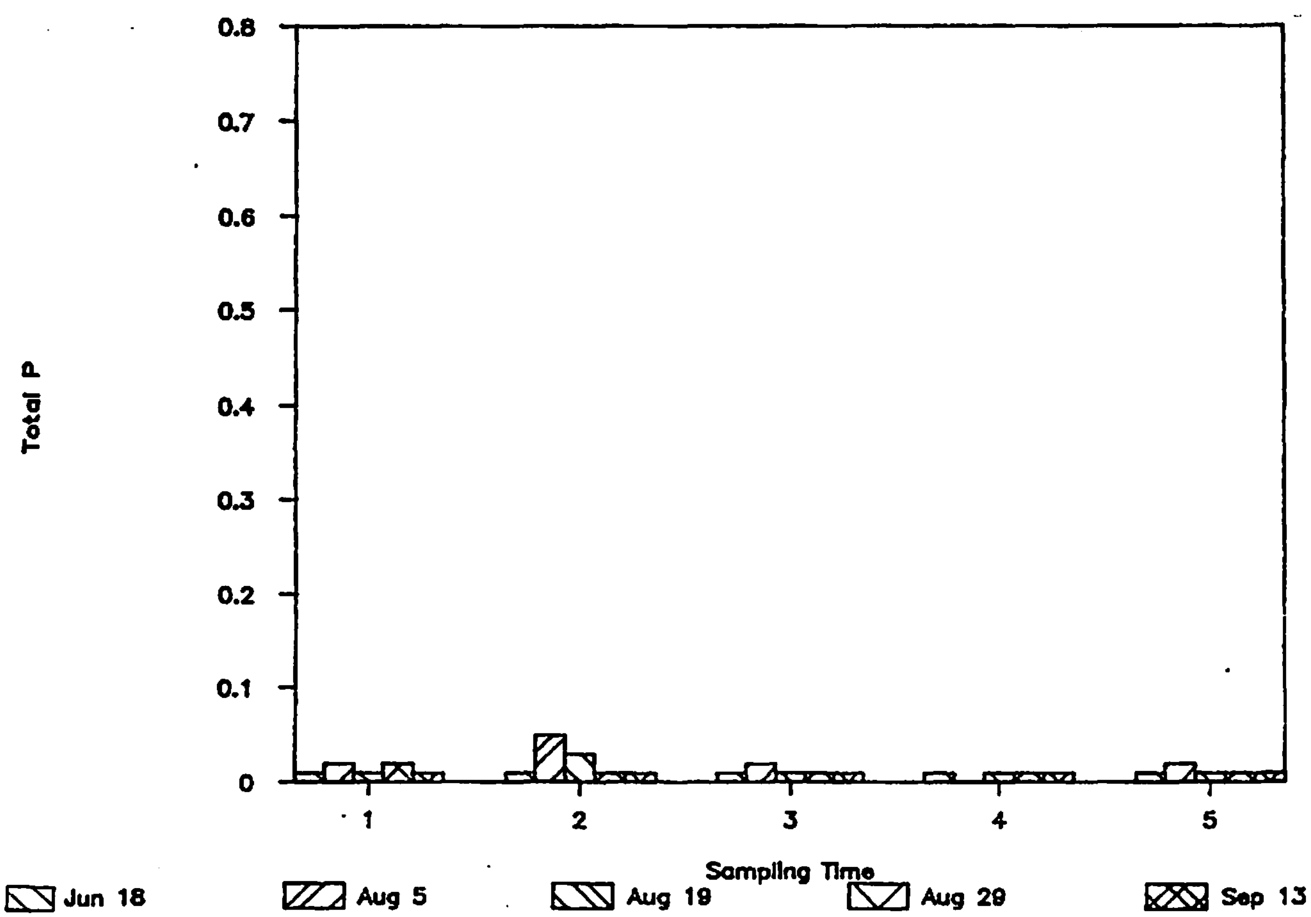
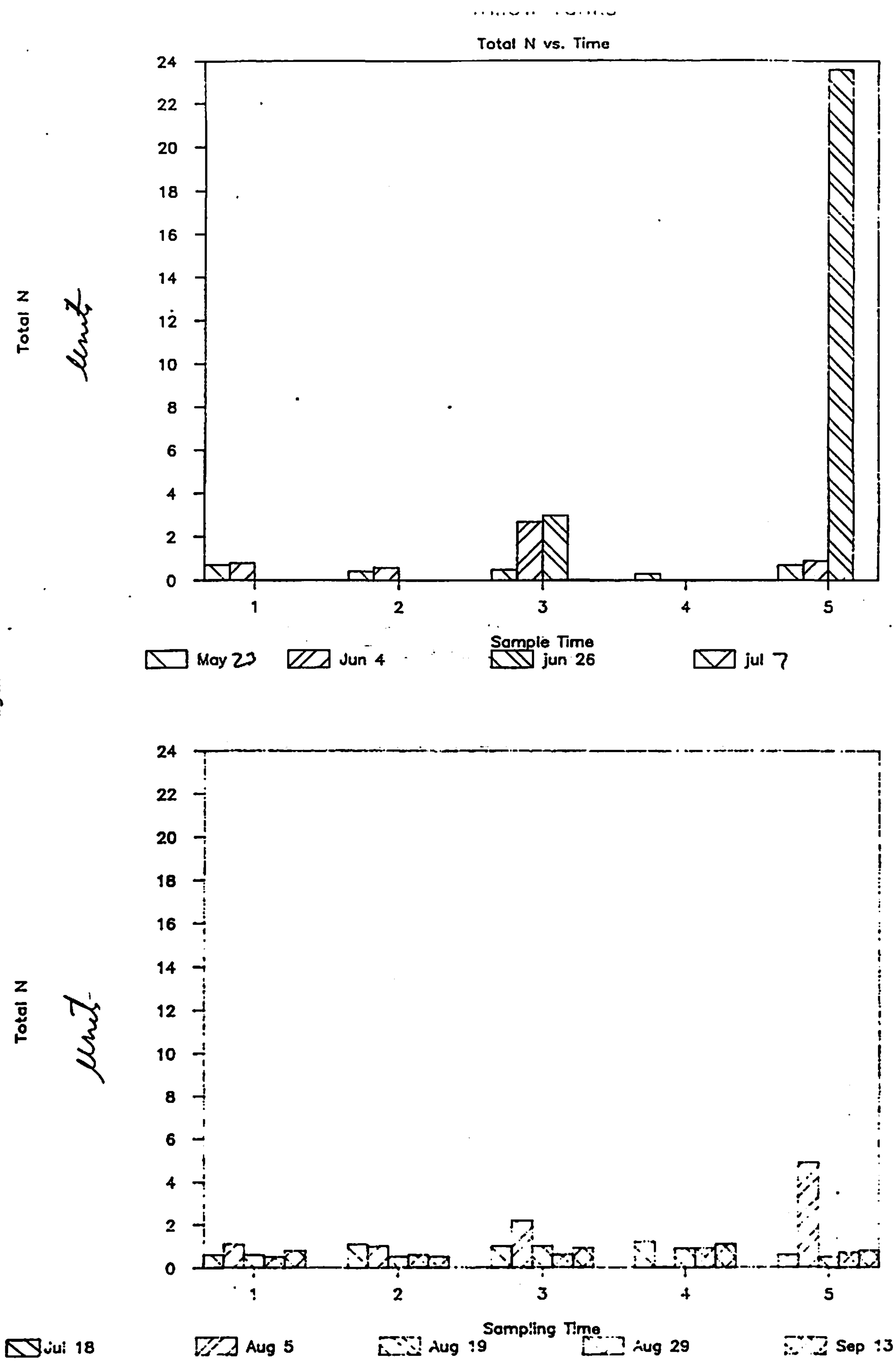

Total P
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Sampling Time
Jun 18
Aug 5
Aug 19
Aug 29
Sep 13

Figure 9


Total N vs. Time
Total N
Unit
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
Sample Time
May 23
Jun 4
jun 26
jul 7
Total N
Unit
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

You know total C for some samples you don't show pH, conductivity.

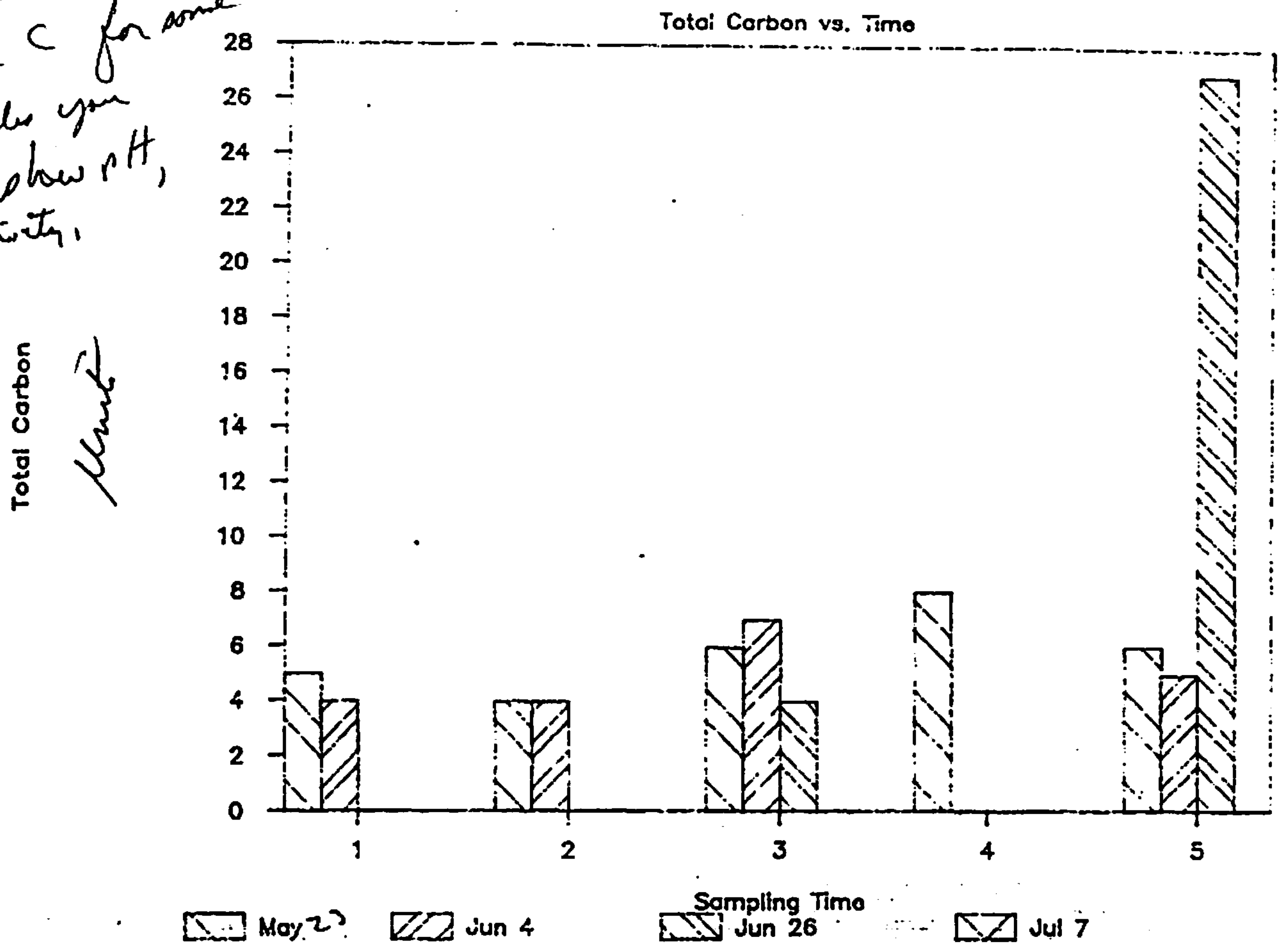
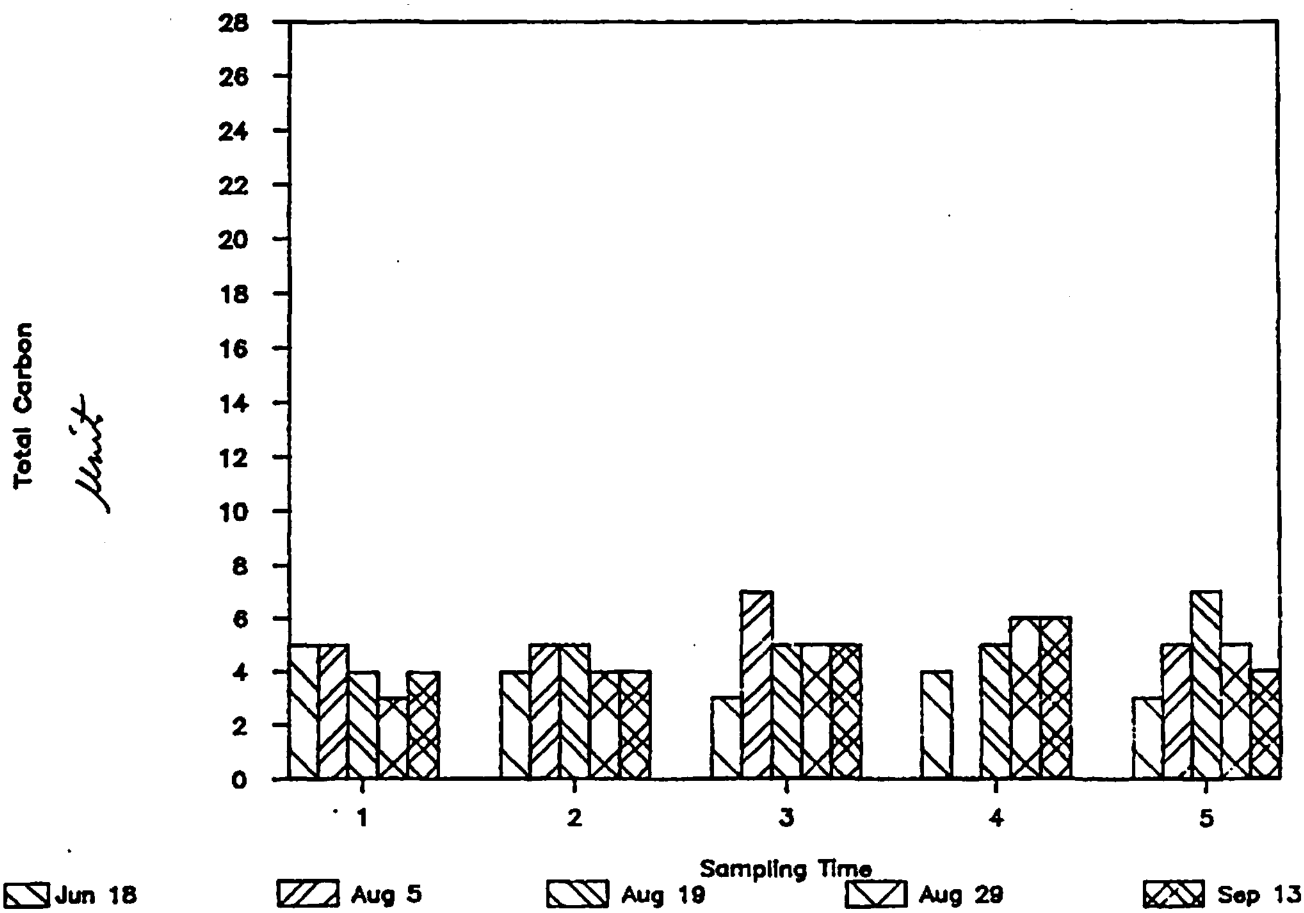
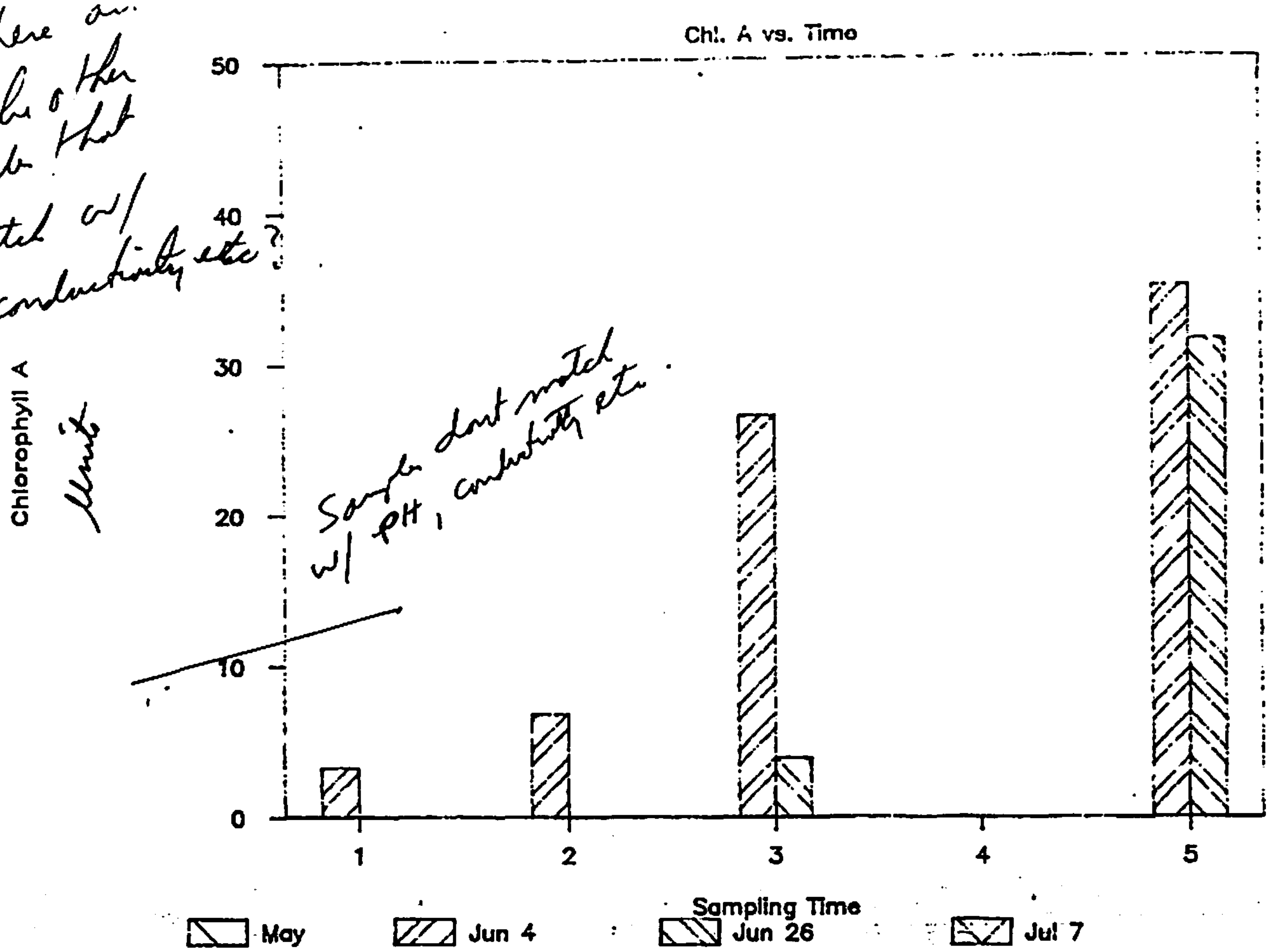


Figure 10

Legend



where are the other sample that match w/ pH, conductivity etc?



Legend

Figure 11

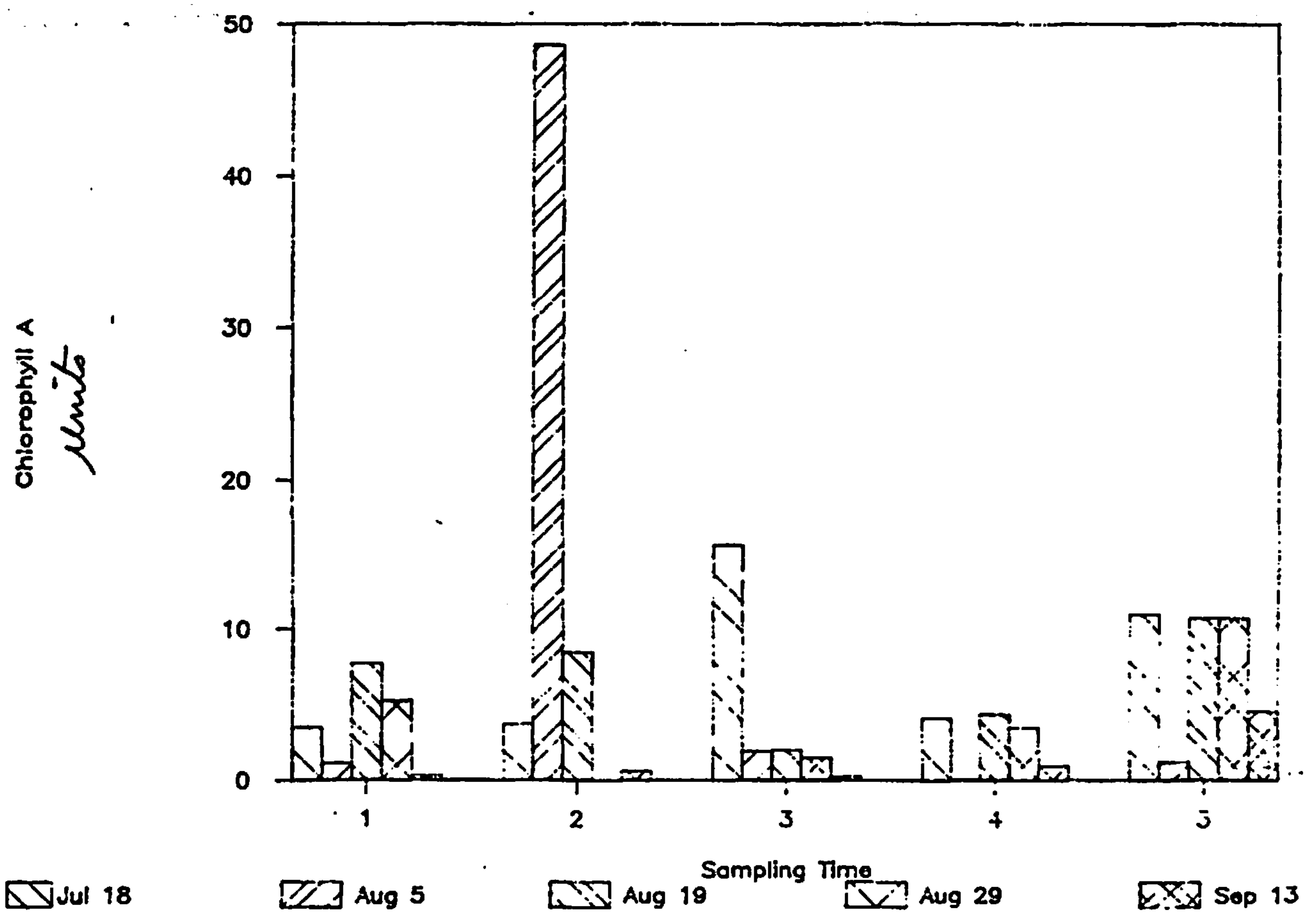
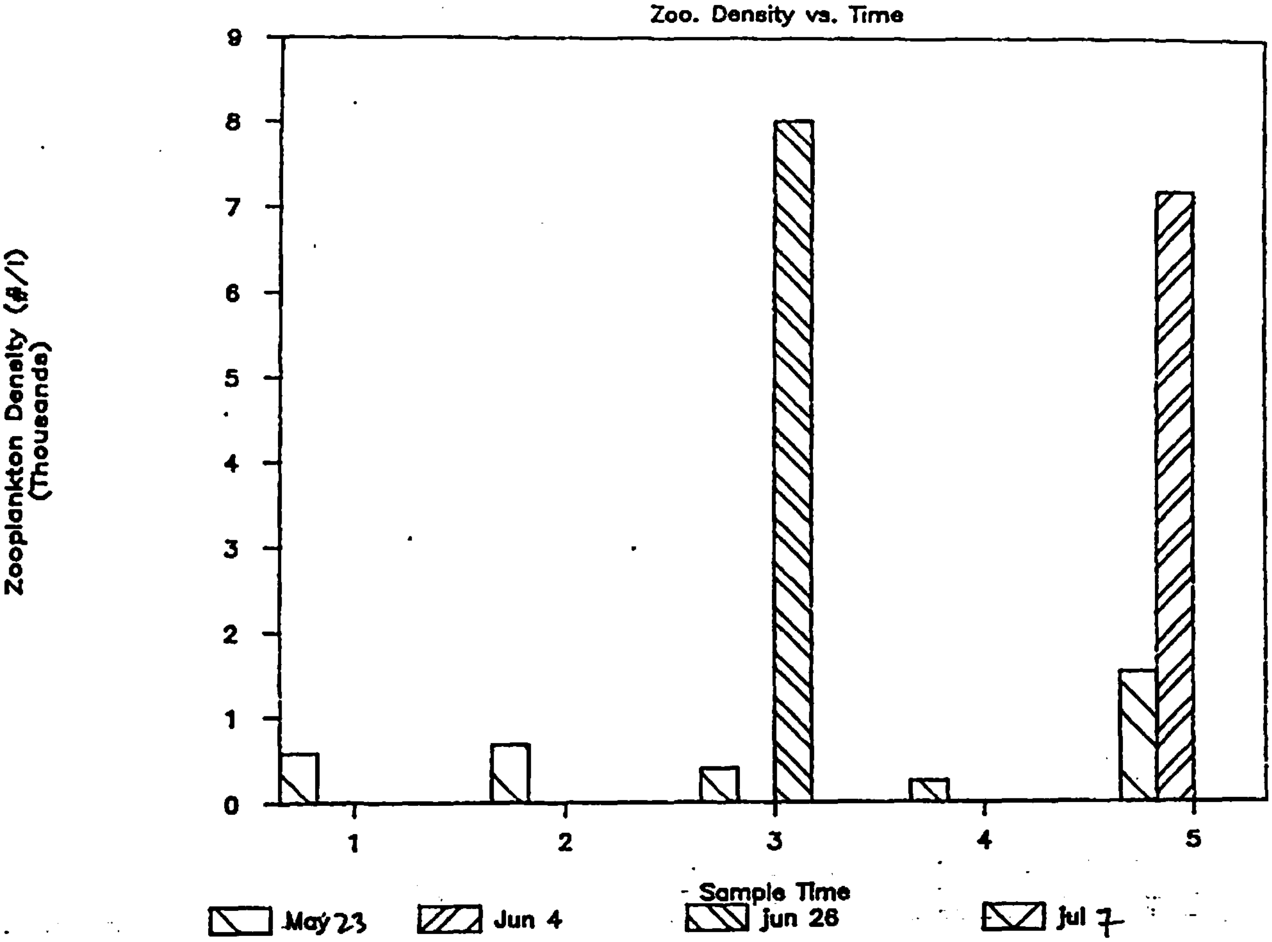
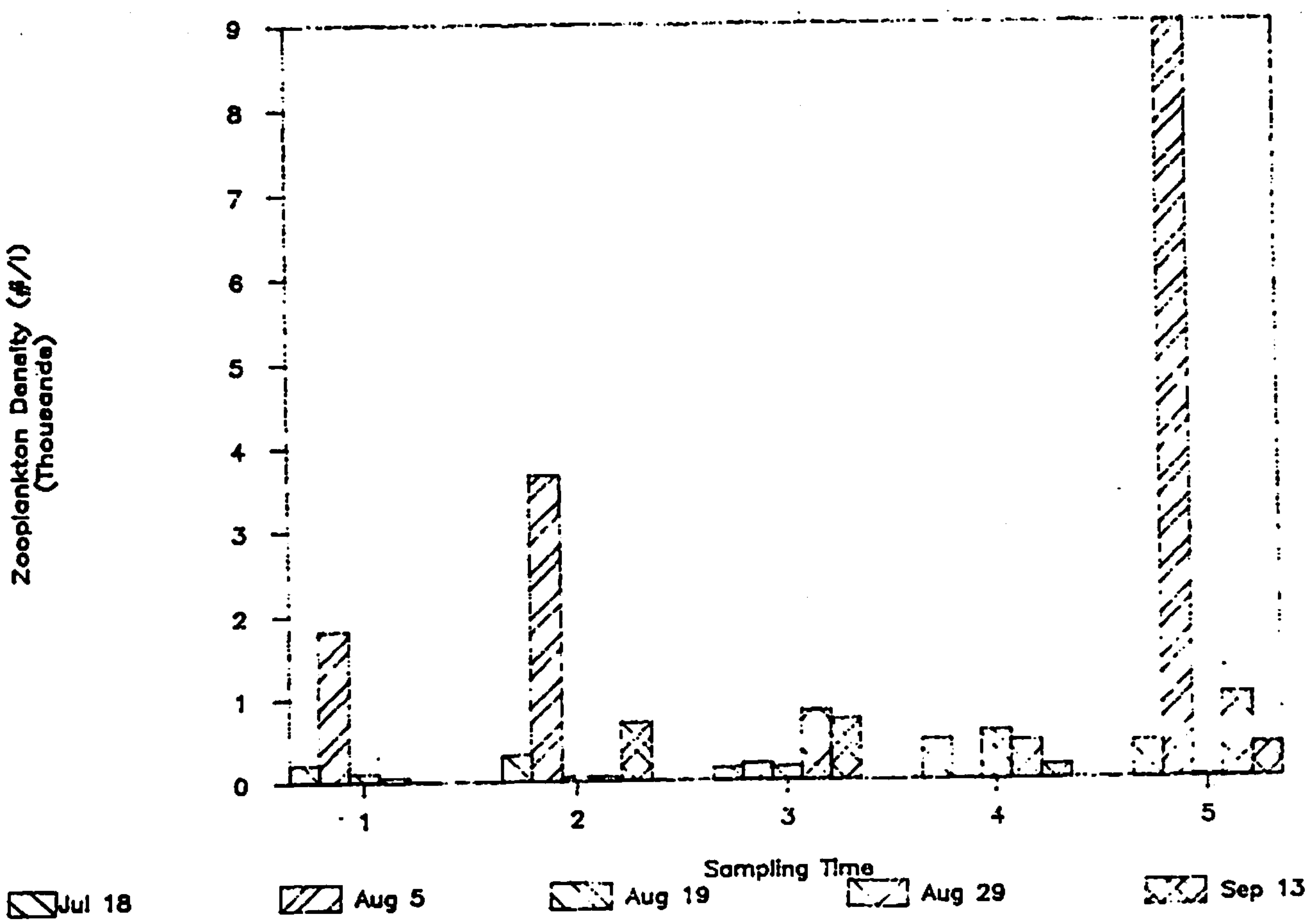


Figure 12

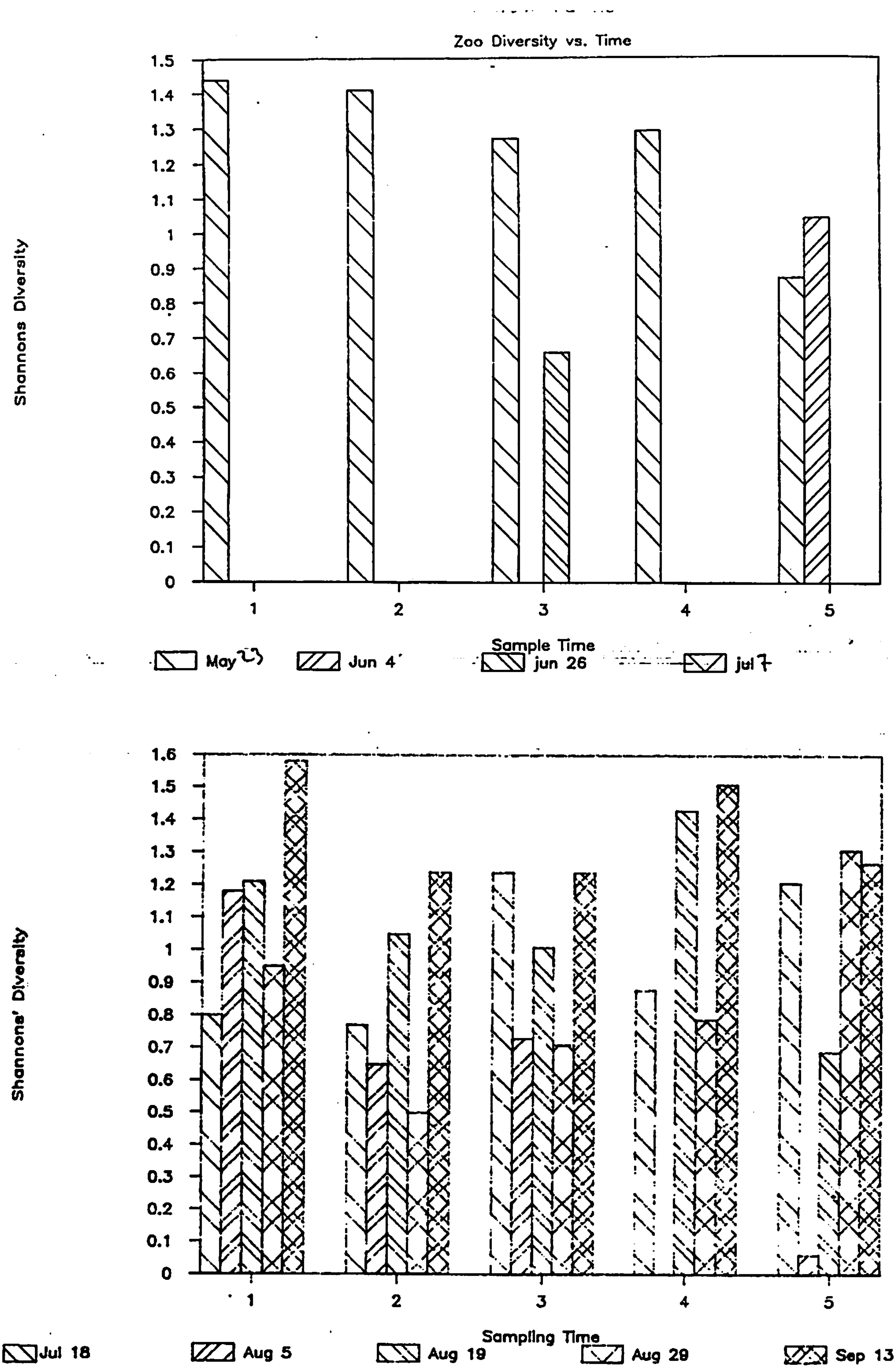


Zoo. Density vs. Time
Zooplankton Density (#/l) (Thousands)
Sample Time
May 23
Jun 4
jun 28
jul 7



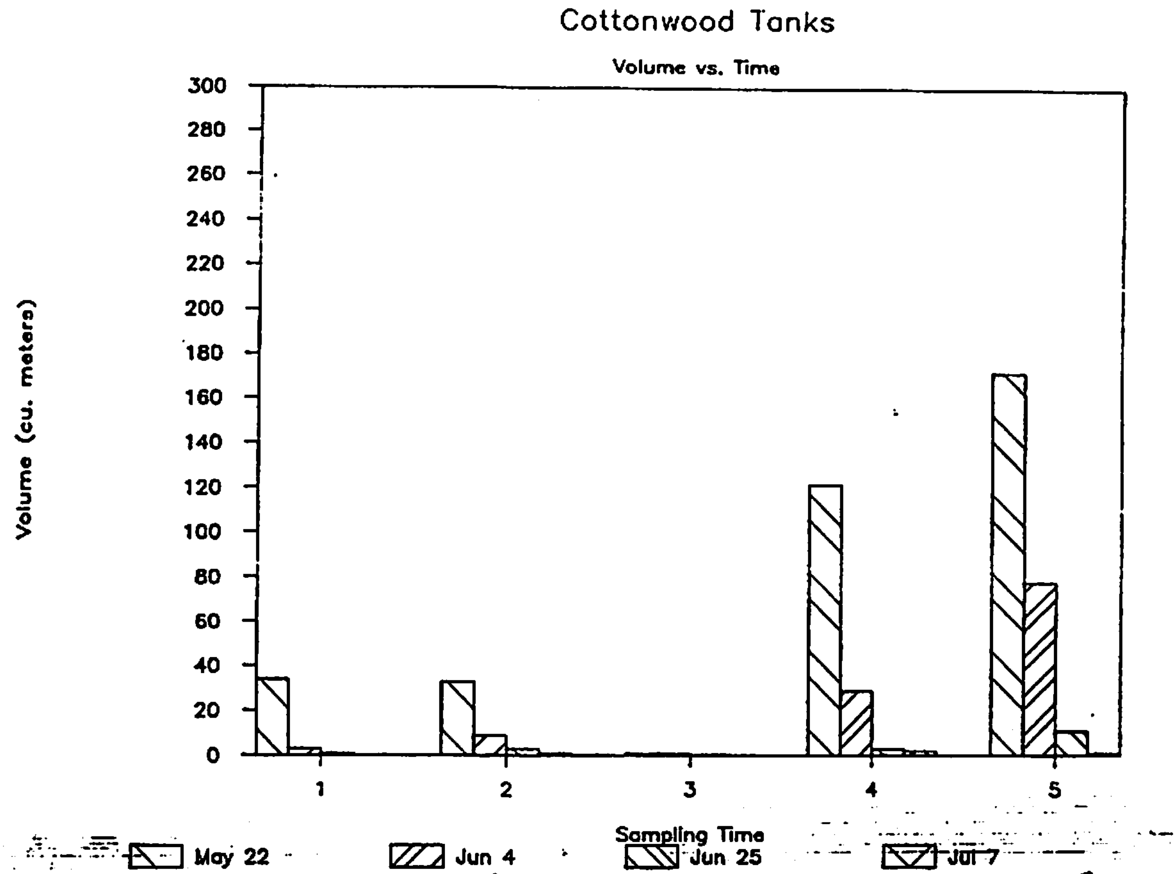
Zooplankton Density (#/l) (Thousands)
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

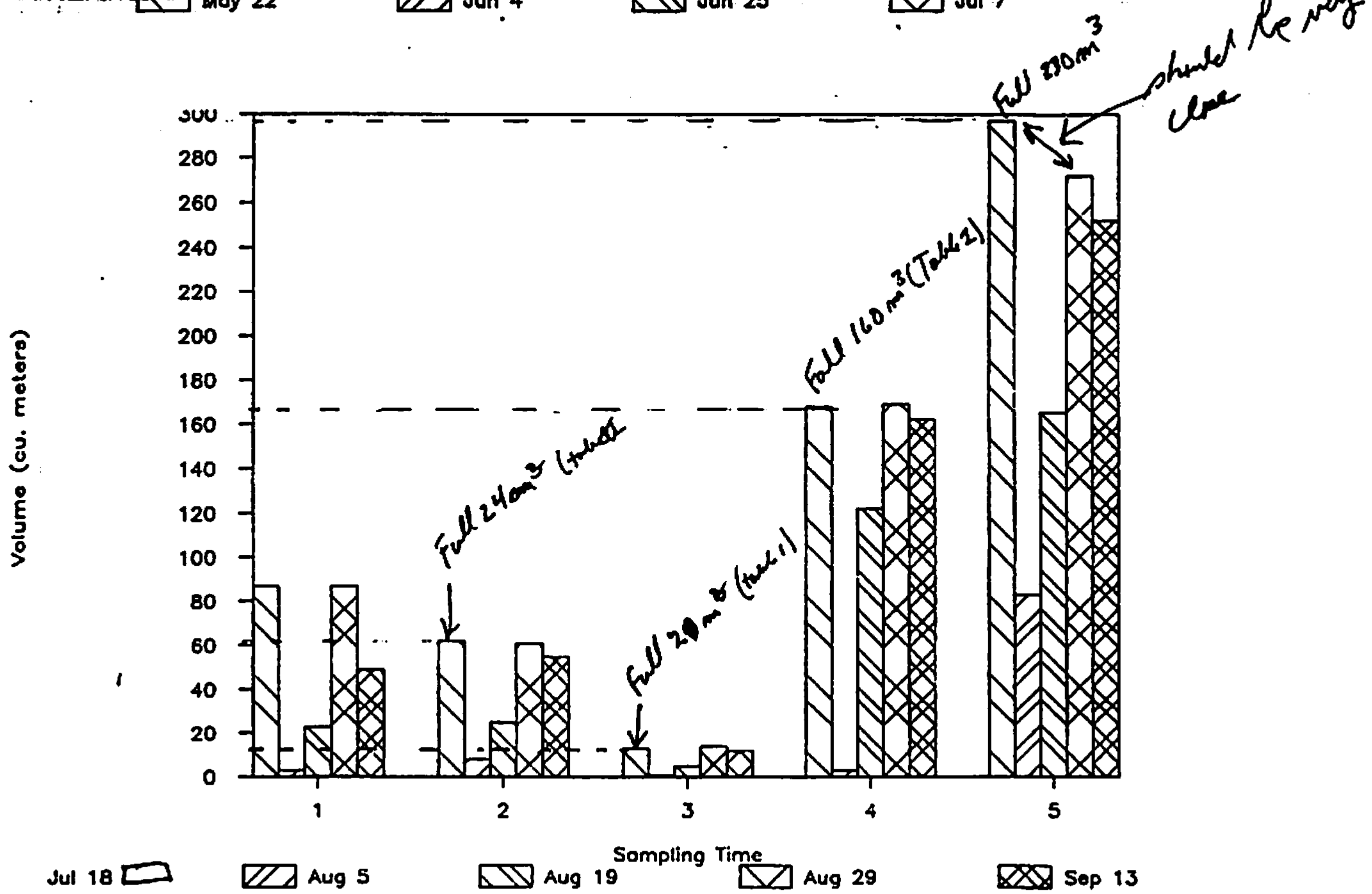
Figure 13



Zoo Diversity vs. Time
Shannons Diversity
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Sample Time
May 23
Jun 4
jun 26
jul 7
Shannons' Diversity
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

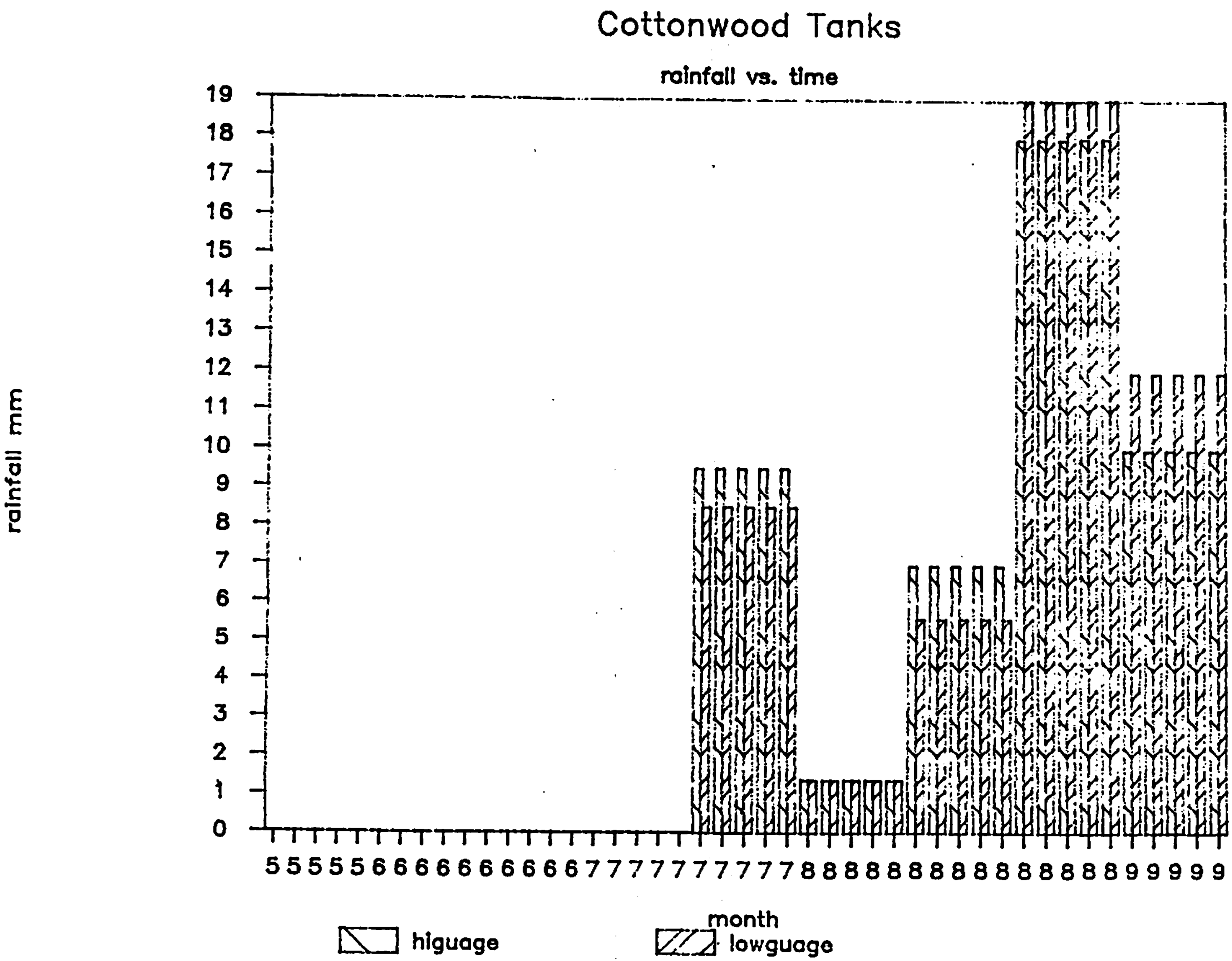
Figure 14





all tanks were full on
July 18 values on graphs don't correspond to Table 1

Figure 15



Cottonwood Tanks
rainfall vs. time
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
rainfall mm
5 5 5 5 5 6 6 6 6 6 6 6 6 6 6 7 7 7 7 7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 9 9 9 9 9
month
higuage
lowguage

Figure 16a

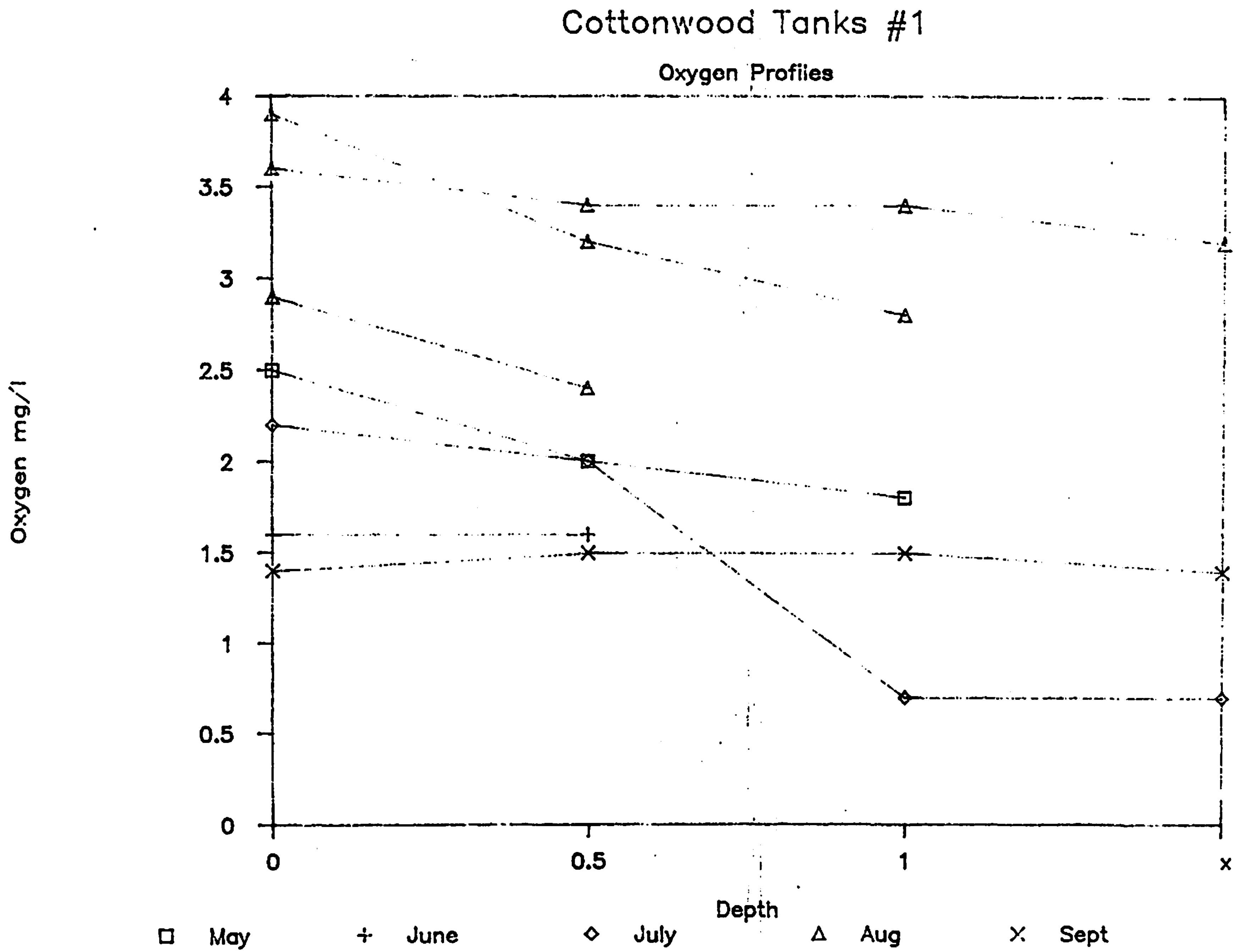

Cottonwood Tanks #1
Oxygen Profiles
Oxygen mg/l
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
x
Depth
May
June
July
Aug
Sept

Figure 16b

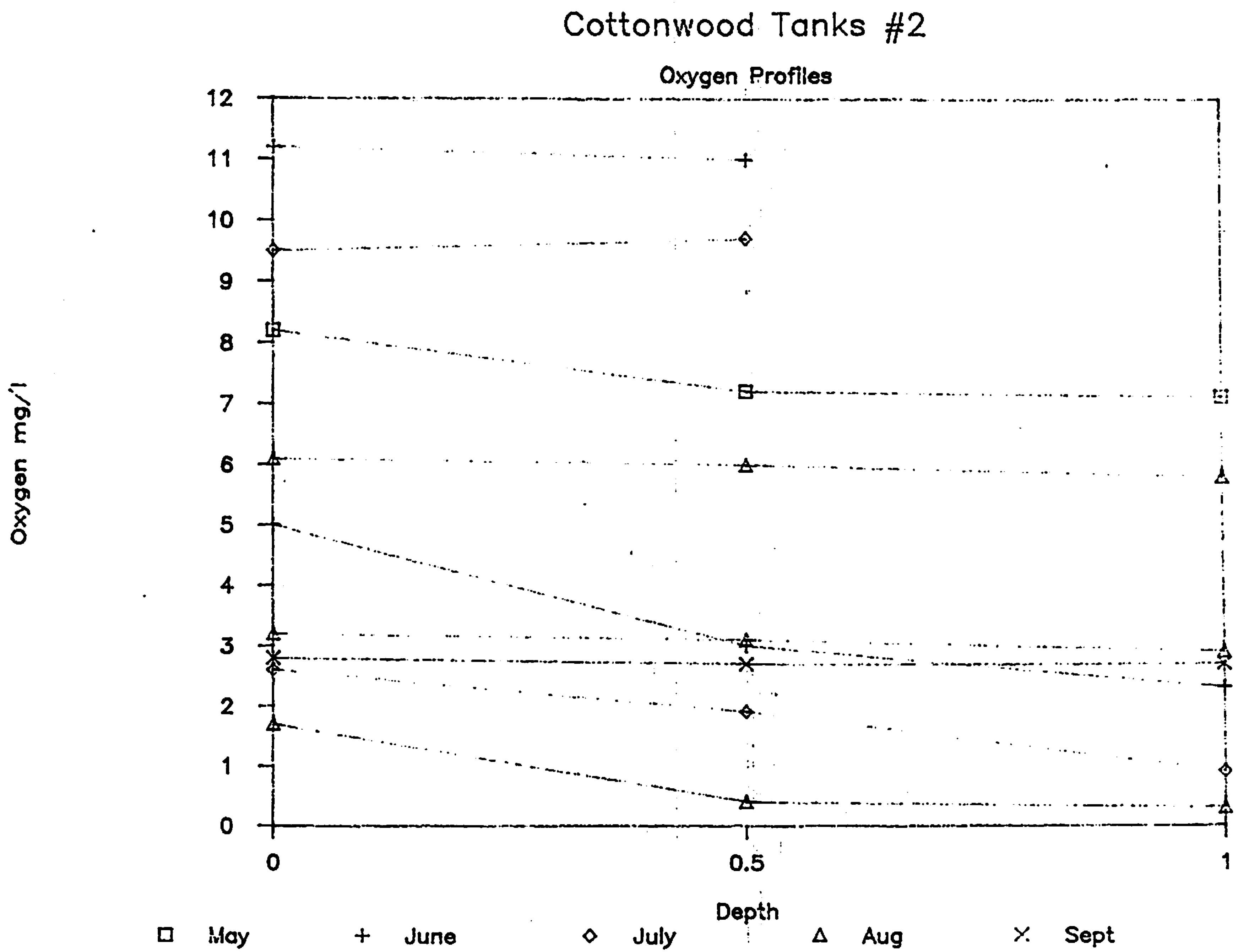

Cottonwood Tanks #2
Oxygen Profiles
Oxygen mg/l
12
11
10
9
8
7
6
5
4
3
2
1
0
0
0.5
1
Depth
May
June
July
Aug
Sept

Figure 16c

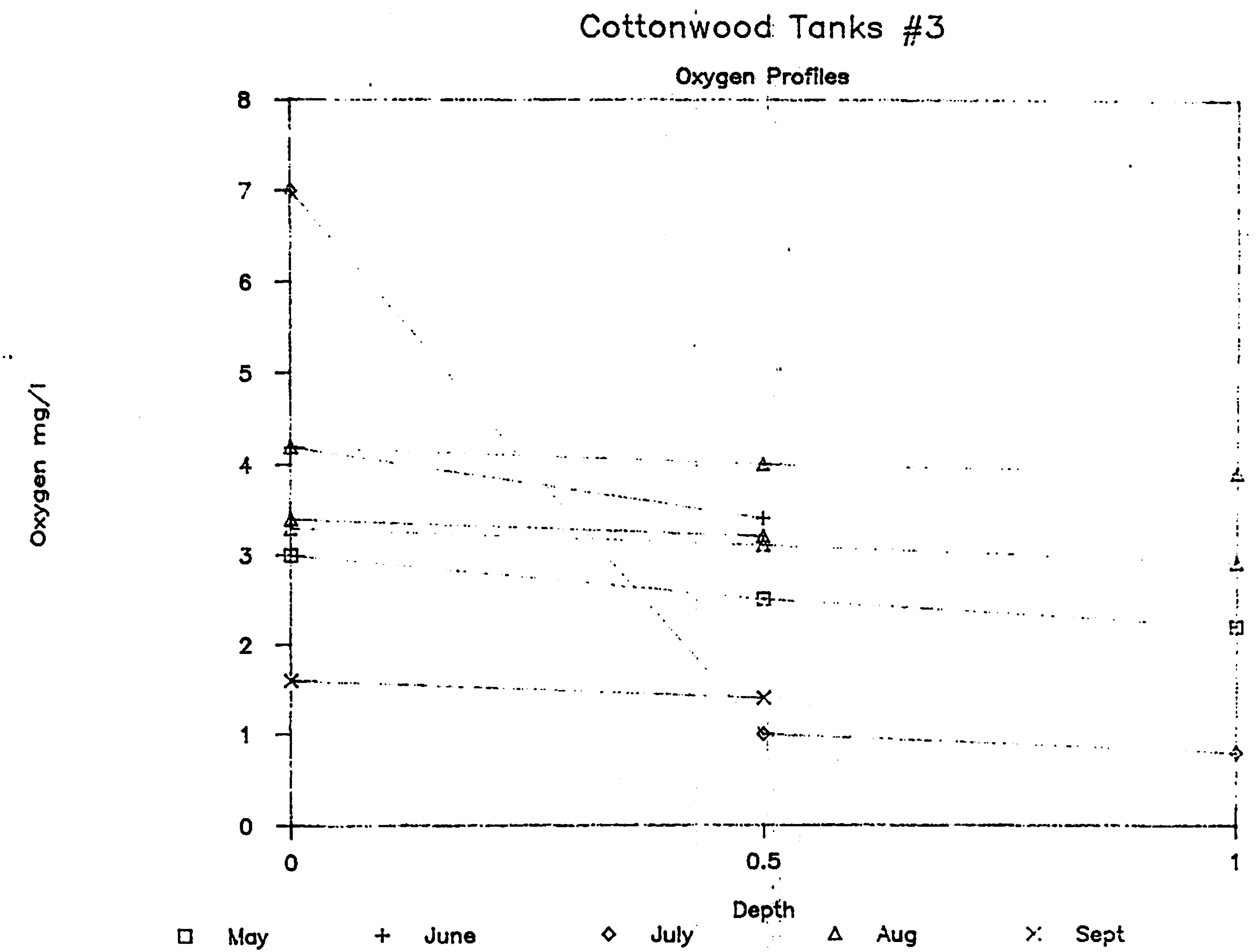

Cottonwood Tanks #3
Oxygen Profiles
Oxygen mg/l
8
7
6
5
4
3
2
1
0
0
0.5
1
Depth
May
June
July
Aug
Sept

Figure 16d

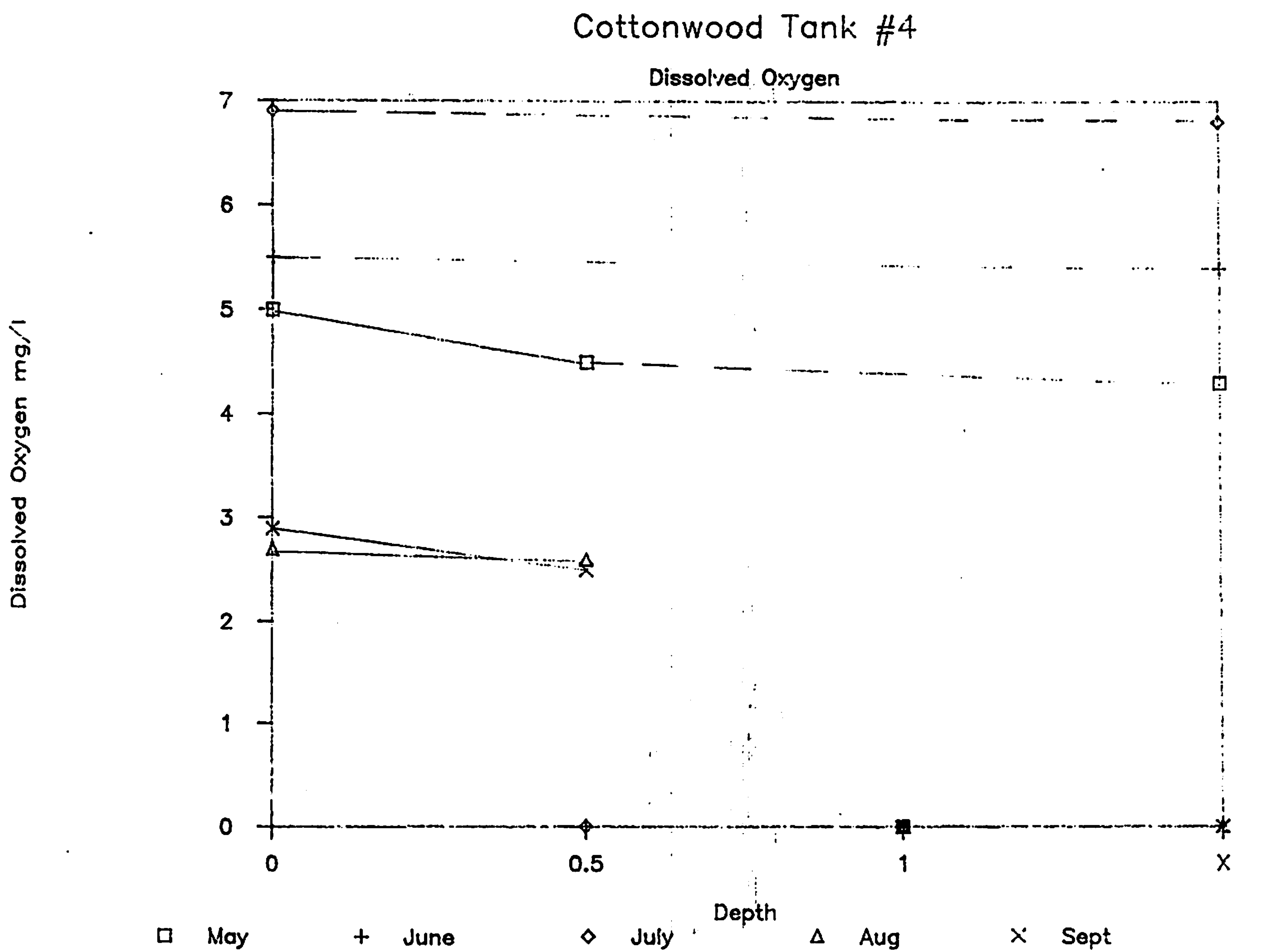
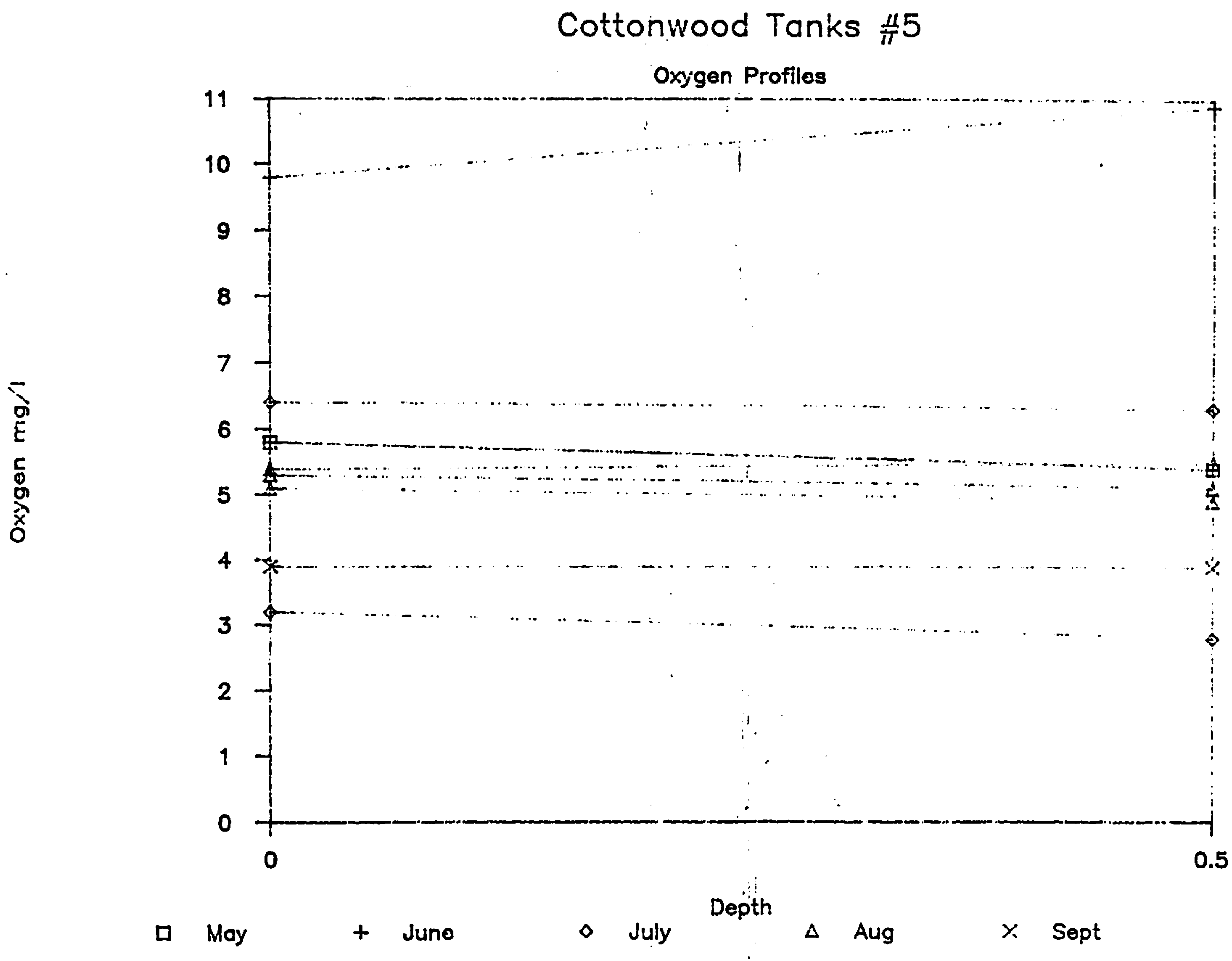
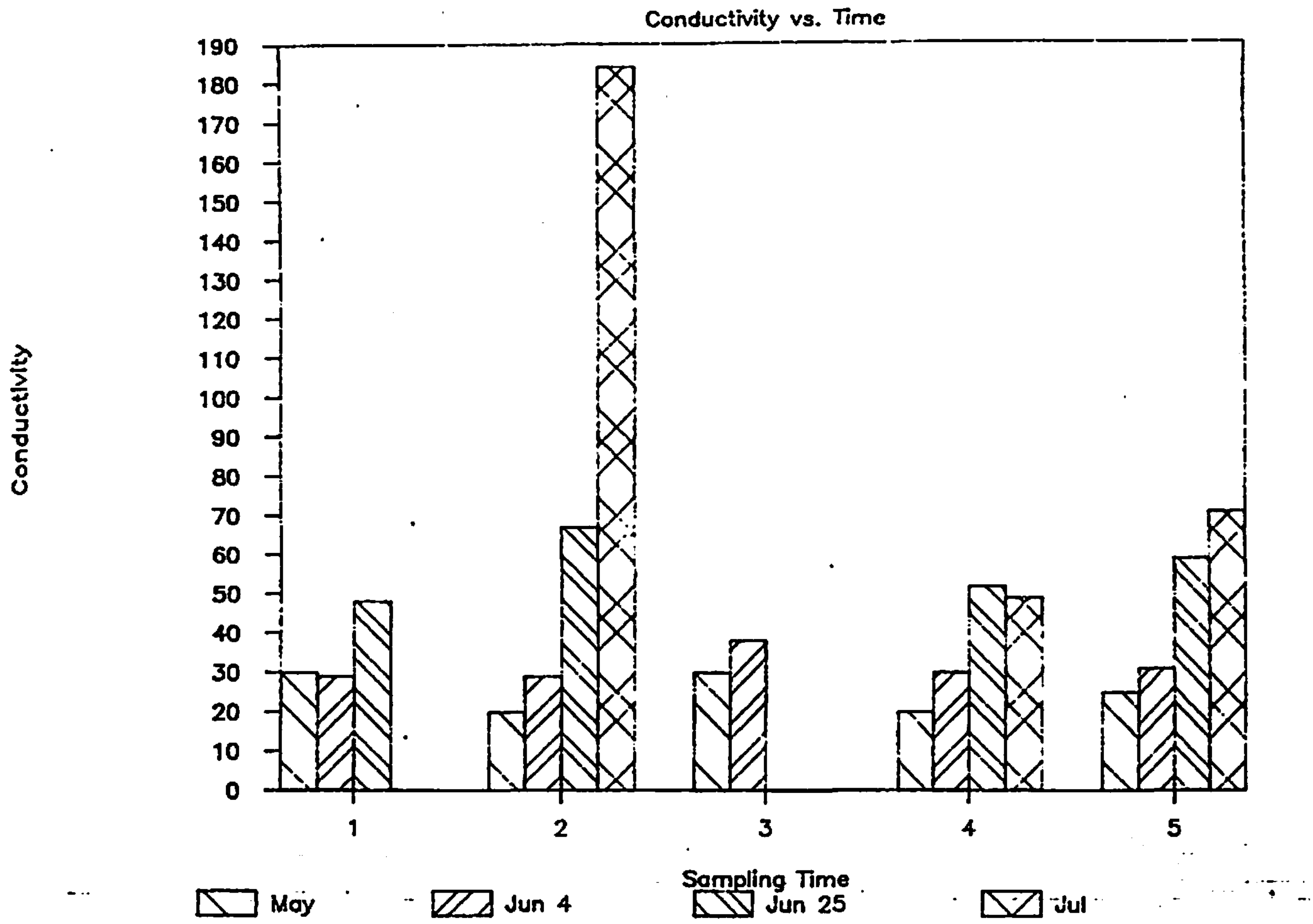

Cottonwood Tank #4
Dissolved Oxygen
Dissolved Oxygen mg/l
7
6
5
4
3
2
1
0
0
0.5
1
X
Depth
May
June
July
Aug
Sept

Figure 16e

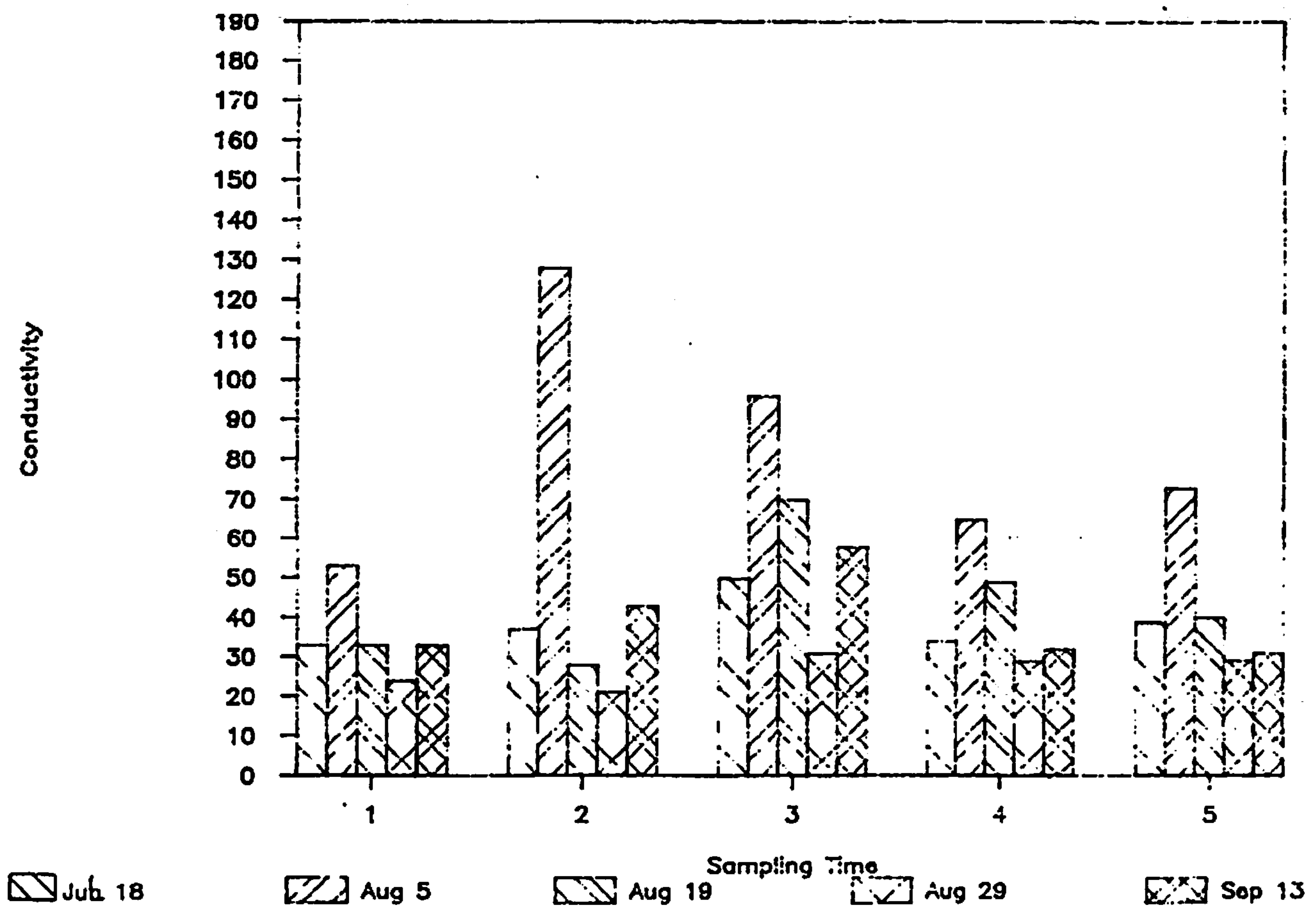


Cottonwood Tanks #5
Oxygen Profiles
Oxygen mg/l
11
10
9
8
7
6
5
4
3
2
1
0
0
0.5
Depth
May
June
July
Aug
Sept

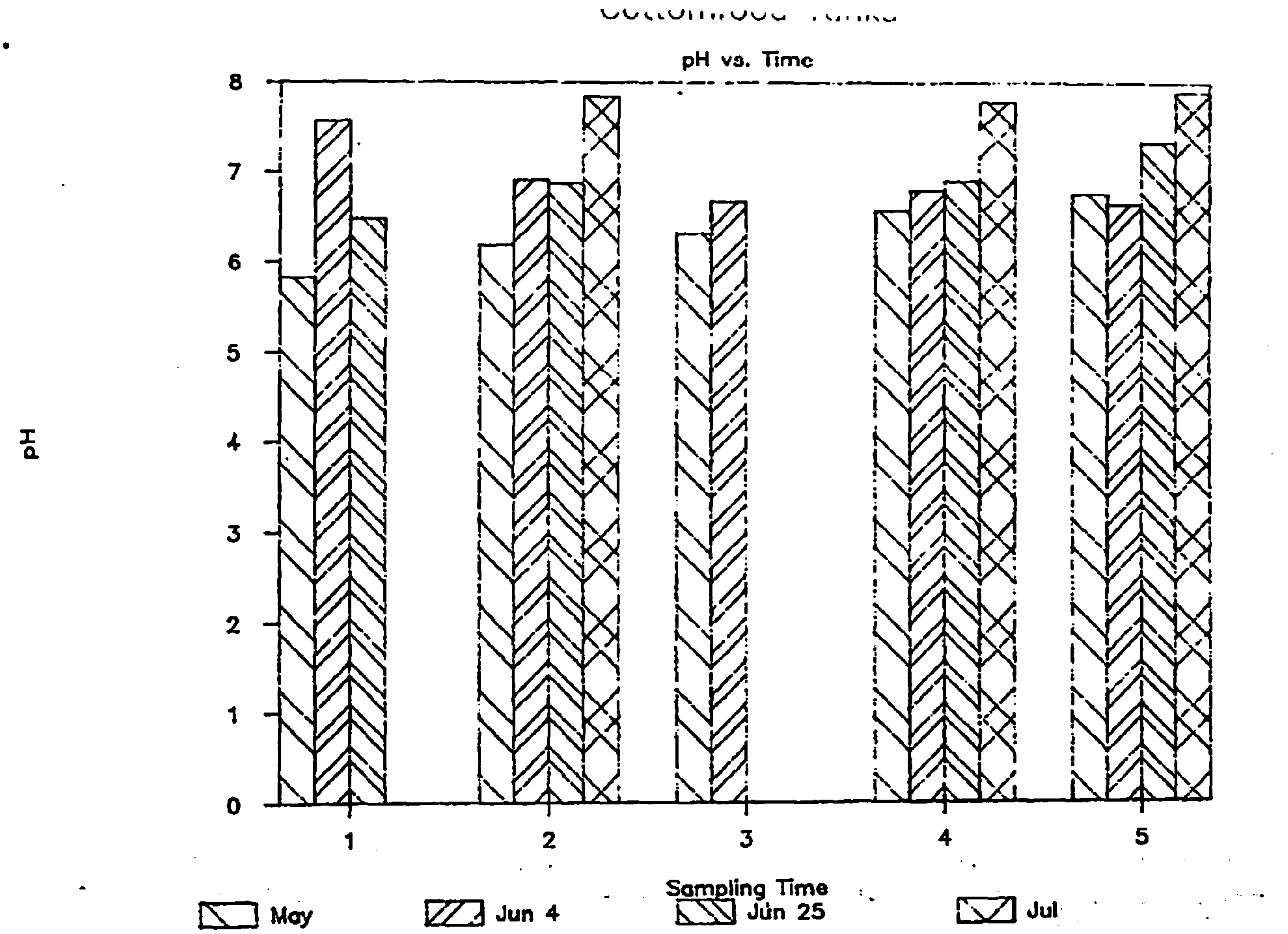


Conductivity vs. Time
Conductivity
Sampling Time
May
Jun 4
Jun 25
Jul

Figure 17



Conductivity
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13


pH vs. Time
pH
Sampling Time
May
Jun 4
Jun 25
Jul

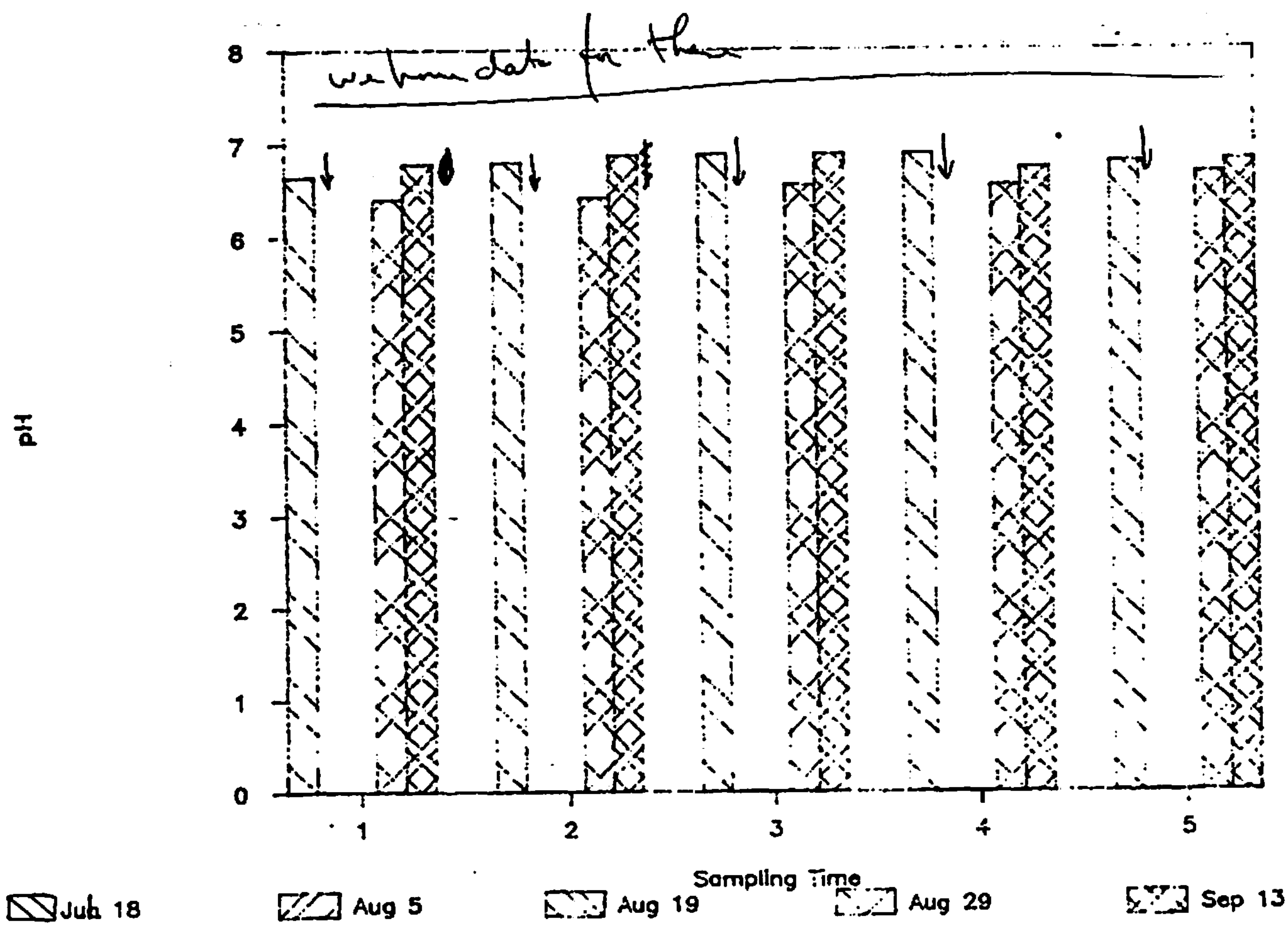
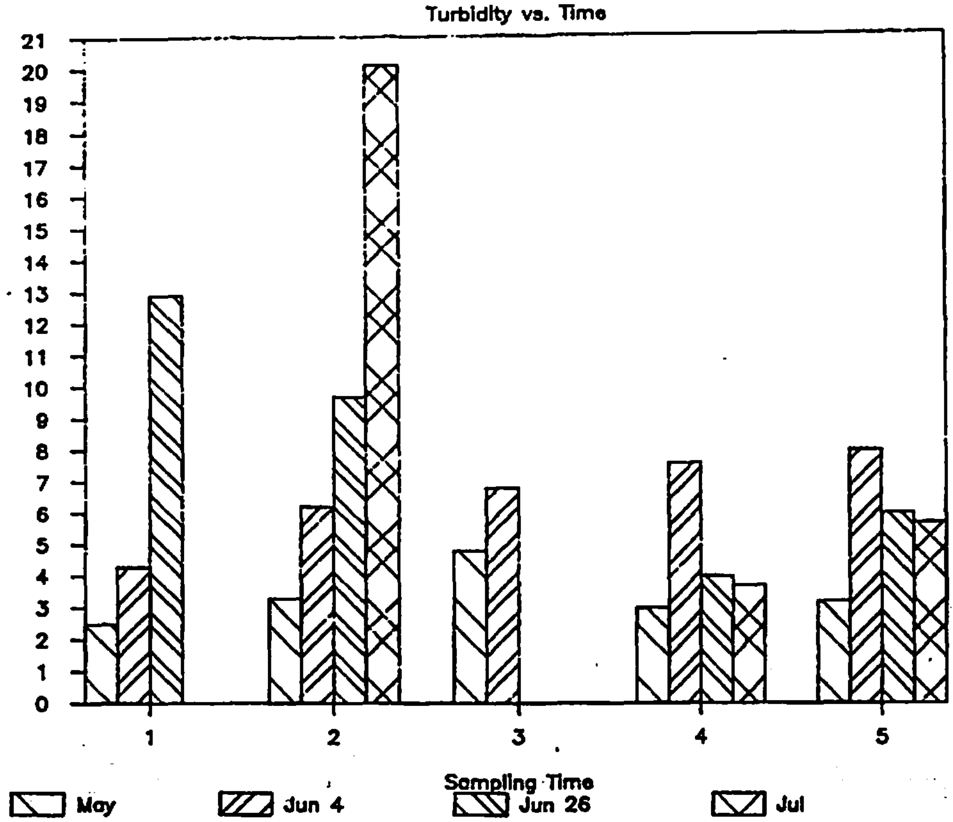

pH
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

Figure 18

Cottonwood Tanks

Turbidity vs. Time



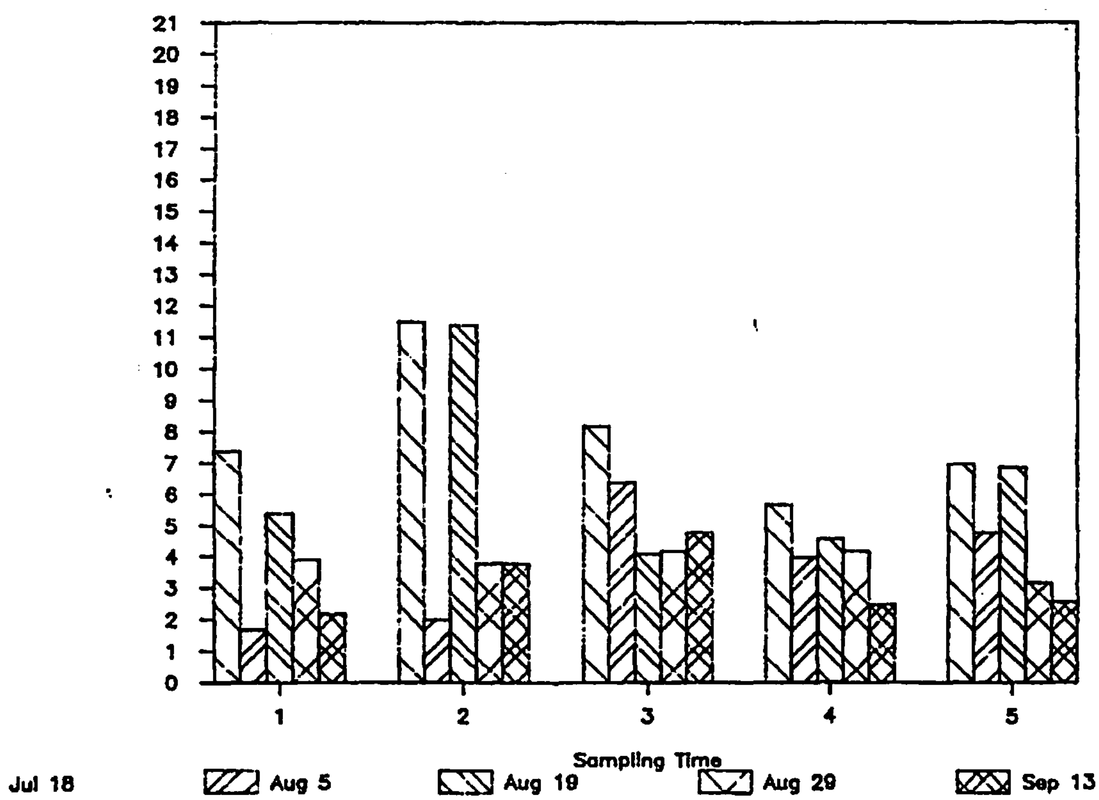


Figure 19

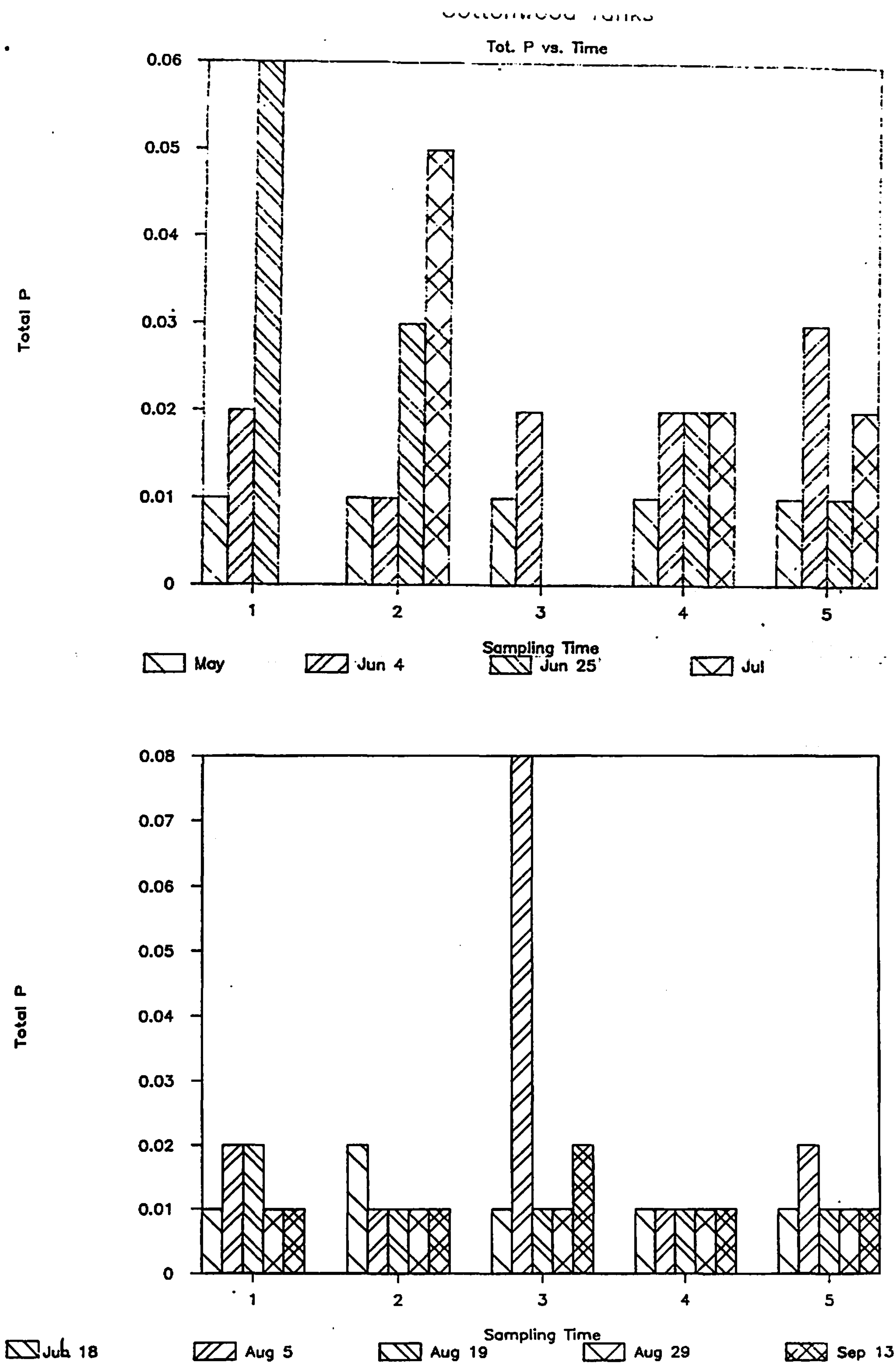
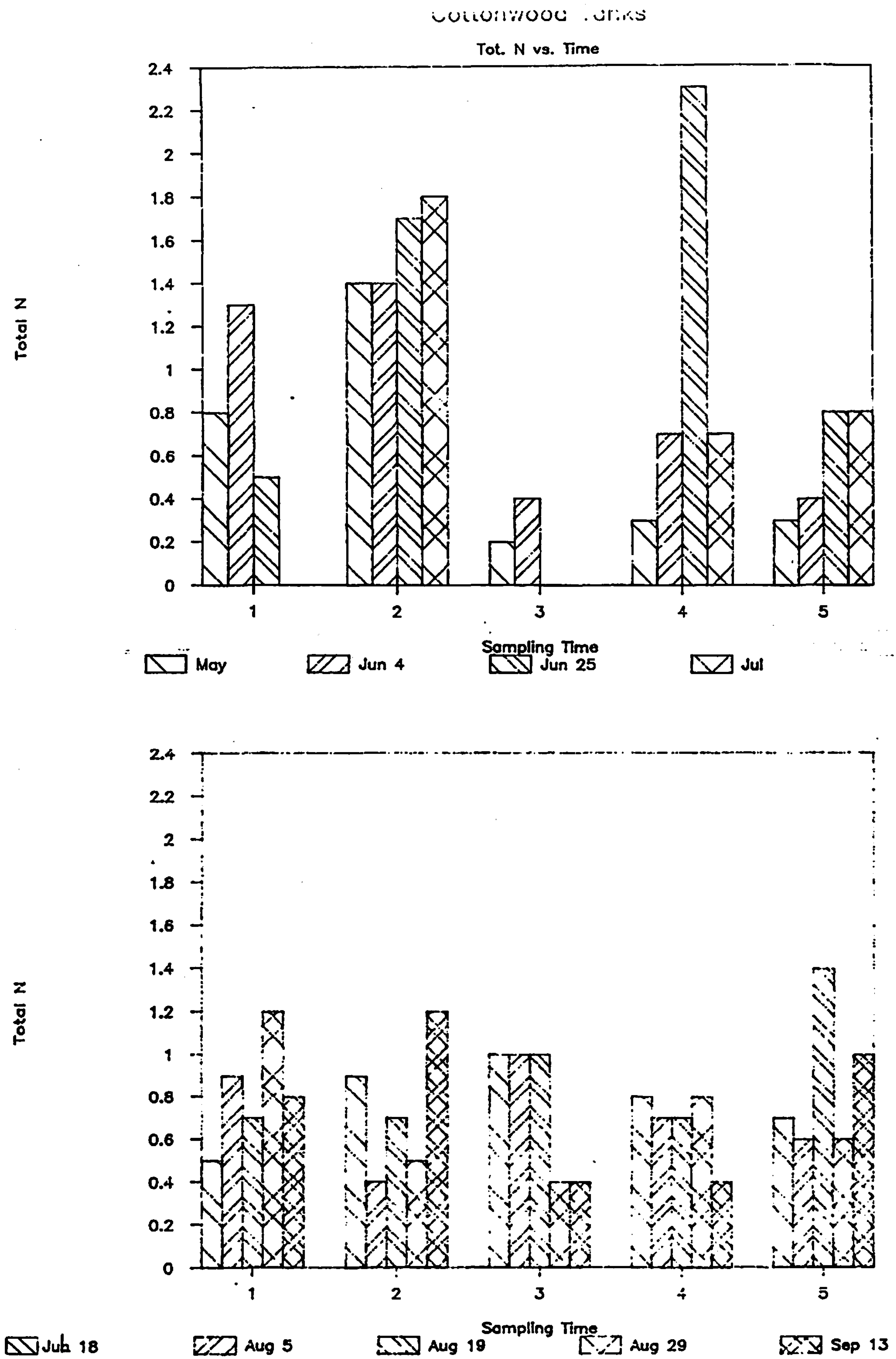
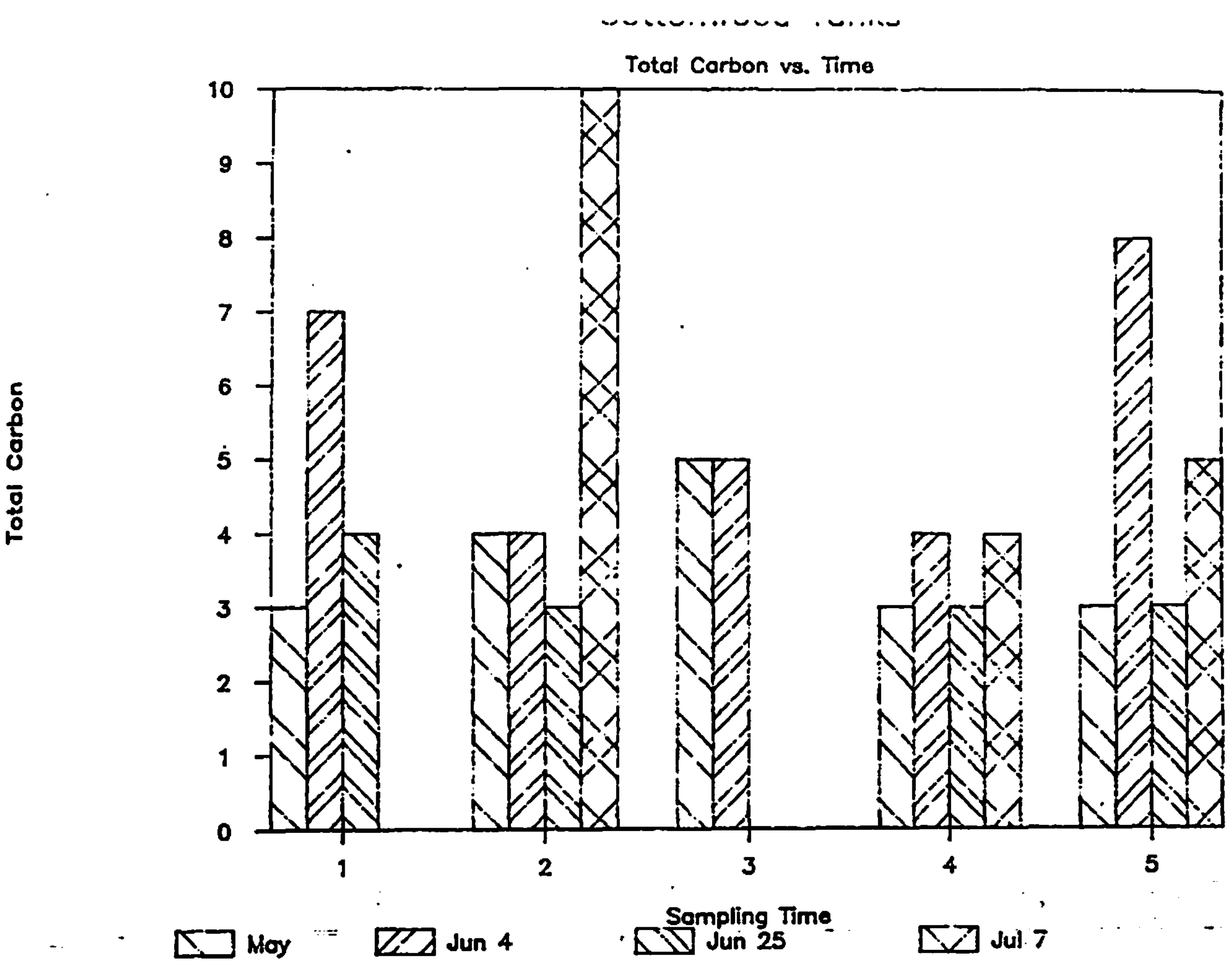

Cottonwood Tanks
Tot. P vs. Time
Total P
0.06
0.05
0.04
0.03
0.02
0.01
0
1
2
3
4
5
Sampling Time
May
Jun 4
Jun 25
Jul
Total P
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1
2
3
4
5
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

Figure 20

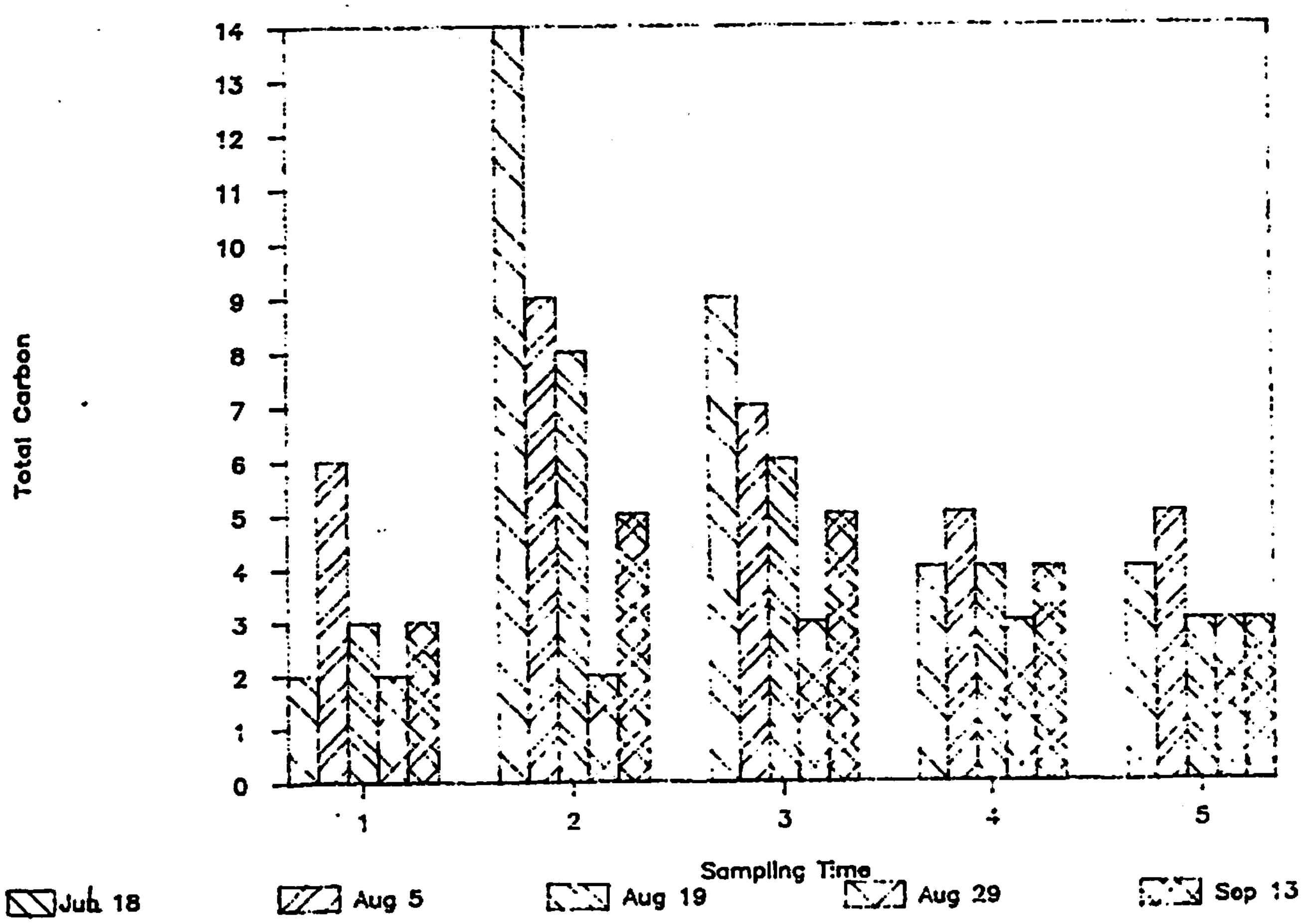
Figure 21


Cottonwood Tanks
Tot. N vs. Time
Total N
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
Sampling Time
May
Jun 4
Jun 25
Jul
Total N
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13



Total Carbon vs. Time
Total Carbon
Sampling Time
May
Jun 4
Jun 25
Jul 7

Figure 22



Total Carbon
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

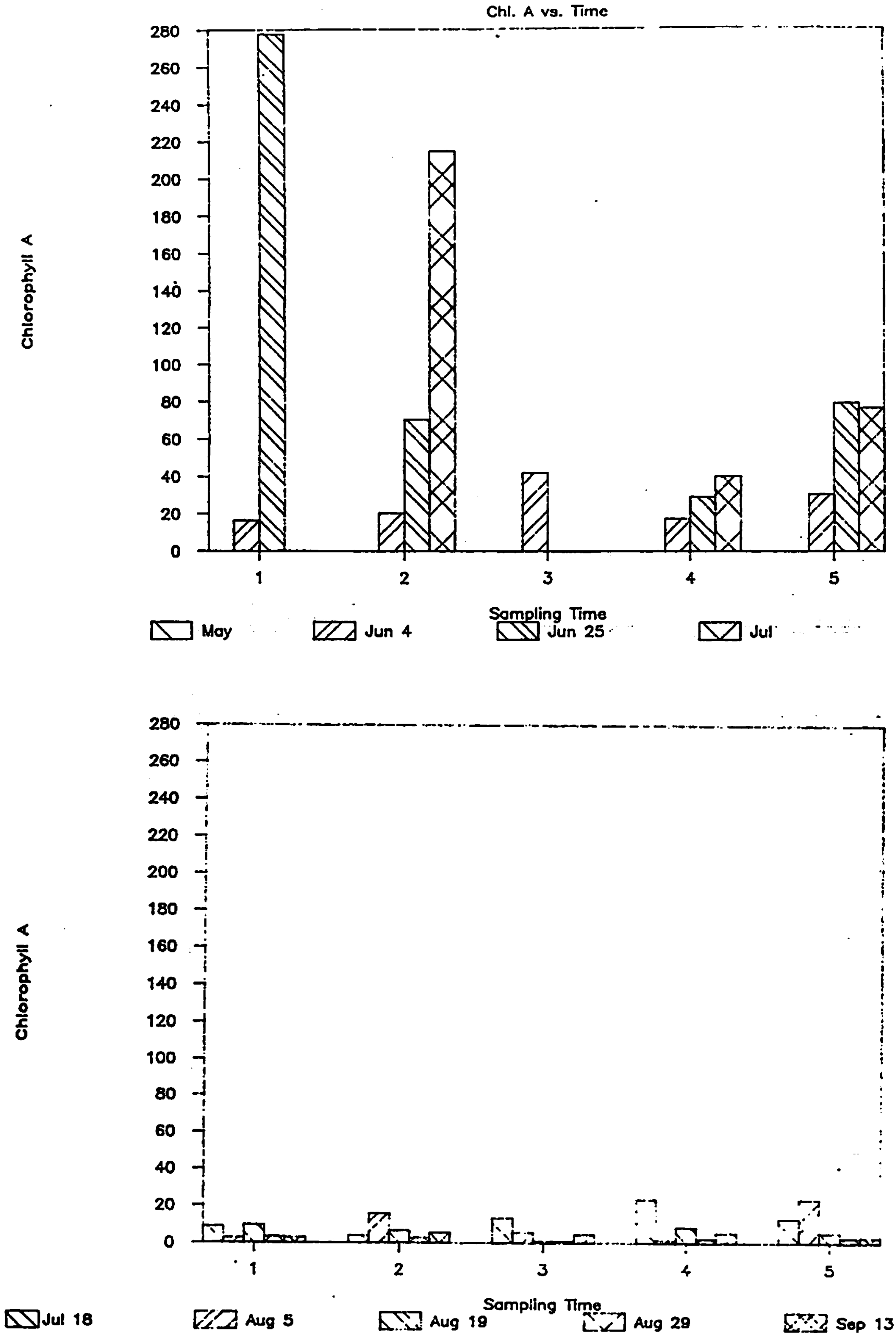
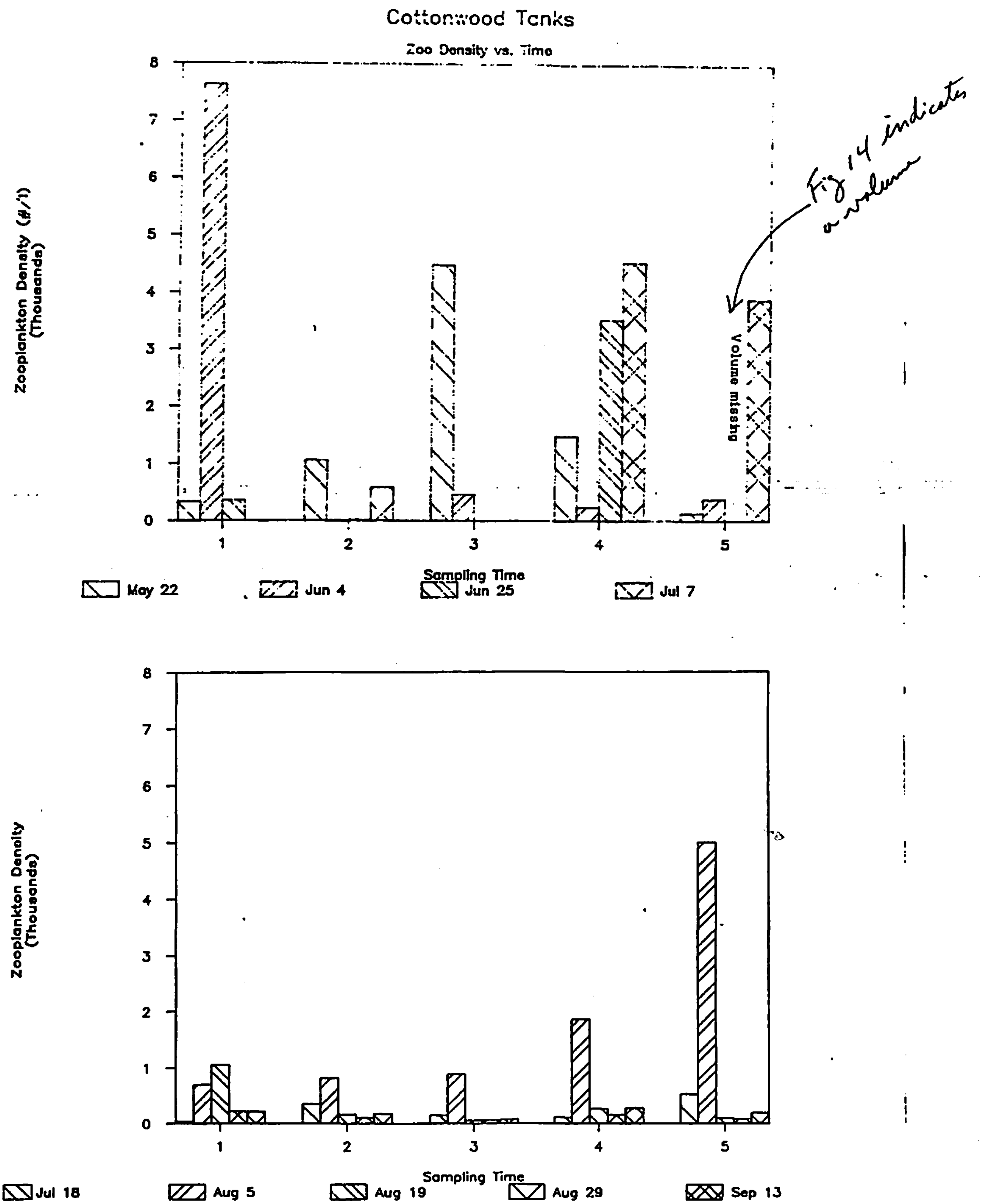
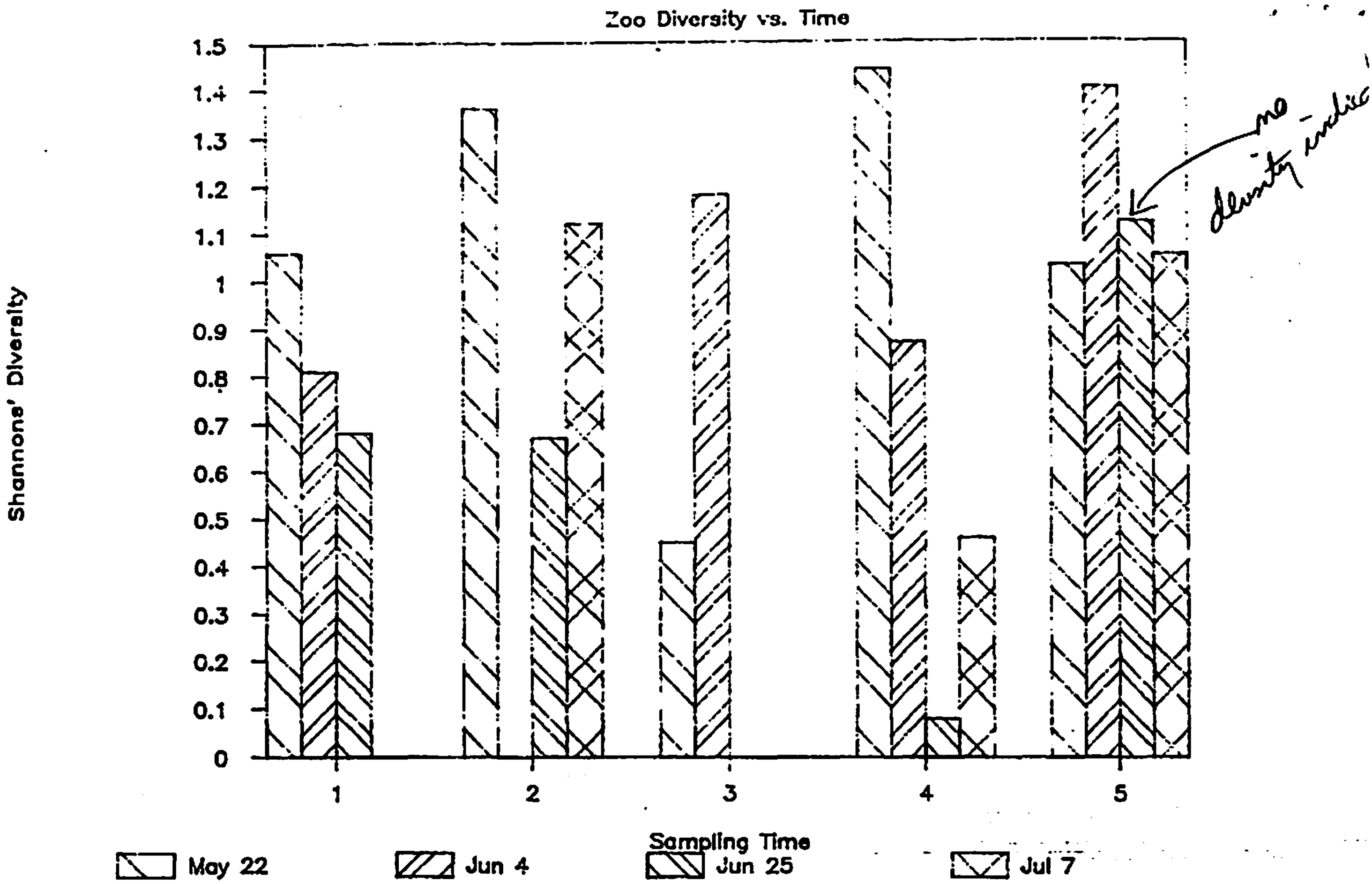

Chl. A vs. Time
Chlorophyll A
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1
2
3
4
5
Sampling Time
May
Jun 4
Jun 25
Jul
Chlorophyll A
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

Figure 23



Cottonwood Tanks
Zoo Density vs. Time
Zooplankton Density (#/l) (Thousands)
Sampling Time
May 22
Jun 4
Jun 25
Jul 7
Volume missing
Fig 14 indicates a volume
Zooplankton Density (Thousands)
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13

Figure 24


Zoo Diversity vs. Time
Shannons' Diversity
Sampling Time
May 22
Jun 4
Jun 25
Jul 7
no density indicated

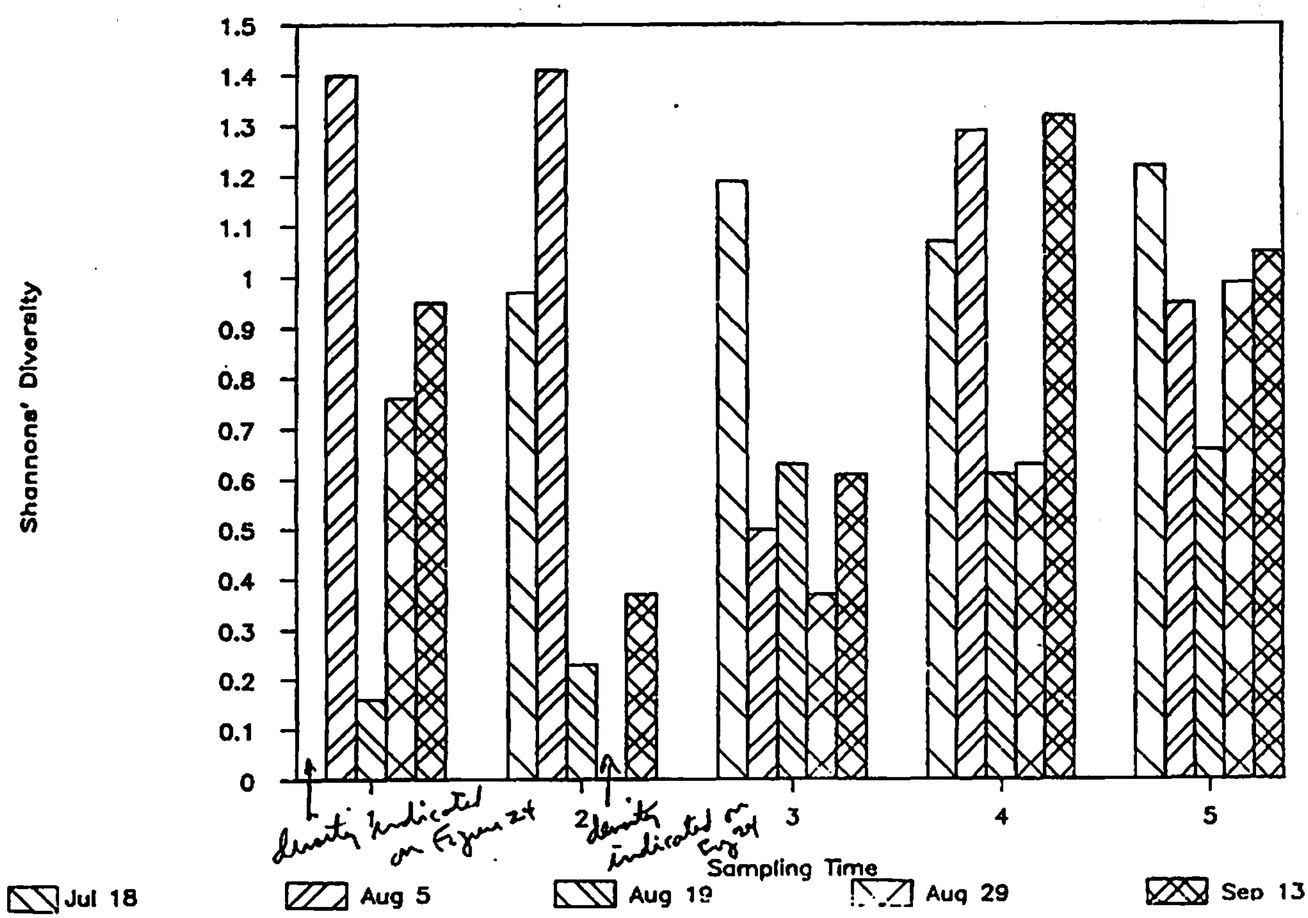
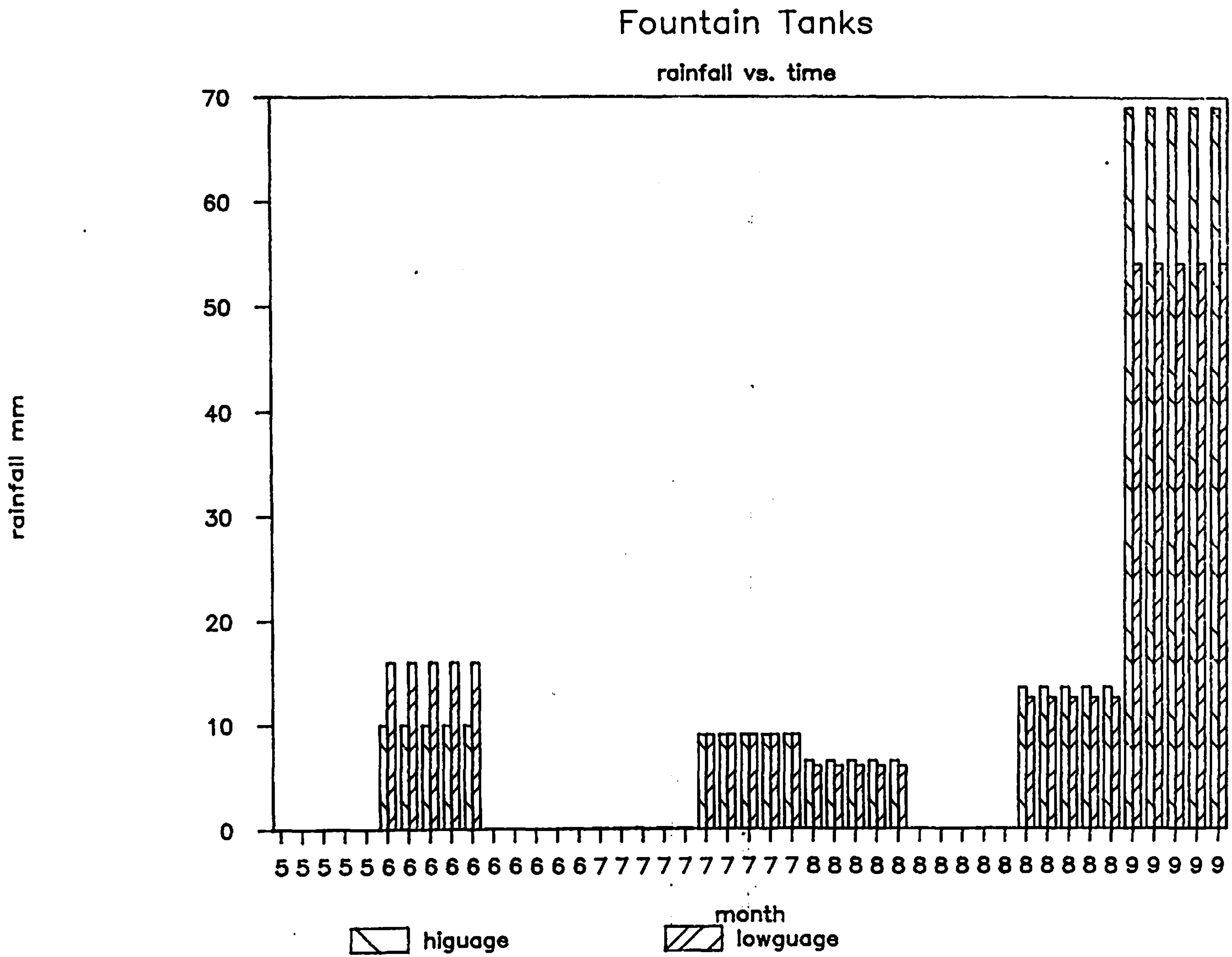
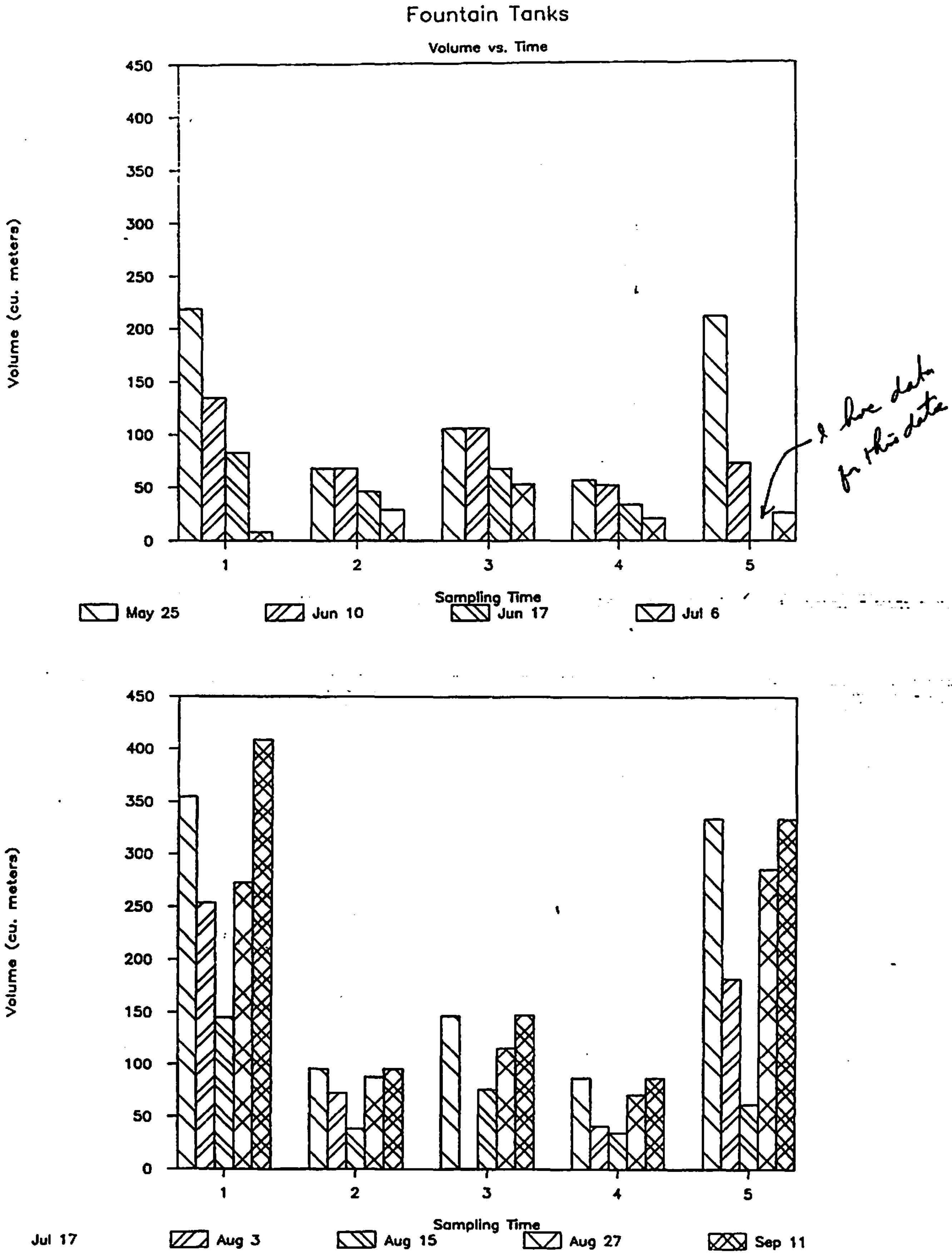

Shannons' Diversity
Sampling Time
Jul 18
Aug 5
Aug 19
Aug 29
Sep 13
density indicated on Figure 24
density indicated on Fig 24

Figure 25

Figure 26

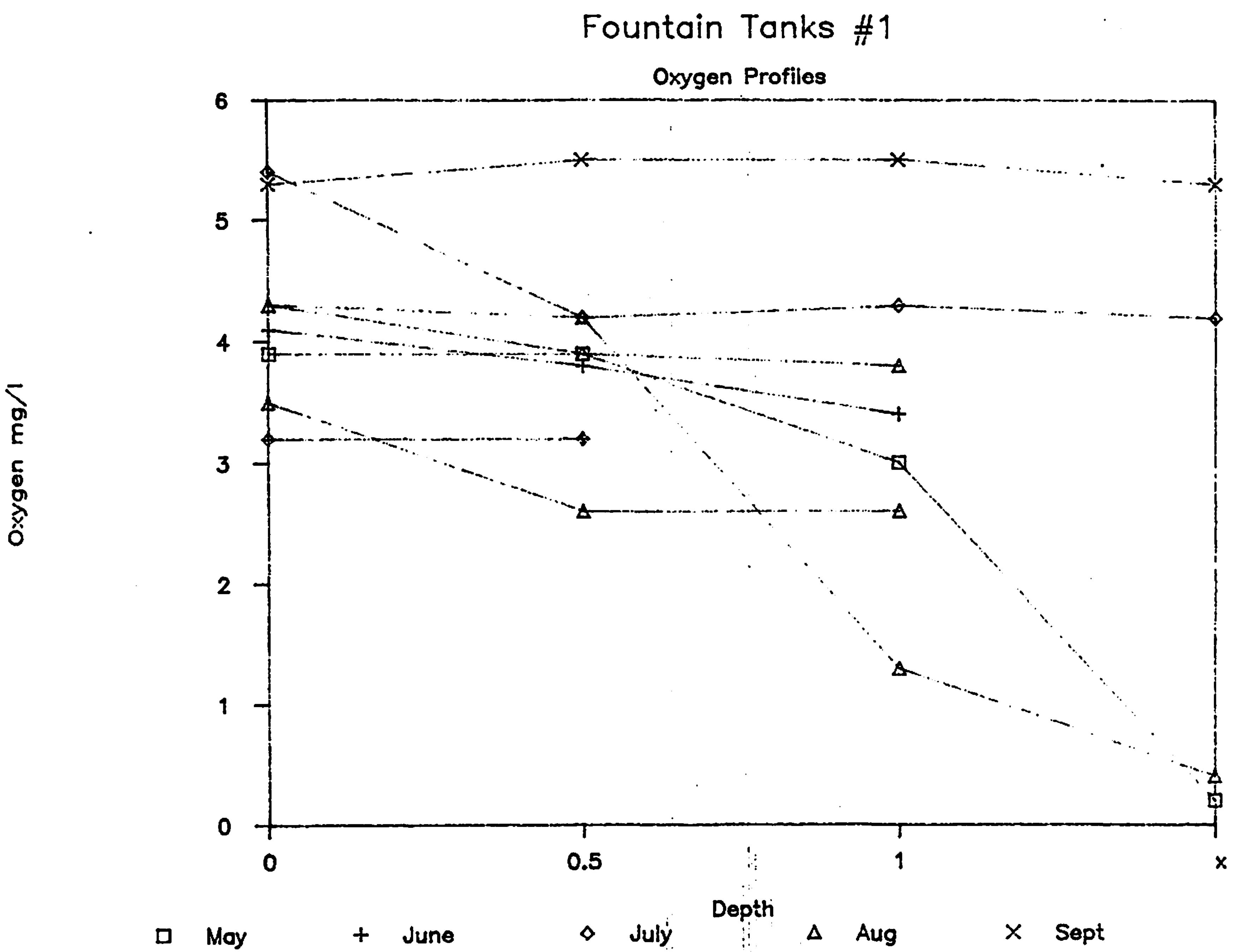

Fountain Tanks
rainfall vs. time
rainfall mm
70
60
50
40
30
20
10
0
5 5 5 5 5 6 6 6 6 6 6 6 6 6 6 7 7 7 7 7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 9 9 9 9 9
month
higuage
lowguage



Fountain Tanks
Volume vs. Time
Volume (cu. meters)
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
Sampling Time
May 25
Jun 10
Jun 17
Jul 6
I have data for this date
Volume (cu. meters)
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
Sampling Time
Jul 17
Aug 3
Aug 15
Aug 27
Sep 11

Figure 27

Figure 28a



Fountain Tanks #1
Oxygen Profiles
6
5
4
3
2
1
0
Oxygen mg/l
0
0.5
1
x
Depth
May
June
July
Aug
Sept

Figure 28b

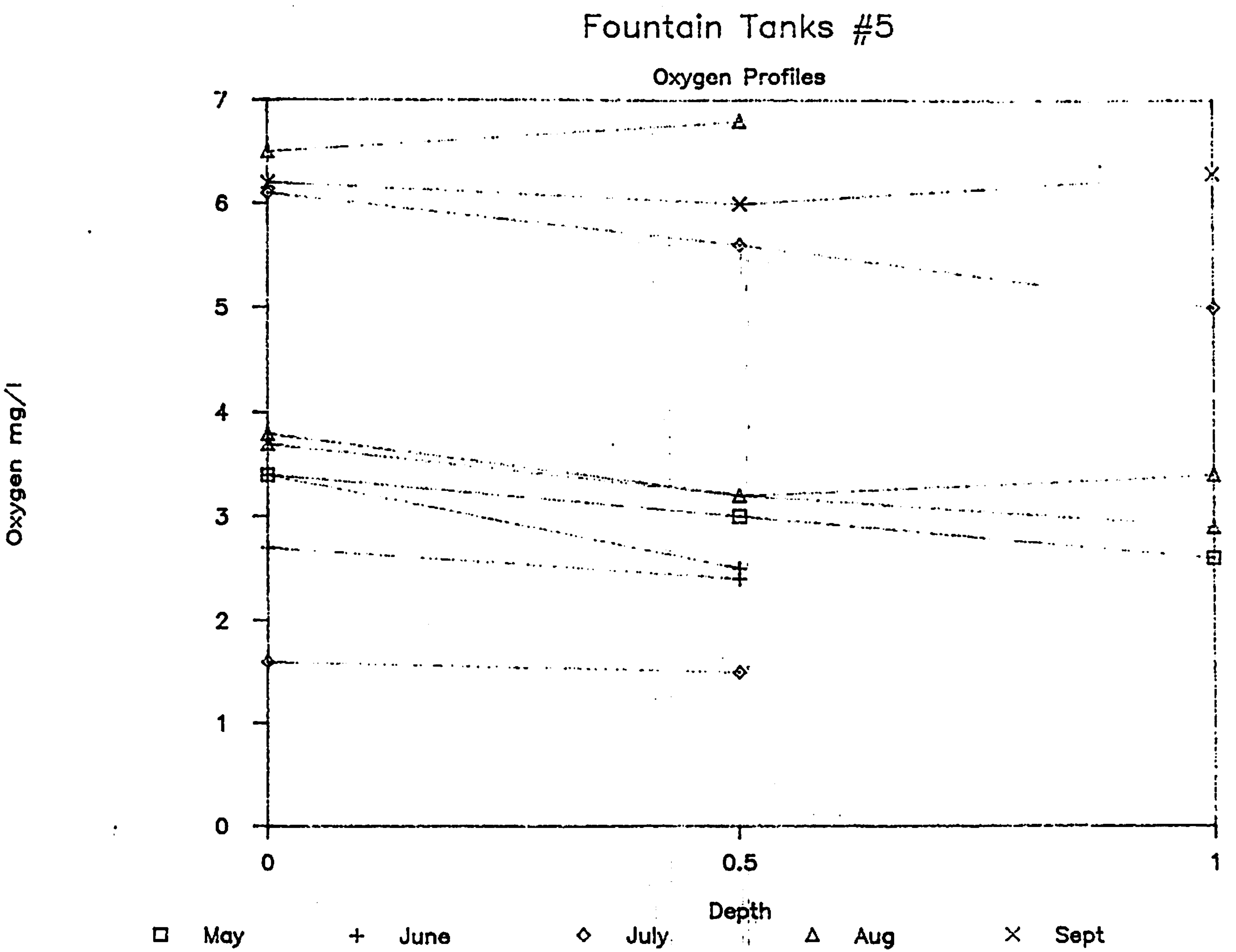
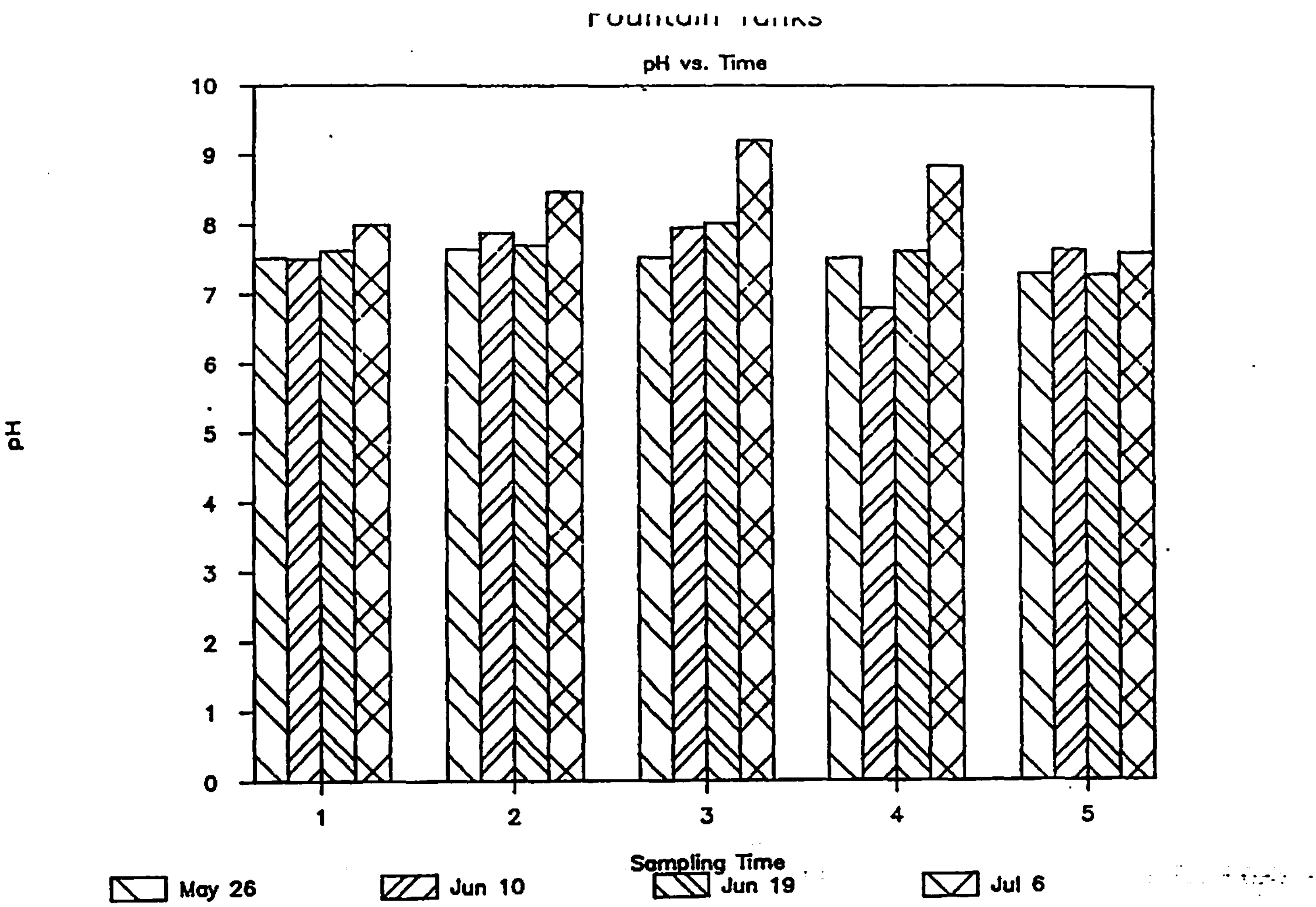
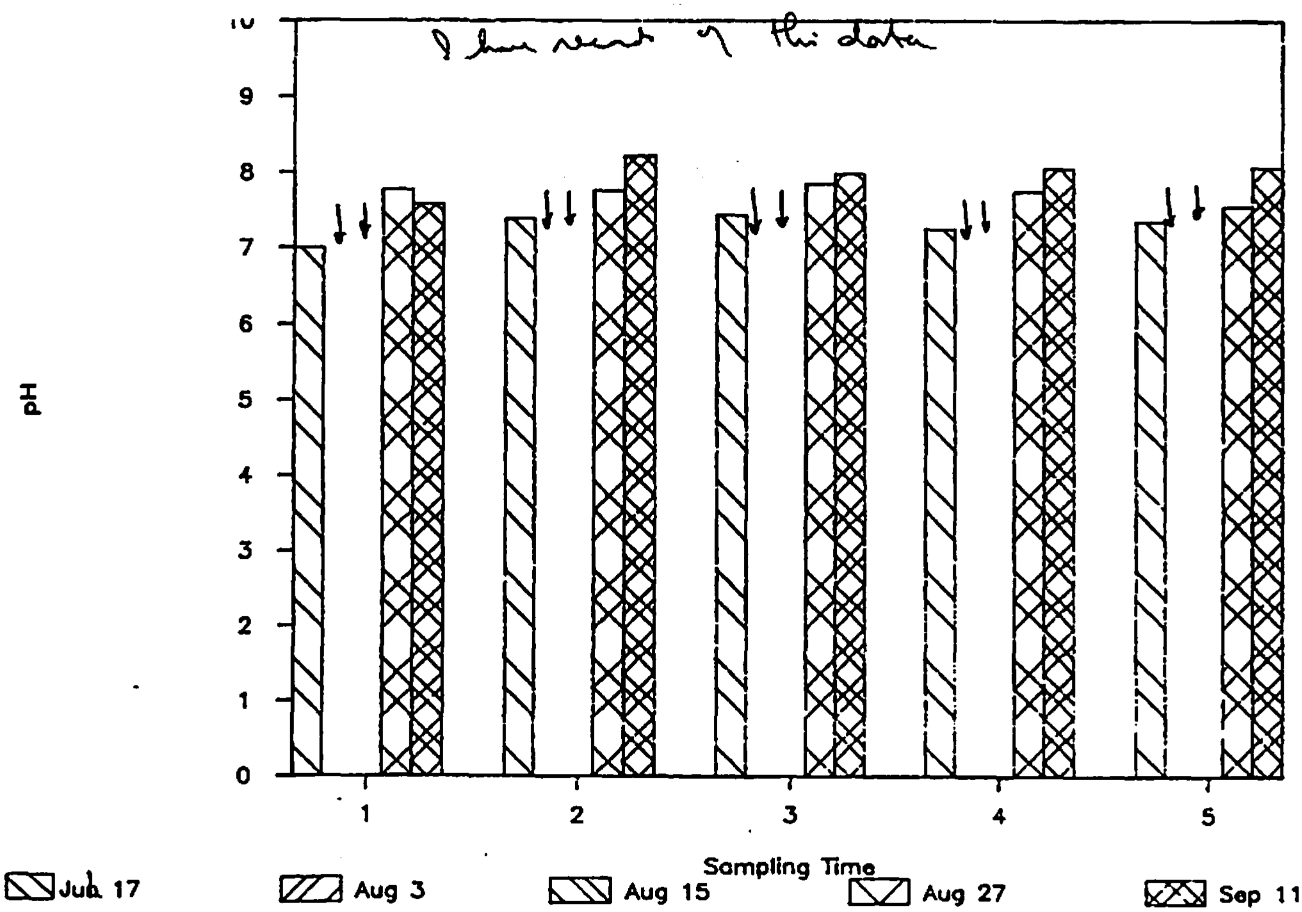
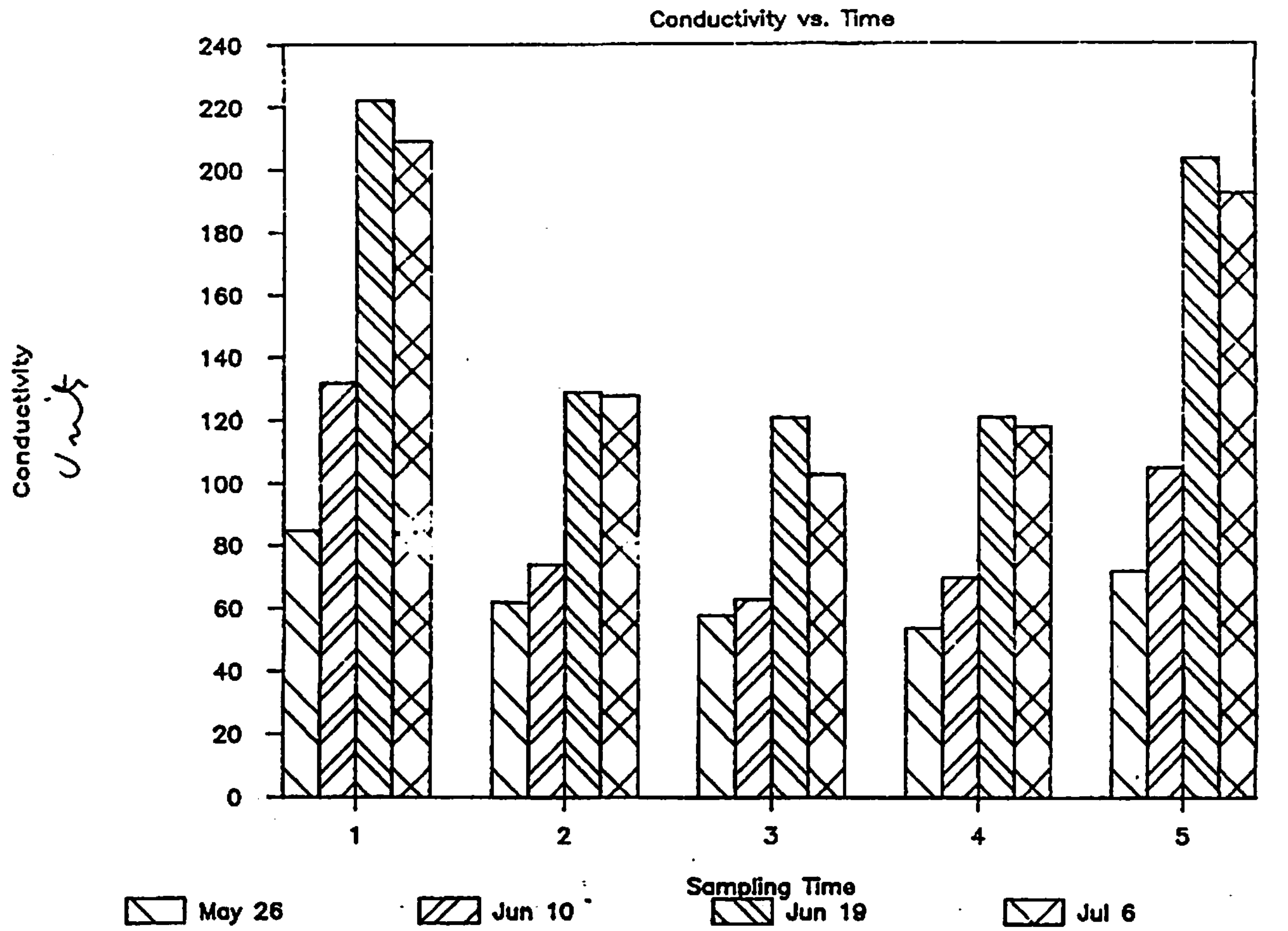

Fountain Tanks #5
Oxygen Profiles
Oxygen mg/l
7
6
5
4
3
2
1
0
0
0.5
1
Depth
May
June
July
Aug
Sept

Figure 29


pH vs. Time
pH
Sampling Time
May 26
Jun 10
Jun 19
Jul 6


pH
Sampling Time
Jul 17
Aug 3
Aug 15
Aug 27
Sep 11


Conductivity vs. Time
240
220
200
180
160
140
120
100
80
60
40
20
0
Conductivity
1
2
3
4
5
Sampling Time
May 26
Jun 10
Jun 19
Jul 6

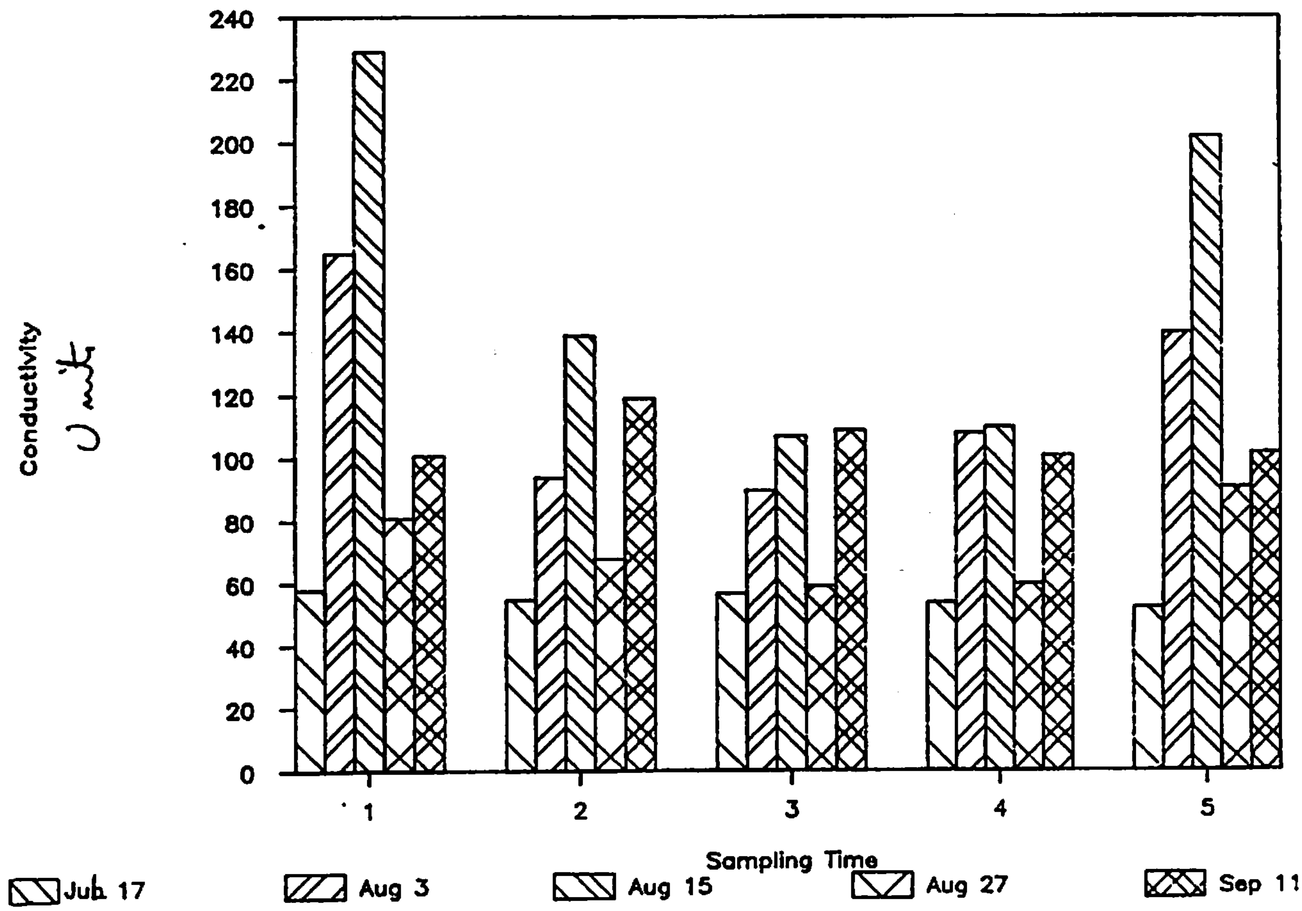
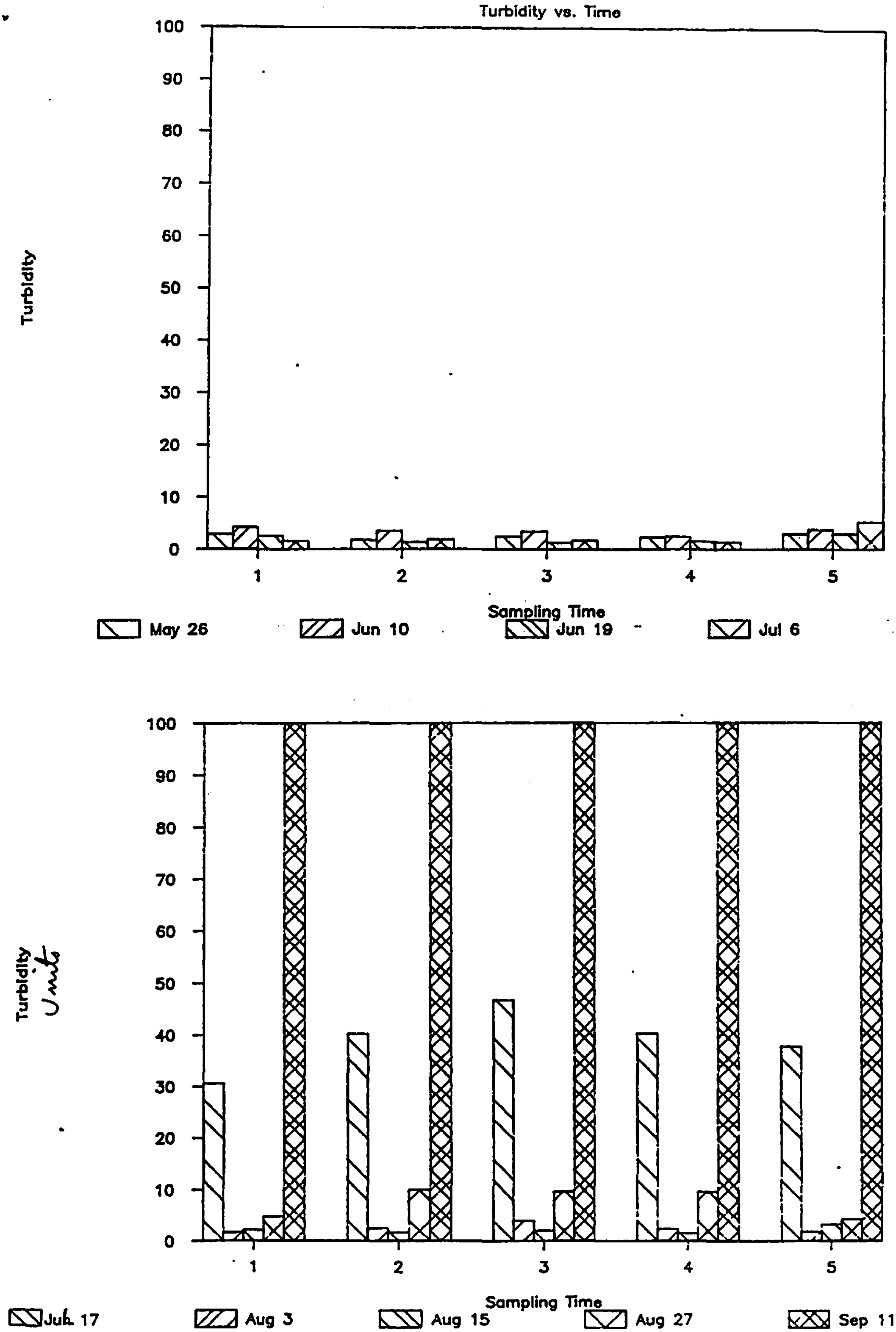

240
220
200
180
160
140
120
100
80
60
40
20
0
Conductivity
1
2
3
4
5
Sampling Time
Jul 17
Aug 3
Aug 15
Aug 27
Sep 11

Figure 30

Figure 31



Turbidity vs. Time
Turbidity
Sampling Time
May 26
Jun 10
Jun 19
Jul 6
Turbidity Units
Sampling Time
Jul. 17
Aug 3
Aug 15
Aug 27
Sep 11

Fountain Tanks

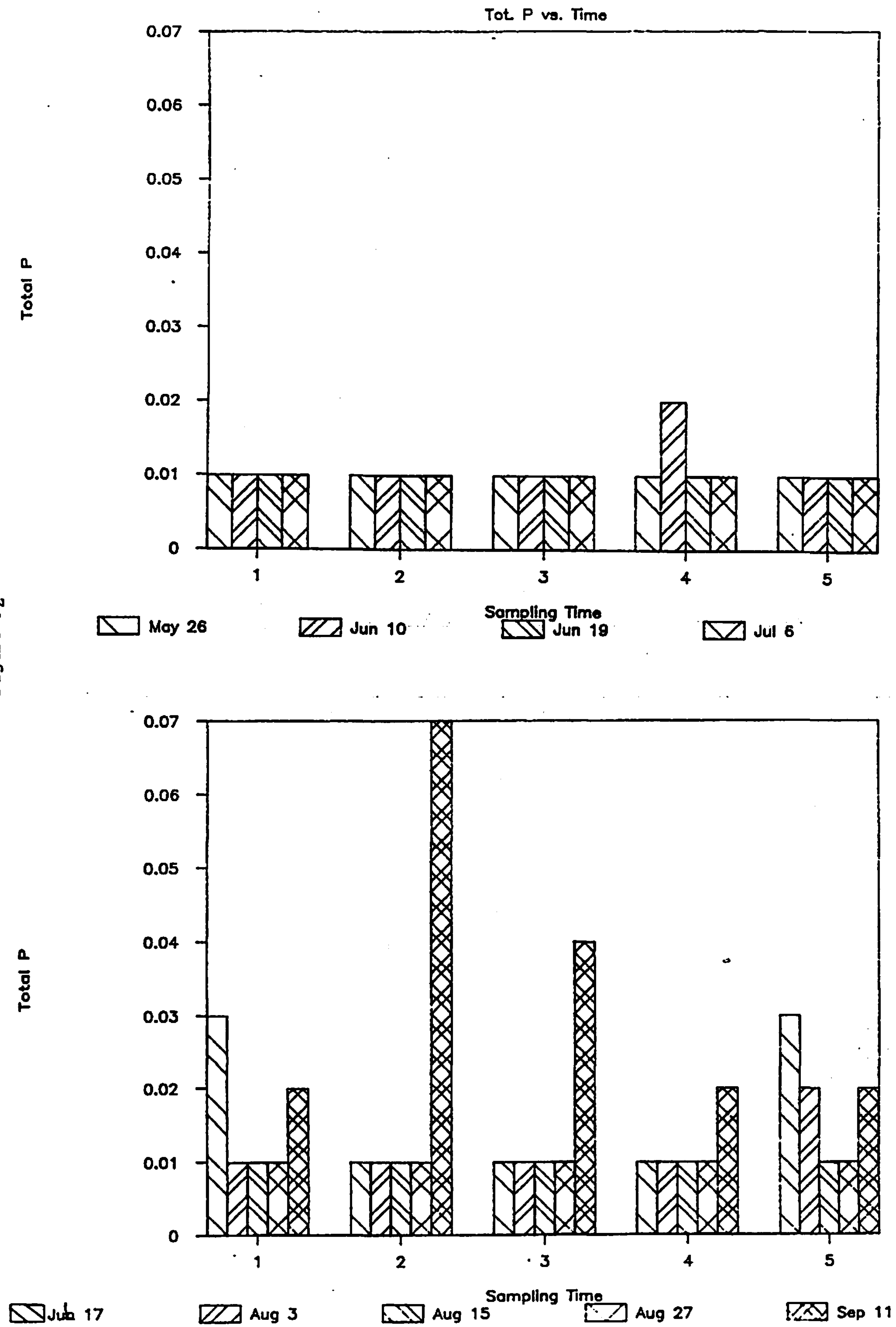
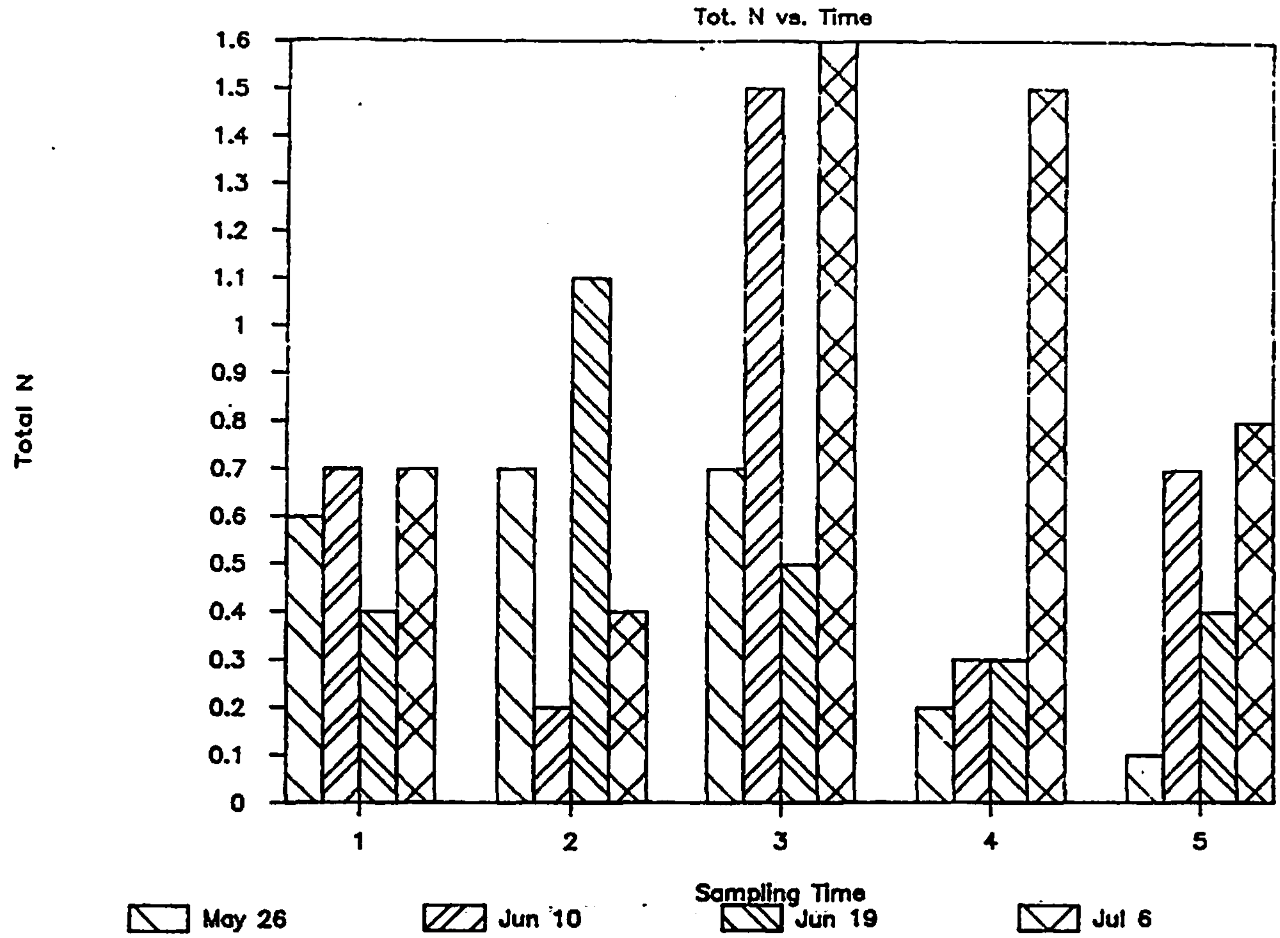


Figure 32

Fountain Tanks



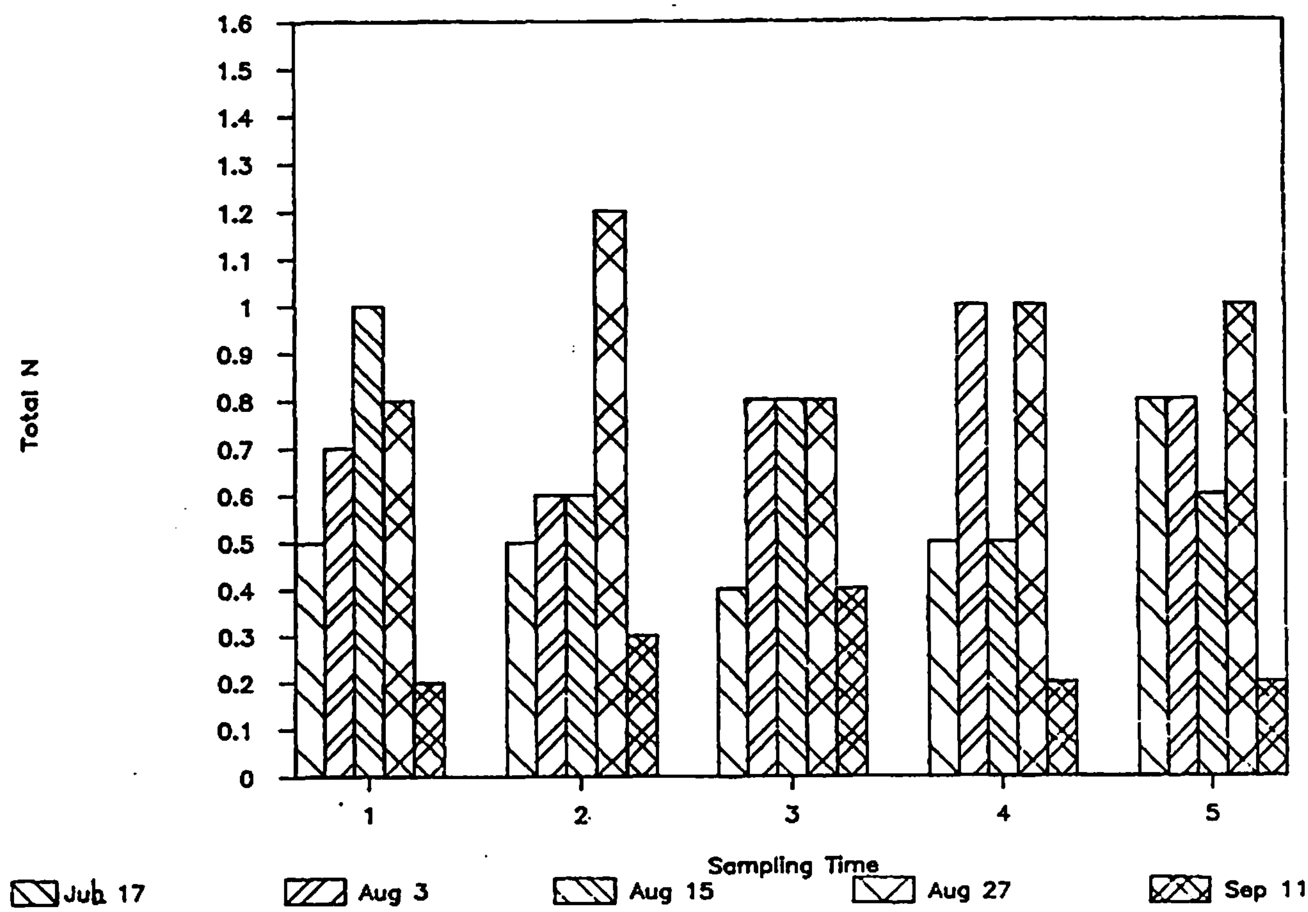


Figure 3a

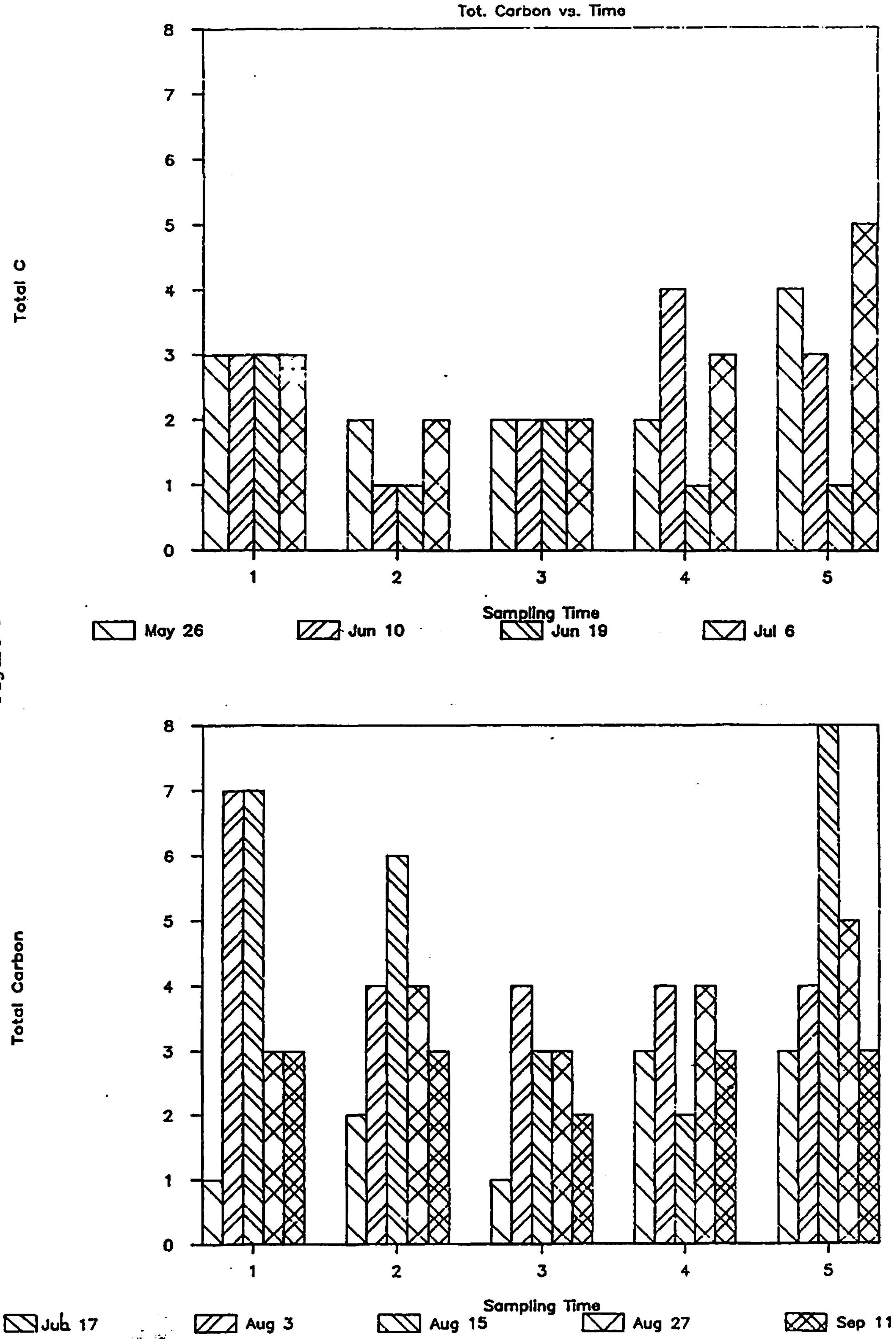
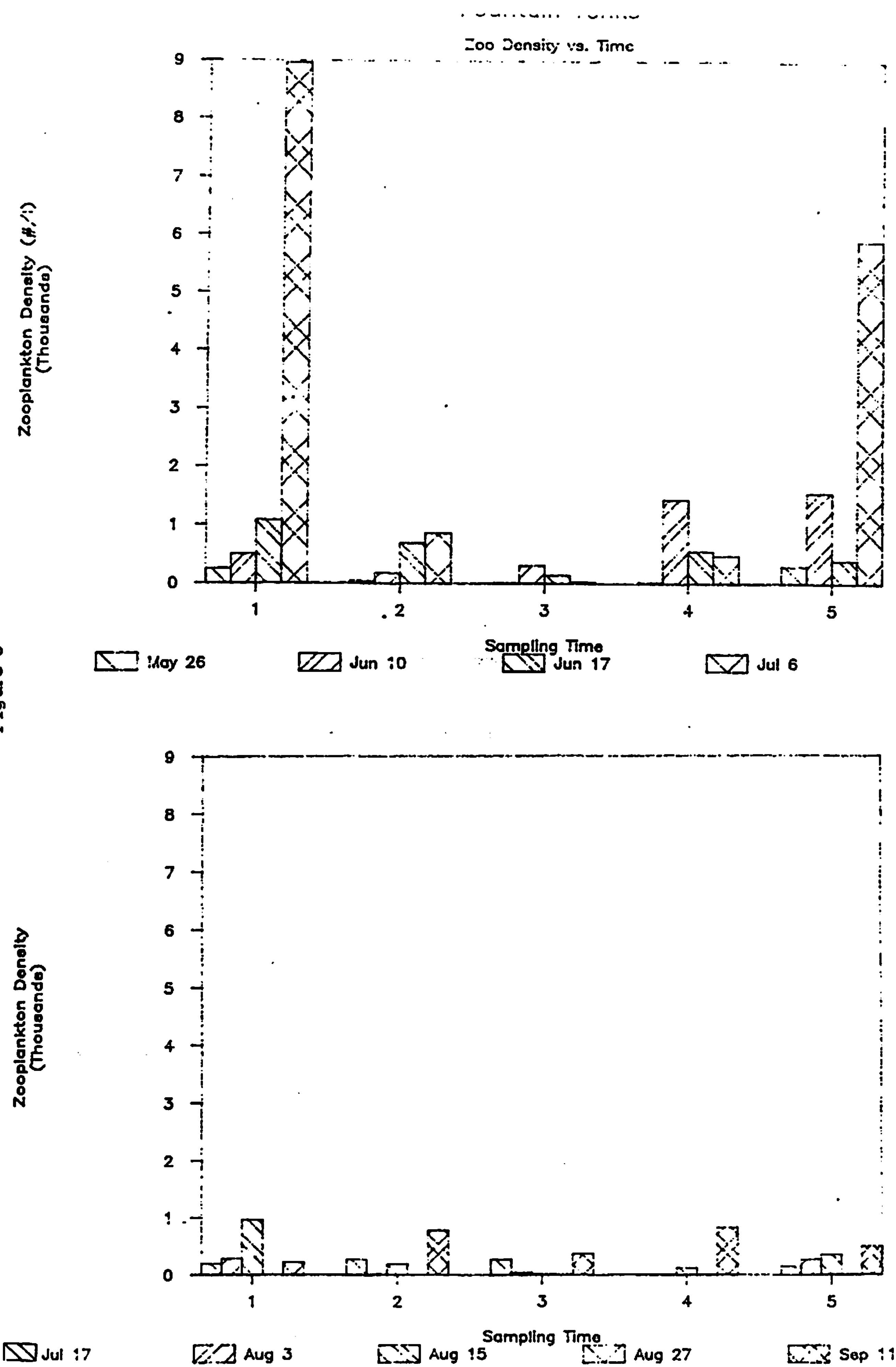

Tot. Carbon vs. Time
Total C
Sampling Time
May 26
Jun 10
Jun 19
Jul 6
Total Carbon
Sampling Time
Jul 17
Aug 3
Aug 15
Aug 27
Sep 11

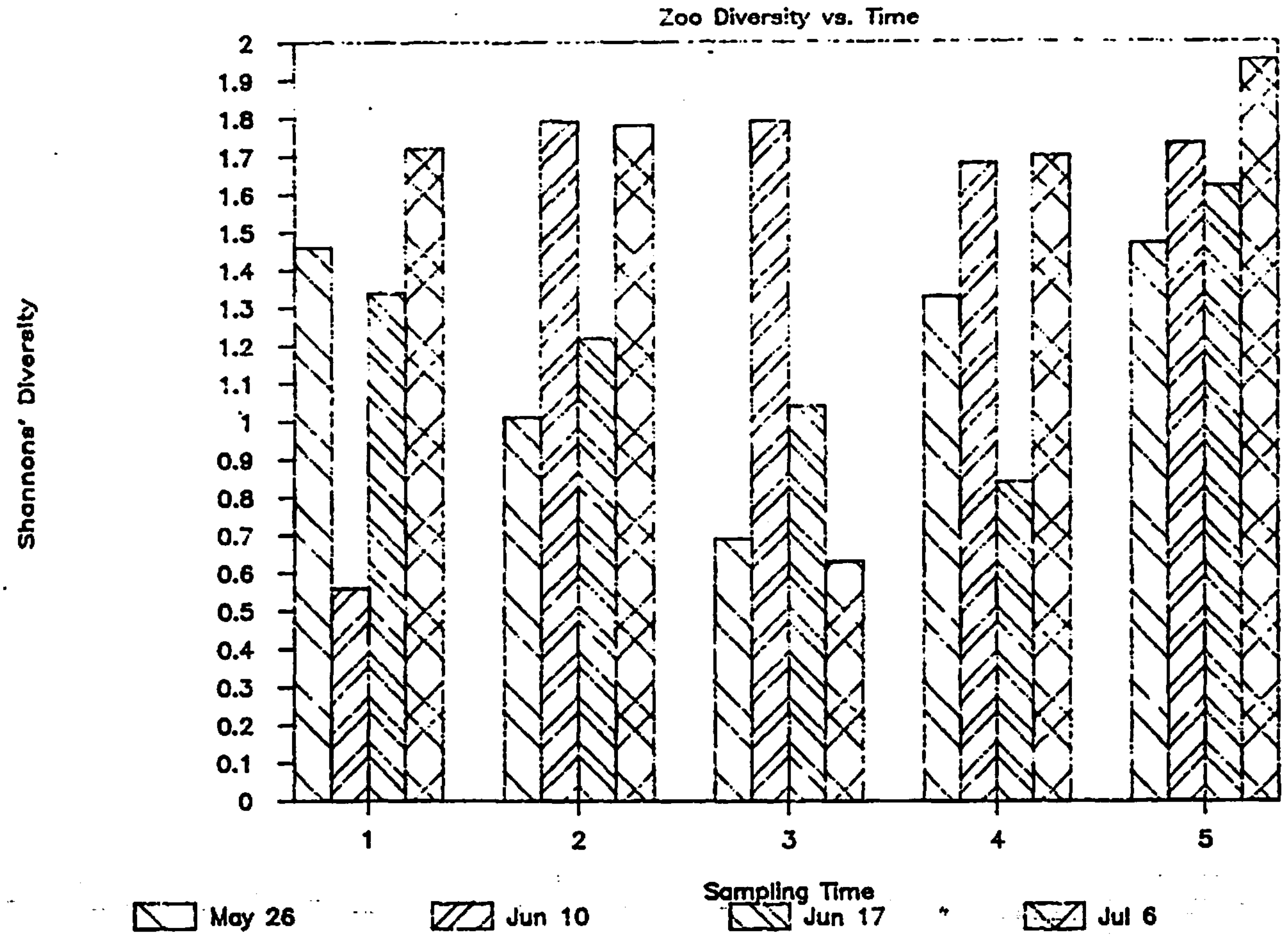
Figure 34

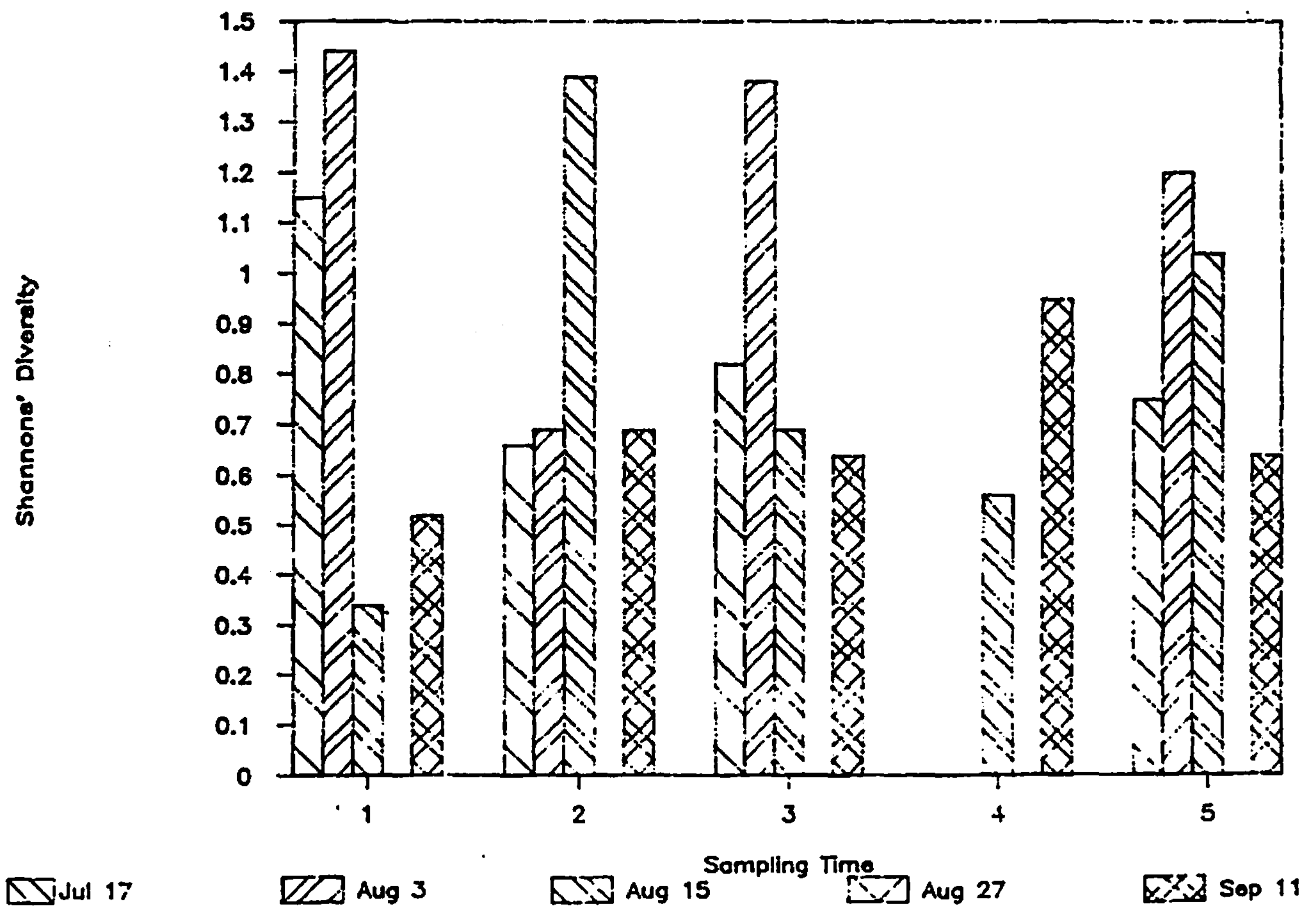


Zoo Density vs. Time
Zooplankton Density (#/l)
(Thousands)
0
1
2
3
4
5
6
7
8
9
1
2
3
4
5
Sampling Time
May 26
Jun 10
Jun 17
Jul 6
Zooplankton Density
(Thousands)
0
1
2
3
4
5
6
7
8
9
1
2
3
4
5
Sampling Time
Jul 17
Aug 3
Aug 15
Aug 27
Sep 11

Figure 35

Figure 36


Zoo Diversity vs. Time
Shannons' Diversity
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Sampling Time
May 26
Jun 10
Jun 17
Jul 6


Shannons' Diversity
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Sampling Time
Jul 17
Aug 3
Aug 15
Aug 27
Sep 11

Henderson

United States Department of the Interior

NATIONAL PARK SERVICE
CAPITOL REEF NATIONAL PARK
TORREY, UTAH 84775

IN REPLY REFER TO:

N22 (CARE-MP)

October 22, 1987

To: Research Ecologist, Water Resources Division

From: Acting Superintendent, Capitol Reef National Park

Subject: Comments on Interim Report regarding livestock effects on the tinajas of Capitol Reef National Park

Enclosed find the park comments regarding the subject report. Many of the specific comments are listed on the report itself; others are included on the separate "comment sheet." Incorporation of these comments and additional data analysis (referenced in your April 13 letter) into the final report should allow for the generation of good final report for this project.

If you have any questions regarding our response to you please contact Resource Management Specialist Norm Henderson at 801-425-3791.

Norman R. Henderson

Enclosure

cc:
Regional Chief Scientist

bcc:
Record Copy - CARE
Reading File
Res. Mgmt. Spec. - CARE

FNP:NRHenderson:nh:10/22/87:(801)425-3791

REVIEW OF THE DRAFT INTERIM REPORT ON THE

ECOLOGY OF AND LIVESTOCK INFLUENCES ON THE WATERPOCKETS OF CAPITOL REEF NATIONAL PARK

This report was reviewed by the Resource Management Specialist at Capitol Reef National Park. The comments made are both editorial and substantive in nature. Many additional editorial comments are written on the pages of the report.

Comments

1. Page numbers should be on any report whether draft, interim, or final. Lack of page numbers confuses the review process. This is especially true of an unbound report. In addition, a basic title for the report should be included.

2. A brief Table of Contents should have been included so that any reader could quickly assess what was included in the report. In addition, the report should have been separated into logical sections, i.e., introduction, materials and methods, discussion etc..

3. Literature was cited in the report but no Literature Cited section was included.

4. The use of bar graphs for presentation of much of the data was confusing since the reader was unsure whether a missing bar meant that the value was zero or was actually missing. Also, if bar graphs are used, they would be more easily read if all collection dates were combined for each tinaja rather than having the dates split between two graphs.

5. A brief map or diagram of Capitol Reef National Park showing the relative location of the studied tinaja systems would have oriented the reader as to where the research took place.

6. Data in certain tables and figures was awkwardly presented. For example, the rainfall data (figures 3, 15, and 26) was shown as a bar graph; a separate bar for each tinaja for each rainfall reading was shown. In fact, only two rain gauges were employed for each tinaja system. As with the other bar graphs, it was impossible to determine whether a missing bar meant a missing or a zero value.

Data in Table 3 could have been greatly condensed by arranging the table differently. A more concise table would have facilitated an easier interpretation of the data by the reader.

Collection dates, symbols, and legends were missing from many of the bar graphs making the figures difficult to interpret. In addition, units for many of graph axes were missing.

7. Spelling errors and awkward or incomplete sentence structure within the body of the text interfered with reader comprehension of the report, and indicated that the author had not proofread his report prior to submittal.

8. Table 5 was not referenced in the body of the text.

9. Table 7 indicated community similarities. Community similarity was not defined, the legend for the table was not clear, and what was meant by "within" and "between" differences was not defined nor was the difference between "census macroinvertebrates" and Benthic Macroinvertebrates.

10. On page 4, the "<>" symbols were reversed making Table 5 inconsistent with the text and interfering with the reader comprehension of the discussed material.

11. On page 4, paragraph 2, line 4, the author refers to statistical significance when a more accurate term would probably have been biological significance. Clarification is needed as to why this is considered to be the only difference that is significant. For example, why weren't differences between tinajas considered important?

12. Line 11 of this same paragraph speaks of a "census of invertebrate density of zooplankton." What does this mean? Are there vertebrate zooplankton?

13. Farther down on that same paragraph, the author states that "Willow and Cottonwood had higher zooplankton densities than Fountain and Miahayen." Table 5, however, indicates that Cottonwood and Fountain are the same.

14. It is unclear why statistical tests were used to compare certain parameters, i.e., density of larval amphibians and density of zooplankton, but not others?

15. Numerous existing data points were missing on many of the tables of the report (some of those found by this reviewer are marked in the text). A careful comparison between the raw data and the tables and figures is necessary.

16. Figure 1 showed the two dimensional relationship between the tinajas within each studied system. To be accurate, however, the figure should have been three dimensional, or the vertical and horizontal relationships could have been diagrammed in separate figures. Having only a two dimensional model causes some of the tinaja relationships to be totally misrepresented. For example, Figure 1b shows tinajas 1 and 2 within the Cottonwood drainage to be a few meters apart when in reality they are many 100's of meters apart in separate drainages within that watershed.

All spacial relationships of tinajas presented in the report should be verified by field observations and/or measurements. Example surficial diagrams (horizontal) prepared by my staff for the studied drainages are enclosed with this review.

17. Many of the Volume vs. Time figures indicate total volumes that exceed the maximum values indicated in Table 1.

18. Total volume values for certain tinajas (Table 1) conflicted with field observations. For example, Fountain 5 is shown to be the largest tinaja overall and Miahayen 5 the smallest. In reality, however, Miahayen 5 was a very large tinaja (over 270 m3 by our calculations). Likewise, other volume relationships in Table 5 don't make sense with what has been observed in the field, i.e., Willow 5 vs. Miahayen 2, 3, 4, 5 etc.

19. Many of the conclusions reached by the author regarding livestock influences were not based on statistical testing. The split plot design that was used for certain biotic parameters did not assess the effects between tanks within the same drainage. Such a comparison would have indicated statistically whether livestock were having an influence. Because no statistical tests were used, many of the conclusions reached in the "Effects of Cattle Section" were conjectural.

20. The ammonia concentration data is not presented or analyzed. Water samples were collected specifically to analyze this parameter.

21. Of major concern was the use of the Shannon-Weiner diversity index as the sole indicator of the health of the zooplankton community. This index does not differentiate between species. That is, a tinaja could have a totally different compliment of zooplankton species but still have the same index value. It is my understanding that in some eutrophic situations, the Shannon-Weiner index actually increases. If so, using it as the sole criterion of the health of a community may not be valid. In such cases the species composition would be very important. This may be the case at Capitol Reef.

Was a zooplankton species list prepared for the tinajas at Capitol Reef? If so, the listing for each tinaja should be included with the report. If groups were identified then the number of species and density of each species should be specified.

22. A clear presentation of all methodologies used in both data collection and analysis is needed so a proper assessment of the report could be made.

23. Another major concern is that correlations were made between livestock use and many of the physical and biological tinaja parameters when no quantification of actual livestock use was made (tracks, pies, urine smell etc.). The correlations made by the author were based on his single observation that livestock were in the study area at the beginning of the study period

(April 24). There is no information provided on the degree to which the livestock actually made use of the tinajas or whether there was any subsequent use of the tinajas after that initial site visit.

The comparisons that were then made between tinajas that were used and and those that were unused by livestock were based on data collected almost a month after this initial site visit and after the livestock had been removed from the range. Also, recorded observations made during the site visit on April 24th indicate that some rain fell during the preceding two days. Rain gauge information on May 22nd indicate that rain had fallen immediately prior to that time also (first sampling period). The author should have discussed how this rainfall and a one month hiatus between livestock removal and the beginning of data acquisition may have affected the results obtained.

Based on the above concerns, the conclusions reached by the author, regarding livestock effects, are suspect. The author concluded that the data indicated that livestock had no influence on several of the measured parameters. While this statement may be technically correct, it infers that livestock have no effect on the systems at all. With no specific measure of livestock use, no data taken while the majority of the cattle were even on the range, and probable fresh water input into the systems prior to the first sampling period; all that I feel can be concluded from the data is that if livestock had impacted the measured parameters during the grazing season this impact was not evident to the author one month after removal.

Conclusions

While this interim report contained some good baseline information, it was apparent to this reviewer it had been produced quickly and hadn't been proofread before submittal. As a result, it was incomplete and had numerous editorial mistakes. These two problems alone made the report difficult to follow and understand. Adding to this, much of the study data was either inaccurate or missing. When taken in total, these problems place many of the conclusions reached by the author in question.

Because of the above, I feel a great deal of additional work is needed on the report before it is acceptable. First, a clear and organized format is needed, including a fully explained materials and methods section. Second, more rigorous statistical analyses are needed using all the data along with an explanation of any inherent limitations of that data or of the techniques used. Third, any results and conclusions must be similarly stated.

Finally, I recommend that the final report be submitted to me in draft form so a complete review can be made prior to final release. I also recommend that this draft final be reviewed by an expert in Aquatic Ecology outside the National Park Service.