THE TROPHIC STATE OF ROME ROCK RESERVOIR, OHIO IN SUMMER 1978

by

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I. Introduction

Many lakes and reservoirs in Northeastern Ohio can be clasified as eutrophic. That is, these lakes and reservoirs have a high concentration of the elements (e.g. nitrogen, phosphorus) which stimulate the growth of nuisance algae. As a consequence, and depending upon the degree of eutrophication, such lakes have impaired water quality in the forms of low transparency, abundance of "rough" fish, taste, odor, and other symptoms.

The degree of eutrophication is directly related to the volume, area, water residence time, and rate of nutrient income. These factors combine to determine nutrient concentration. In nearly every lake or reservoir, an increase in the concentration of phosphorus, rather than any other element, is most likely to bring about an increase in the production of algae and a deterioration of water quality. Weeds, or rooted and floating vascular plants are also a severe nuisance but their abundance is more directly related to the amount of shallow water than to dissolved nutrients.

The most important first step in reservoir or lake management and eutrophication control is to assess the present "health" or state of the system. This assessment permits an estimate of the reservoir's position on a quantitative scale, which scores lakes from the most pristine to the most degraded with respect to the quality of the deeper open water. Knowledge of the state of a lake reveals the degree to which the lake can tolerate further income of nutrients before severe eutrophication comes about.

The purposes of this report, as assigned to me by the Rome Rock Association Board of Directors on 1 April 1978, are to describe the present "health" or state of Rome Rock reservoir, to determine whether the present management of aquatic weeds with herbicidal chemicals is consistent with the use of the reservoir for potable water, and to ascertain whether the Association is eligible for Clean Lakes restoration money under Section 314 of P.L. 92-500. I will also make some suggestions for abatement of the sediment pollution of the reservoir and describe some possibilities for weed control.

The herbicide report was submitted to the Association on 7 June 1978.

II. Methods

Rome Rock Reservoir was visited on three dates, 24 June, 22 July and 27 August 1978. Four sampling stations, in four basins proceeding from the shallow upper end to the dam were sampled. The stations were labelled A - D respectively. After the first visit, only B and D (at the dam) were sampled.

Measurements of temperature, Secchi Disc transparency of the water, dissolved oxygen, total phosphorus, chlorophyll, algal cell volume, and zooplankton were made, following procedures outlined in APHA (1965), USEPA (1971), and Strickland and Parsons (1968). Chlorophyll was measured at the surface only. Cell volume was determined from surface samples concentrated in Lugol's Solution and counted by inverted microscope. Zooplankton were counted from duplicate vertical net tows from lake bottoms to surface.

The samples were obtained with the generous assistance of Mr. and Mrs. Newt Bakely and other members of the Association who volunteered to operate the boat.

III. The Trophic State Index

Carlson (1977), a limnologist from Kent State University, described the Trophic State Index (TSI) which was used in this study. Clarity or transparency of water is usually considered to be an index of lake or reservoir water quality since the amount of algae and other suspended and dissolved material directly affects water clarity. Thus a reservoir with high concentrations of nutrients usually has a dense growth or "bloom" of algae in the summer, and also has the attendant low water clarity. Usually these algae are of the "nuisance" variety (blue-green algae) which also cause water taste and odor. Carlson's index is based upon the amount of algal biomass, which is directly related to Secchi Disc transparency.

The index is scaled so that for every increase of 10 units on the index the transparency of the water is halved and algal biomass doubles (Table 1 lists the relationships between index numbers and actual measurements). Note that a lake with an index number of 50 is therefore twice as bad as one with an index of 40,

Table 1

Relationship between Carlson (1977) Trophic State Index numbers and water transparency, phosphorus concentration, and chlorophyll concentration.

Index Number	Transparency (meters)*	Surface Phosphorus (μgPl/l)	Surface Chlorophyll (mg/M^3)
0	64	0.75	0.04
10	32	1.50	0.12
20	16	3.00	0.34
30	8	6.00	0.94
40	4	12.00	2.60
50	2	24.00	6.40
60	1	48.00	20.00
70	0.5	96.00	56.00
80	0.25	192.00	154.00
90	0.12	384.00	427.00
100	0.062	768.00	1183.00

*meters x 3.28 = feet

four times as bad as an index of 30, and so forth.

Carlson also found a significant correlation between transparency and chlorophyll and total phosphorus. Thus a TSI value can also be obtained from these measurements. An exact correspondence between the three measurements (water transparency, chlorophyll, total phosphorus) cannot be expected because of small errors by the observer and because other factors such as silt may lower transparency below that expected from concomitant measures of chlorophyll or phosphorus.

Lakes and reservoirs which have a composite or mean TSI score below 37 are usually considered to be of high quality, and those above 47 are considered to be eutrophic. A reservoir with an index number above 65 is considered to be in serious trouble and in need of immediate attention, such as nutrient diversion or other abatement techniques. If drinking water is obtained from the system, an index above 60 would indicate that there will be problems with taste and odor.

IV. Results

A. Temperature, Dissolved Oxygen, Phosphorus

The data used to assess the trophic state or "health" of Rome Rock Reservoir are listed in Table 2.

The deep stations, C and D, were thermally stratified at the first sampling on 24 June, and probably had been in this condition for 4-6 weeks. Thermal stratification is normal, and is caused by rapid heating of lake surface waters in the spring.

Table 2

Rome Rock Reservoir

Temperature (C^o), Dissolved Oxygen (mg O_2/l), Chlorophyll (mg Chl A/M^3), Total Phosphorus (µg P/l), and Secchi Disc Transparency (meters)

Date	Depth (M)	Trans.	Chloro.	Total P	Diss. O_2	^oC
Station A						
24 June	Surf.	1.00	8.02	42.67	8.05	--
	1					--
	2				6.80	--
Station B						
24 June	Surf.	2.25	8.51	29.68	7.50	24.1
	1			33.39		23.8
	2			40.81		21.5
	3				5.20	19.0
22 July	Surf.	1.60	18.67	25.97	--	27.8
	1			24.12	--	26.9
	2			33.39	--	25.0
	3			35.25	--	24.0
27 Aug	Surf.	1.20	17.15	31.54	7.95	25.1
	1			31.54	7.36	25.0
	2			48.23	7.31	24.9
	3			37.10	7.36	24.5
	4			37.10	4.57	23.9
	5			44.52	1.34	21.9
Station C						
24 June	Surf.	2.50	5.15	20.41	7.45	24.0
	1			16.70	7.15	23.9
	2			24.12	7.35	23.0
	3			29.68	7.40	21.9
	4			25.97	4.45	19.1
	5			24.12	0.75	16.7
	6			38.96	0.20	14.9
27 Aug	Surf.	1.70	✓	--	--	24.2
	1				--	24.1
	2				--	23.9
	3				--	23.5
	4				--	23.0
	5				--	21.9
	6				0.00	17.0
	7				0.00	15.5
	8				0.00	13.5

Table 2 (continued)

	Depth (M)	Trans	Chloro.	Total P	Diss. O_2	^oC
24 June	Surf.	2.25	5.59	20.41	7.75	23.3
	1			20.41	7.95	22.9
	2			22.26	7.70	22.8
	3			24.12	8.15	22.5
	4			27.83	7.10	20.0
	5			24.12	1.45	16.8
	6			31.54	0.70	13.9
	7			33.39	0.55	12.9
	8			--	0.15	12.0
22 July	Surf	2.30	5.66	20.41	7.67	27.2
	1			20.41	8.00	27.0
	2			20.41	8.06	27.0
	3			18.56	8.09	25.8
	4			25.97	4.51	22.8
	5			29.68	0.19	19.1
	6			33.39	0.05	15.0
	7			35.25	0.05	13.3
	8			42.67	0.05	12.3
	9			111.30	0.00	11.8
27 Aug	Surf	1.90	11.24	24.12	7.50	24.9
	1			27.83	7.36	24.8
	2			37.10	7.36	24.2
	3			25.97	7.26	24.2
	4			24.12	7.16	24.1
	5			24.12	5.96	22.2
	6			33.39	0.80	18.3
	7			33.39	0.00	14.9
	8			59.36	0.00	13.0
	9			--	0.00	12.5

Water becomes lighter as it warms so that on calm hot spring days surface waters will become much warmer and much lighter than deeper water and cannot be mixed by the wind. This thermal stratification persists throughout the summer until cool fall days, and effectively divides the water mass into a warm, lighted, circulating zone overlying a deep, cold, dark, stagnant zone. In shallow eutrophic lakes (less than 20 meters), such as those commonly found in Northeastern Ohio, the deep, stagnant, dark waters rapidly become devoid of dissolved oxygen because they have no net photosynthesis (yielding oxygen in excess of respiration), no mixing, and heavy microbial respiration or decomposition. Under these oxygenless conditions, plant nutrients are released from lake sediments and may greatly stimulate algae growth in the upper waters under certain conditions. These algae die, sink to the lake bottom, decompose, and further deplete dissolved oxygen. Thus eutrophic lakes with thermal stratification may literally "feed" themselves and become worse. Of course no cold-water fish can survive in these lakes.

It was particularly surprising to find that the two deep stations (C and D) had dissolved oxygen in deep water on 24 June. In other lakes of the area, oxygen is depleted completely in 2-3 weeks--usually by early June. Station D did not exhibit severe oxygen depletion until 22 July. These data strongly suggest that while all basins of Rome Rock are now eutrophic (see Trophic State Index below), this is a recent event and lake sediments are comparatively free of organic matter. Prevention of a more serious future problem is thus possible.

The phosphorus concentrations in Basins C and D confirm that while levels of phosphorus in upper waters are high enough (about 20 μg P/l) to create algal blooms and eutrophic conditions, the phosphorus is probably not coming from lake sediments. If this were a significant source deep water concentrations under oxygen-free conditions would be much higher than was found.

Phosphorus concentrations in the upper (A and B) basins were as much as twice as high as the lower basins, suggesting that the main external sources of phosphorus are in this region and that as water moves down the basin, phosphorus-containing particles are lost to the sediment. An analysis of the water dynamics of the reservoir are needed to estimate the rate at which lower basin concentrations will increase over the years.

These data on dissolved oxygen and phosphorus strongly suggest that while all basins are eutrophic, the phenomenon is recent and that there is an opportunity to protect the relatively higher quality lower basins.

B. Phytoplankton, Zooplankton, and Transparency

The quantity and species composition of phytoplankton (= algae) are an important indicator of the degree of eutrophication. The algae of Rome Rock were measured by concentrating a surface sample, counting cells and filaments of the various species and multiplying these counts by the volumes of their cells. Results are thus expressed as cell volume. Chlorophyll pigments, another measure of the quantity of algae, were also measured.

The quantity of algae in Basin B at the upper end of the reservoir was 2-3 times greater than in Basin D at the dam. This was also true for the amount of chlorophyll (Table 3). These results are consistent with the difference in phosphorus concen-

Table 3

Chlorophyll A, Algal cell volumes, and percent blue-green algae in two Rome Rock Reservoir basins in 1978

Date	mg Chl A/M^3	Volume	%	mg Chl A/M^3	Volume	%
6/24	8.51	-	X	5.59	8.79	65
7/22	18.67	15.06	62	5.66	4.74	90
8/27	17.15	24.52	86	11.24	9.09	81

tration between the basins.

The amount of algae in Basin B increased greatly over the summer (Table 3) while the amount at the dam changed only slightly. This may have been due to the higher water replacement at the dam since this is the site of drinking water withdrawal.

The actual cell volume values at the dam are consistent with other classificatory data in that volumes at this level (4-9 µl/l) are at the lower end of those lakes which are classified as eutrophic. Cell volumes in Basin B are well within the "very eutrophic" range.

Of the total cell volume, 65-90% was blue-green algae at both stations (Table 3). This observation is significant, particularly at the dam where drinking water is obtained, because these algae are the cause of severe taste and odor problems in potable water supplies of many municipalities in Ohio. These algae in sufficient density may render water unfit for consumption. Their abundance is usually directly related to the degree of eutrophication and so prevention of further deterioration of Basin D water quality must be considered.

Water transparency, the best overall indicator of lake state or health because it is directly related to the amount of suspended and dissolved material in the water, was much lower in the upper basins than in Basins C and D. Tranparency declined over the summer coincident with the increase in algae.

Table 4

Phytoplankton species lists, cell volumes and percent distribution among phyla for two basins in Rome Rock Reservoir, 1978.

Station D

Date	Species	Cell Vol. ul/l	%
June 24	Fragilaria crotonensis	0.27325	
	Oocystis pulsilla	0.22637	
	Gymnodinium sp.	0.13099	
	Sphaerocystis Schoedteri	1.39756	
	Anabaena spiroides	0.53384	
	Trachlemonas sp.	0.03097	
	Staurastrum chaetoceros	0.83395	
	Navicula sp.	0.01456	
	Ochromonas sp.	0.05589	
	Chlamydomonas sp.	0.02515	
	Scenedesmus Bernarii	0.11644	
	Oscillatoria limosa	5.14973	
		8.78870	
	Cyanophyceae		64.67
	Chlorophyceae		29.58
	Bacillariophyceae		3.27
	Euglenophyceae		0.35
	Chrysophyceae		0.64
	Dinophyceae		1.49

Station B

Date	Species	Cell Vol. ul/l	%
July 22	Aphanizomenon flos-aquae	7.90521	
	Microcystis aeuginosa	1.38982	
	Ankistrodesmus falcatus	0.01289	
	Euglena sanguinea	4.67539	
	Trachlemonas sp.	0.04389	
	Asterionella formosa	0.99068	
	Mallomonas sp.	0.01592	
	Oocystis pulsilla	0.02228	
		15.05608	
	Cyanophyceae		61.74
	Chlorophyceae		0.43
	Euglenophyceae		31.34
	Bacillariophyceae		6.58
	Chrysophyceae		0.11

Table 4 (continued)

Station D

Date	Species	Cell Vol. ul/l	%
July 22	Aphanizomenon flos-aquae	2.05752	
	Microcystis aeruginosa	1.73728	
	Navicula sp.	0.00859	
	Sphaerocystis Schoeteri	0.41261	
	Cyclotella sp.	0.00990	
	Anabaena spiroides	0.05254	
	Lyngbya Birgeii	0.45846	
		4.73690	
	Cyanophyceae		90.27
	Chlorophyceae		9.34
	Bacillariophyceae		0.39

Station D

Date	Species	Cell Vol. ul/l	%
Aug 27	Oocystis sp.	0.02547	
	Chlamydomonas sp.	0.00742	
	Gleocystis sp.	0.01707	
	Tetraspora sp.	0.02955	
	Coelastrum sp.	1.02759	
	Aphanizomenon flos-aquae	2.33040	
	Microcystis aeruginosa	3.48178	
	Anabaena limnetica	0.44899	
	Anabaena spiroides	0.03939	
	Aphanocapsa sp.	0.04465	
	Coelosphaerium sp.	0.49892	
	Cyclotella sp.	0.51556	
	Euglena sp.	0.02039	
	Cryptomenas sp.	0.05056	
	Mallomonas sp.	0.03184	
		8.56958	
	Cyanophyceae		81.00
	Chlorophyceae		12.20
	Bacillariophyceae		5.67
	Euglenophyceae		0.22
	Chrysophyceae		0.35
	Cryptophyceae		0.56

[redacted] 4 (continued)

Station B

Date	Species	Cell Vol. ul/l	[redacted]
Aug 27	Oocystis sp.	0.81056	
	Gleocystis sp.	0.54316	
	Coelastium sp.	0.75363	
	Quadrigula sp.	0.05014	
	Aphanizominon flos-aquae	7.35897	
	Microcystis aeruginosa	1.57194	
	Anabaena limnetica	10.27385	
	Anabaena spiroides	0.52227	
	Coelosphaerium sp.	1.43022	
	Cyclotella sp.	0.49213	
	Fragillaria sp.	0.34992	
	Ceratium hirundinella	0.36559	
		[redacted]	
	Cyanophyceae		86.30
	Chlorophyceae		8.80
	Bacillariophyceae		3.43
	Dinophyceae		[redacted]

Table 5

Density (no./M^3) and species list of zooplankton in Rome Rock Reservoir in 1978, at the dam.

Species	6/22	7/24	8/27
Daphnia galeata mendotae	17680	3081	949
Daphnia parvula	3182	161	657
Daphnia ambigua	177	0	0
Ceriodaphnia lacustris	11315	1822	8545
Chydorus sphaericus	0	0	73
Eubosmina coregoni	25106	241	146
Bosmina longirostris	5127	509	2189
Diaphanosoma leuchthenbergianum	2122	830	731
Diaptomus reighartii	6719	2167	5841
Mesocyclops edax	3359	563	948
Tropocyclops prasinus	2475	778	0
Orthocyclops modestus	0	0	439
Ergasilus chautauquensis	0	0	803
Copepodites	9194	1072	950
Nauplii	6542	777	13657

Zooplankton, the microscopic free-floating animals in the water column, are the base of the fish food chain in lakes, since they eat algae and other small organic particles. In Rome Rock, there is a very abundant and diverse zooplankton, indicating that the reservoir will support a sizeable fishery.

In Tables 4 and 5 the quantitative phytoplankton and zooplankton counts and lists of species are given. These are of little or no value to the layman, but if large changes in the reservoir do occur, the changes will be reflected in the abundance and identity of these organisms. Any future limnological investigations will be greatly strengthened by a comparison to these 1978 lists.

C. The Trophic State of Rome Rock Reservoir

The data for Secchi Disc transparency, total phosphorus, and Chlorophyll A (Table 2) have been used to calculate Carlson's Trophic State Indices, as described in the Methods. The reader will recall that the index is based upon the relationship between the above variables and amount of algae and other suspended particles (mostly dead algae) in the water. An index number below 37 indicates water of high quality, and above 47, eutrophic conditions. Every increase of 10 units on this scale represents a doubling of suspended matter in the water, so that a value of 60 is twice as bad as 50, four times as bad as 40, and so forth.

The mean trophic state of Rome Rock for each category, is ranked in Table 6, along with other Northeastern Ohio lakes.

The upper basin (A) is very eutrophic and at least

Table 6

Comparison of Carlson Trophic State Index Values for Northeastern Ohio Lakes. Lakes are Ranked from Least to Most Eutrophic by Transparency.

Lake	Transparency	Chlorophyll	Phosphorus
1. Crystal - 1978 (Summit Co.) N = 1	35.83	41.12	44.77
2. Stewart - 1978 (Portage Co.) N = 2	40.76	40.42	38.91
3. East Twin - 1978 (Portage Co.) N = 15	45.91	49.25	45.75
4. West Twin - 1978 (Portage Co.) N = 15	46.62	49.42	43.57
5. Dollar - 1978 (Portage Co.) N = 13	47.66	50.79	46.28
6. Rome Rock "D" - 1978 (Ashtabula Co.) N = 3	49.01	49.77	48.46
7. Geauga - 1978 (Geauga Co.) N = 12	49.55	54.65	53.86
8. Rome Rock "C" - 1978 (Ashtabula Co.) N = 2	49.56	46.65	47.66
9. Punderson - 1978 (Geauga Co.) N = 1	50.00	56.71	53.94
10. Rome Rock "B" - 1978 (Ashtabula Co.) N = 3	52.96	56.44	52.71
11. Rome Rock "A" - 1978 (Ashtabula Co.) N = 1	60.00	50.99	58.30
12. Silver - 1977 (Summit Co.) N = 13	65.27	66.59	73.19
13. Aurora - 1976 (Portage Co.) N = 14	77.00	64.10	73.20

twice as bad as the lower basin. The low value for chlorophyll is probably due to the large amount of weeds at this end of the lake, which tend to inhibit algae growth. Basin A is exceeded only by the hypereutrophic Aurora and Silver Lakes, two lakes with impaired recreational activities due to eutrophication. This end of the reservoir is in serious trouble and will rapidly become much worse until steps are taken to abate sources of nutrient income.

The lower basins (C and D) are borderline eutrophic--about half as bad as the upper basin. This knowledge is especially critical since it means that small increments in phosphorus concentration will probably bring about increases in algae over the next few years. There will be at least two negative aspects to this: (1) decay of these algae "blooms" will increase the rate of oxygen consumption after thermal stratification, thus exacerbating the situation, and (2) the high percentage of blue-green algae will continue to be high and may seriously impair drinking water quality through changes in taste and odor. That concentration will go up is a virtual certainty unless there is nutrient income control, because the water residence time of the reservoir appears to be high and materials probably accumulate.

Reservoirs with a TSI of 50-60 can be expected to recover to the more desirable 40-50 range within a few years after abatement of the most important sources of plant nutrients.

V. Discussion and Conclusions

Rome Rock is a comparatively deep impoundment, about 10 years old. The water is used for drinking, boating, contact recreation, and fishing, in that order of importance. No sewage appears to enter the reservoir, although there are reports that a livestock operation has added wastes to the water. During its brief history, the reservoir has experienced a high income of suspended solids from erosion on the watershed, including home construction. Shoreline erosion from boats and wind-generated waves has probably added significantly to the load of suspended solids. In this short period, the reservoir has developed a serious "weed" problem and the beginning of a serious algae problem.

The present "state" or health of Rome Rock is about average for Northeastern Ohio, except in the shallow upper end and in the bays, where it ranks among the worst lakes. It should be noted that Rome Rock has reached this state in a fraction of the time that others have. The lower basin, at the dam, is just at the margin of being eutrophic with all the attendant problems of nuisance algae, taste and odor, oxygen depletion, etc. The selection of 1978 as a year to begin an examination of the reservoir is fortunate since there is time to protect and improve it.

Solutions to the present problems and prevention of future problems are intimately linked. Means must be found to control weed growth without altering drinking water quality through herbicides. At the same time, steps must be taken to control the income of suspended solids which make the bays shallow enough for weeds. The income of plant nutrients (particularly phosphorus) which will stimulate algae growth and lead to the deterioration of the deep basin must also be controlled.

The nuisance weed in the lake at the time of my visits was Myriophyllum. I suspect that Potamogeton is also abundant in early summer. This problem will be the most difficult to solve since it will involve abatement of further sediment income, a deepening of the bays, and possibly a control agent. The following paragraphs are a list of options and/or procedures which I recommend, based upon the limited information available from three visits.

1. The most obvious, and perhaps the cheapest and potentially most successful weed control technique is reservoir drawdown during fall and winter. The dam was apparently not built for this possibility.
2. Herbicides, except for copper sulfate and Cutrine for algae control, are not registered for use in potable waters in Ohio (see my earlier report). The reasons for this involve persistent residues and other adverse impacts and I agree with this position by the Ohio Department of Agriculture. The Association should take a position against their use by individuals.
3. Dredging is the answer to the excessive shallowness which permits weed growth. The impact of such an operation on drinking water quality and on downstream users of the reservoir's water will have to be examined, particulary if there are herbicide residues in sediments. Also an Impact Assessment may have to be filed with the U. S. Army Engineers. An added cost to this

operation will be spoil disposal, which will have to be out of the reservoir's drainage area. I recommend that dredging be given lowest priority among those steps which must be accomplished.

4. Land use controls are not a feasible solution at this time for the problem of excessive sediment and nutrient income since there are presently few, if any, enforceable codes to implement such a strategy. The drainage basin is also large. The Association should, however, draft a plan for homebuilders to include a set back of at least 300 feet (from the State of Wisconsin building code) and the retention of 60-80% of the natural tree cover on the lot. Currently developed lots, in some areas, are contributing suspended solids through bank erosion. This should be controlled.

The construction of sediment-water detention ponds on major streams seems to be the only feasible solution to the erosion problem. If done properly, these can be very effective and could become valuable recreational sites. To implement this will require a study to determine which streams are most damaging to the reservoir, the flows and solids load of such streams, and the availability of land to build the basins. Such a study should also include a measure of the phosphorus content of the streams. These data will allow the investigator to predict the rate of filling-in of the reservoir, the rate of eutrophication, and the degree of diversion needed to protect the deep basins. I strongly recommend that the Association proceed with these steps.

5. The use of weed harvesters to control nuisance plants has been suggested. The effectiveness and environmental impact of this method has been reviewed by Carpenter and Adams (1977). The following summarizes their review of the literature:

a. There may be a decrease in the sedimentation rate in the bays following harvesting since incoming materials will not be trapped by plants. They will deposit instead in the deep open water.

b. There may be an increase in the plant nutrients reaching the open water due to the absence of uptake by weeds.

c. There will be, in most cases, an increase in the mat-like filamentous, floating algae in harvested areas.

weed harvester

d. After one or several seasons of harvesting, there will be a shift in dominance among the weeds to shorter-stalked species.

e. There will be unknown changes in fish populations.

f. On balance, Carpenter and Gasith (1978) conclude that there will be little adverse environmental impact.

The primary weed nuisance in Rome Rock is milfoil (Myriophyllum), a rooted vascular plant (in contrast to filamentous or unicellular floating algae). The plant spreads rapidly by seeds and asexually by stem fragments and buds. Harvesting must therefore include removal of the cut material or else the plants will spread. Nichols (1974) reports that a single early summer cutting in experimental plots resulted in a regrowth of milfoil to about half the density of controls. Three harvests per year eliminated virtually all plant material for that year.

The costs of harvesting operations vary widely and are difficult to interpret because some reports do not include some or all of the costs for labor, materials, repair, initial investments, etc. The Aquamarine Corporation (cited in Nichols, 1974) estimates costs in 1973, excluding machinery and amortization, to be about $20.00/acre. Neil (1977) believes these costs to be unrealistic and estimates that a 3-4 month operation, including truck disposal, will be about $150.00/acre.

Since there does not seem to be another viable option for weed control at Rome Rock, I recommend harvesting, with disposal by truck away from the lake. The predicted resurgence of filamentous algae may be legally controlled with Cutrine.

This report is necessarily very preliminary in view of the small (3) number of sampling dates, and the confinement of analysis to the "state" of the lake. Adequate lake management requires the following basic knowledge:

1. An accurate contour map of the entire reservoir basin, a calculation of lake volume, and a drainage map of the watershed.
2. Measurement of the annual income-outgo of suspended solids, water and phosphorus, from which data certain mathematical models will provide a close estimate of the amount of sediment and nutrient control required to maintain current trophic state or to lower trophic state.
3. Measurement of shoreline erosion rate.
4. A continual monitoring of transparency in each basin during the recreation season. This can be accomplished by the Association by building a 20 cm. diameter disc of ¼" metal

and painting alternating quadrants black and white. A line marked in lengths of meters (not feet) is attached. The device is lowered over the shaded side of an anchored boat until it disappears. The line is slowly retrieved until the disc is just visible. This takes about 3-4 minutes to do, no less. Record the depth in meters. Trophic State, using the Carlson (1977) index is:

$$10\left(6-\frac{\ln \text{depth in meters}}{\ln 2}\right)$$

where $\ln = \log_2$

Values of about 50 or above are to be considered indicative of eutrophic condition. To confirm the values obtained, measurement of chlorophyll and total phosphorus concentration should be taken at intervals over the summer.

3. Adequate lake management is expensive but it clearly is in the best interest of all, assuming that the primary reason for residence or ownership at Rome Rock is the lake. There have been too many instances of loss of property value and recreation value due to eutrophication. I urge that the Association make lake management its primary job. Among the first steps might be the development and implementation of land use controls for developers, including the maintenance of maximum ground cover. If controls cannot be developed or enforced, then I recommend the preparation of a home owner's manual for lake protection. I also suggest that you build retaining walls to control shore erosion, and detention ponds to control sediment income. Finally, if my understanding of the present annual homeowner's dues is correct, they are too low.

Rome Rock reservoir is not eligible for any Clean Lakes money, under section 314 of the 1972 Water Pollution Act 92-500 because the reservoir is not open to public use.