Smith Mountain Lake Association Water Quality Volunteer Monitoring Program

1994 Report

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December 1994

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1994

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1. EXECUTIVE SUMMARY

The Smith Mountain Lake Water Quality Volunteer Monitoring Program (SMLWQVMP) is a water quality program initiated in 1987 and designed to monitor the trophic status of Smith Mountain Lake. In May, an organizing and training session was conducted by Ferrum College and the SMLA. Monitors collected samples weekly from the first week of June to the last week of August.

The parameters measured included water turbidity, observed with a Secchi disc; total phosphorus, measured spectrophotometrically after persulfate digestion; and chlorophyll-*a*, determined using the acetone extraction method with fluorimetric detection. The average total phosphorus concentration was 29 ppb, the average chlorophyll-*a* concentration was 23 ppb and the average Secchi depth was 2.3 meter. (Note: Values for chlorophyll-*a* were calculated incorrectly. See Appendix Table A2a for corrected values. Corrected average value: CHA = 3.5 ppb.) These parameters, evaluated on the weekly average for all stations, followed a fluctuating pattern similar to previous years. When the average value of each water quality parameter is correlated with distance from the dam, the trends observed are typical for this type of reservoir; water clarity decreases while both nutrient concentration and algal biomass increase in the upper channels of the lake.

Results from this year's monitoring program indicate little overall change in water quality. Average values for Secchi depth and chlorophyll concentration are almost exactly the same as last season while the average concentration of total phosphorus decreased by a third. This indicates that water clarity and algal production are unchanged and nutrient levels have gone down. That the rapid increase in chlorophyll has leveled off while phosphorus concentration decreased is reason for optimism. As eutrophication progresses, increased nutrient input will lead to increased algal production. The rising algal population leads, in turn, to decreased water clarity and larger fluctuations in dissolved oxygen. The lower phosphorus level seen this past summer may translate to lower algal production in the future. However, very little has changed with respect to watershed management and so there is no reason to expect a dramatic change in water quality. Short-term variations in water quality reflect changes in precipitation patterns. In 1994, for the first time in several years, there was no severe flooding in the spring and this could be the reason for the lower phosphorus levels observed this past summer.

The Carlson Trophic State Index is calculated from the three parameters monitored and can range from 1 to 100, with values over 50 indicating eutrophic status. Values for the Combined Trophic Status Index (TSI) for Smith Mountain Lake over the past several years are given below:

Year	1990	1991	1992	1993	1994
TSI	48	47	51	56	56

Watershed protection is the key to maintaining water quality in Smith Mountain Lake. The following initiatives, supported by the SMLA and taken to protect the Watershed, are also cause for optimism:

> *The Fifth Planning District has finished a study of the Roanoke River Corridor and developed plans for overlay zoning to protect critical habitat. Some localities have already approved and begun implementing overlay zoning ordinances and the process needs to be supported in localities all along the corridor.
>
> *The SMLA and Ferrum College are working on a GIS (Geological Information System) to map the SML watershed and identify areas with high potential for nonpoint source pollution.
>
> *The Franklin County Office of the Natural Resources Conservation Service continues work on the Blackwater Hydrologic Unit project to demonstrate how BMPs (Best Management Practices on agricultural land) can improve water quality in streams receiving agricultural runoff. In addition, the EPA has approved funding for a second demonstration project has been. This project will demonstrate how building alternative animal watering systems and getting the animals out of streams and off of stream banks decreases silt and nutrient loading. The project will also employ GIS procedures for ranking potential demonstration sites and following progress on the developing management plan for nonpoint source pollution.

None of the initiatives are producing big water quality dividends at this point but they are movement in the right direction and laying the groundwork for continued progress.

2. INTRODUCTION

The Smith Mountain Lake Water Quality Volunteer Monitoring Program (SMLWQVMP) is a water quality program designed to monitor the water quality of Smith Mountain Lake located in South Western Virginia. The program is jointly coordinated by scientists from Ferrum College in Ferrum, Virginia and members of the Smith Mountain Lake Association (SMLA), a lake resident citizen's association. This document reports on the 1994 monitoring efforts of the SMLWQVMP, which is the eighth year of this ongoing program. The detailed data, data analysis, and conclusions for the first three years (1987, 1988 and 1989) can be found in the Final Report to the Virginia Environmental Endowment (VEE) by Johnson and Thomas (March, 1990). The VEE provided primary funding for the project during the first three years. Detailed reports on the 1990 and 1991 monitoring effort can be found in the Smith Mountain Lake Association Water Quality Monitoring Program 1990 -1991 Report, the Smith Mountain Lake Association Water Quality Monitoring Program 1992 Report and the Smith Mountain Lake Association Water Quality Monitoring Program 1993 Report, all by both Thomas and Johnson (December 1991, 1992 and 1993)

In May a training session was organized and taught by the Ferrum College scientists and the SMLA Volunteer Monitoring Coordinator with assistance from the student technicians. In 1994 the student technician was Chris Carr and Tracy Rakes completed her internship in the program. In 1994 the training session was held at the Bethlehem United Methodist Church in Moneta. 43 volunteers including returning monitors and many new volunteer monitors attended the 1994 training session. The number of monitors participating was very consistent with some experienced monitors leaving the program but new monitors joining the program each year. The program included a review of the previous year's findings and planning the schedule for the upcoming year. Experienced monitors confirmed their sample site locations on the map of Smith Mountain Lake provided by the program directors, received new supplies (sample bottles and filters), and had their monitoring equipment checked. The program co-directors worked with the new volunteer monitors to assign sample site locations, explain the sampling procedures and issue sampling equipment and supplies.

Sample collection began the week of May 29 through June 4 and the first sample bottles and sample filters were picked up Tuesday, June 7. The sample bottles and sample filters were picked up and new supplies issued each Tuesday. Samples were collected for twelve weeks until the third week of August. Newsletters were written and published by the program co-directors and student technician during the summer reporting on activities of the program. Announcements were included in the newsletters in addition to advice or tips on more efficient sample collection. Four newsletters were written in 1994. In September, the annual end-of-the-season meeting and social event was held. At these combination picnic/business meetings, the co-directors of the program from Ferrum College give reports on the results of the sample collection and analyses and the monitoring program coordinator of SMLA makes a presentation on the program and plans for the coming year.

The results of the data analyses and conclusions and comparisons with the previous seven years of data will be discussed in the following sections.

3. METHODS

Detailed methods of sample collection, preservation and analyses, and quality control/quality assurance procedures can be found in the VEE Report (Johnson and Thomas, 1990).

The parameters measured include water turbidity, observed with a Secchi disc; total phosphorus, measured spectrophotometrically after persulfate digestion; and chlorophyll-*a*, determined using the acetone extraction method and measured using fluorimetry.

The quality control and quality assurance procedures evaluated sample collection and storage by the volunteers as well as laboratory procedures.

4. 1994 RESULTS

4.1 Smith Mountain Lake

The three water quality parameters monitored on Smith Mountain Lake are water turbidity, total phosphorus and chlorophyll-*a*. In 1994 Secchi depth averaged 2.3 meters, total phosphorus averaged 28.6 ppb, and chlorophyll-*a* averaged 23.4 ppb. (Values for chlorophyll-*a* were calculated incorrectly. See Appendix Table A2a for corrected values. Corrected average value: CHA = 3.5 ppb.)

In 1994 these parameters, evaluated on a weekly mean of all stations, followed a fluctuating pattern similar to the previous years as illustrated in Figure 1. The Secchi depth exhibited the highest mean value in weeks six and seven indicating the lake water was the clearest during those weeks of the sampling period in 1994. The lowest mean value during Week one indicates that the water was the most turbid during the first week of 1994. The grand mean of Secchi depth values including all 920 values for all stations and all 12 weeks was 2.3 ± 0.7 m. Total phosphorus concentration exhibited the lowest mean value in Week nine of the sampling period, and the highest mean value in Week six of the sampling period in 1994. The grand mean of all 616 samples was 28.6 ± 12.8 ppb. Chlorophyll-*a* concentrations exhibited the lowest mean value in Week five indicating the lake water had the lowest population of algae during the fifth week of the sampling period in 1994. The highest mean value occurred during Week two indicating that the highest algal population occurred during the second week of the sampling period. The grand mean for 612 samples was 23.4 ± 21.2 ppb (corrected value: CHA = 3.5 ppb).

When these three water quality parameters are evaluated based on the means for each station and correlated with miles to the dam, trends are exhibited which would be considered typical of a reservoir. The upper reaches of the tributaries are more riverine in water quality, and the lower reaches (closer to the Smith Mountain Lake Dam) exhibit more lacustrine water quality, as illustrated in Figure 2. The Secchi depth increased as miles to the dam decreased, indicating better water clarity closer to the dam and in the larger expanse of water. The station averaging the lowest water clarity as measured by Secchi depth (mean SD = 1.3 m) was located 6.9 river miles from the dam in Craddock Creek. The highest water clarity, indicated by an average

Secchi depth of 3.6 m, occurred at two different stations. One station was located 8 river miles from the dam on the Roanoke River; the other was 1.5 river miles from the dam in the main channel.

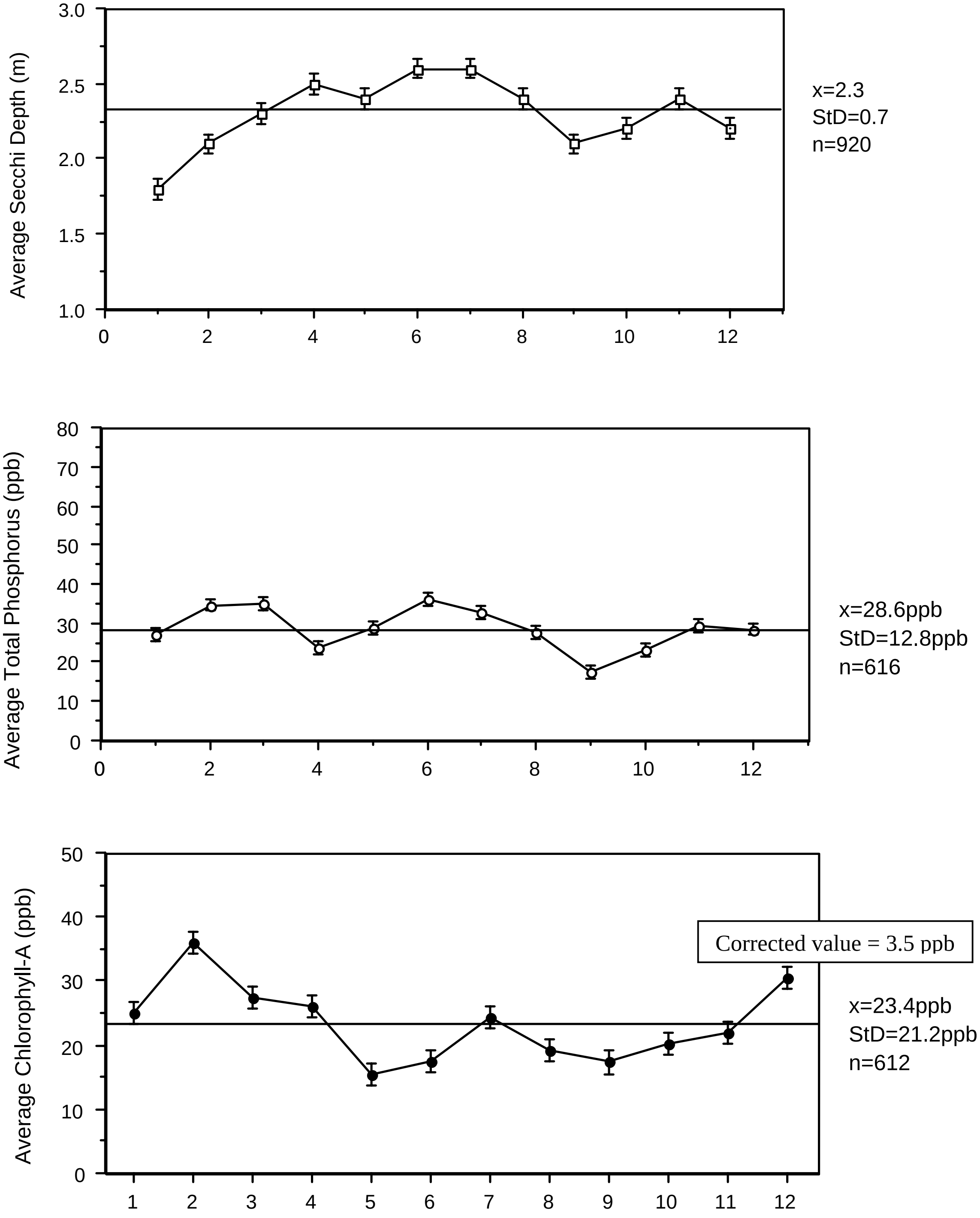

Figure 1. 1994 Smith Mountain Lake data averaged by sampling period.

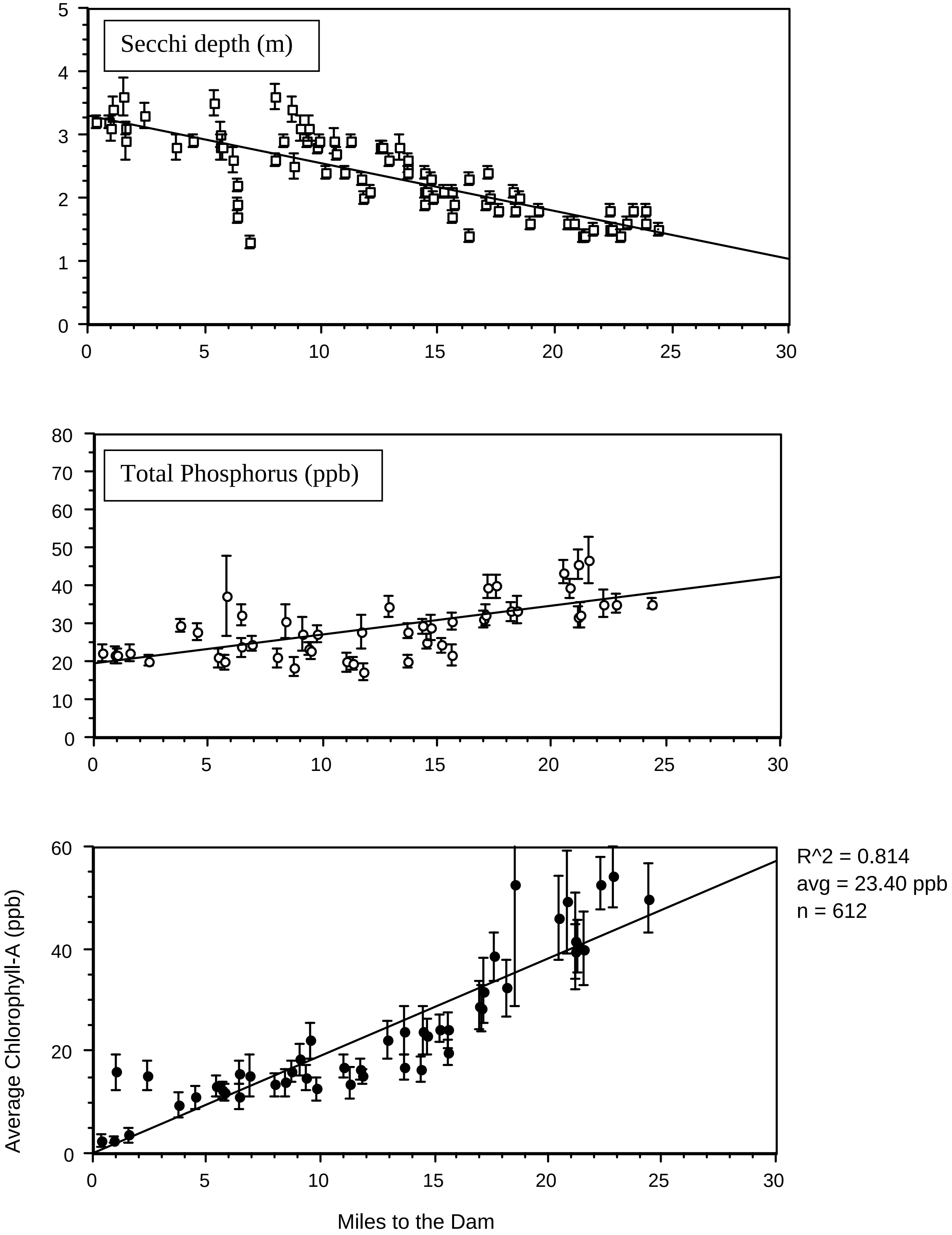

Figure 2. **1994 lake sample station averages versus miles to the SML Dam.**

The total phosphorus concentration (TP) decreased as miles to the dam decreased, indicating less nutrient-enriched water toward the main basin (Figure 2). The highest total phosphorus concentration (TP = 51.0 ppb) was measured at a station near the headwaters of Gills Creek. Within the lake boundary, the highest total phosphorus values of 46.6 ppb and 45.6 ppb were the averages at stations located 21.6 and 21.2 river miles from the dam, respectively. The lowest total phosphorus values (mean TP = 17.4 ppb and 18.4 ppb) were measured at stations approximately 11.8 and 8.7 miles from the dam.

The chlorophyll-*a* concentration (CHA) decreased as miles to the dam decreased, indicating less algal growth as the larger expanse of water is approached (Figure 2). The highest average chlorophyll-*a* concentrations (CHA = 54.1 ppb and 52.8 ppb) were sampled and measured at stations approximately 22.8 and 18.5 river miles from the dam. The lowest average chlorophyll-*a* concentration (CHA = 2.5 ppb) occurred at two different stations, 0.4 and 0.9 river miles from the dam. The decrease in the chlorophyll-*a* concentrations was significantly correlated with the decreasing miles to the dam.

When the data is separated and grouped according to area (the Roanoke River and the Blackwater River and the main basin of the lake), the same trends are demonstrated as described above with the complete data set. The results are shown in Figures 3, 4 and 5. The trends in the Blackwater River are shown in Figure 3 that shows a significant decrease in Secchi disk depth with increasing miles to the dam, and Total Phosphorus and Chlorophyll-*a* both showing significant increases in concentration with increasing miles to the Dam. These trends are similarly exhibited in Figure 4 in regard to the Roanoke River. In both of these tributaries there is a closer fit to the regression lines as indicated by larger values for R^2. The greater the R^2 value, the more highly correlated the two parameters (miles to the dam and TP, CH-A, or SD). In Figure 5 the main basin data shows a much lower correlation between each of the three parameters (TP, CH-A, SD) and Miles to the Dam. This is reflective of the riverine nature of the channels compared to the more completely mixed main basin. In the channels of the tributaries there is a greater current velocity in a constant direction downstream that would cause the gradient observed in the parameters in the tributaries. In the main basin the volume of water is greater; therefore, the current velocity is decreased and does not occur in only one direction. This results in greater mixing and a greater homogeneity of parameter values, which decreases the correlation between miles-to-dam and parameter value.

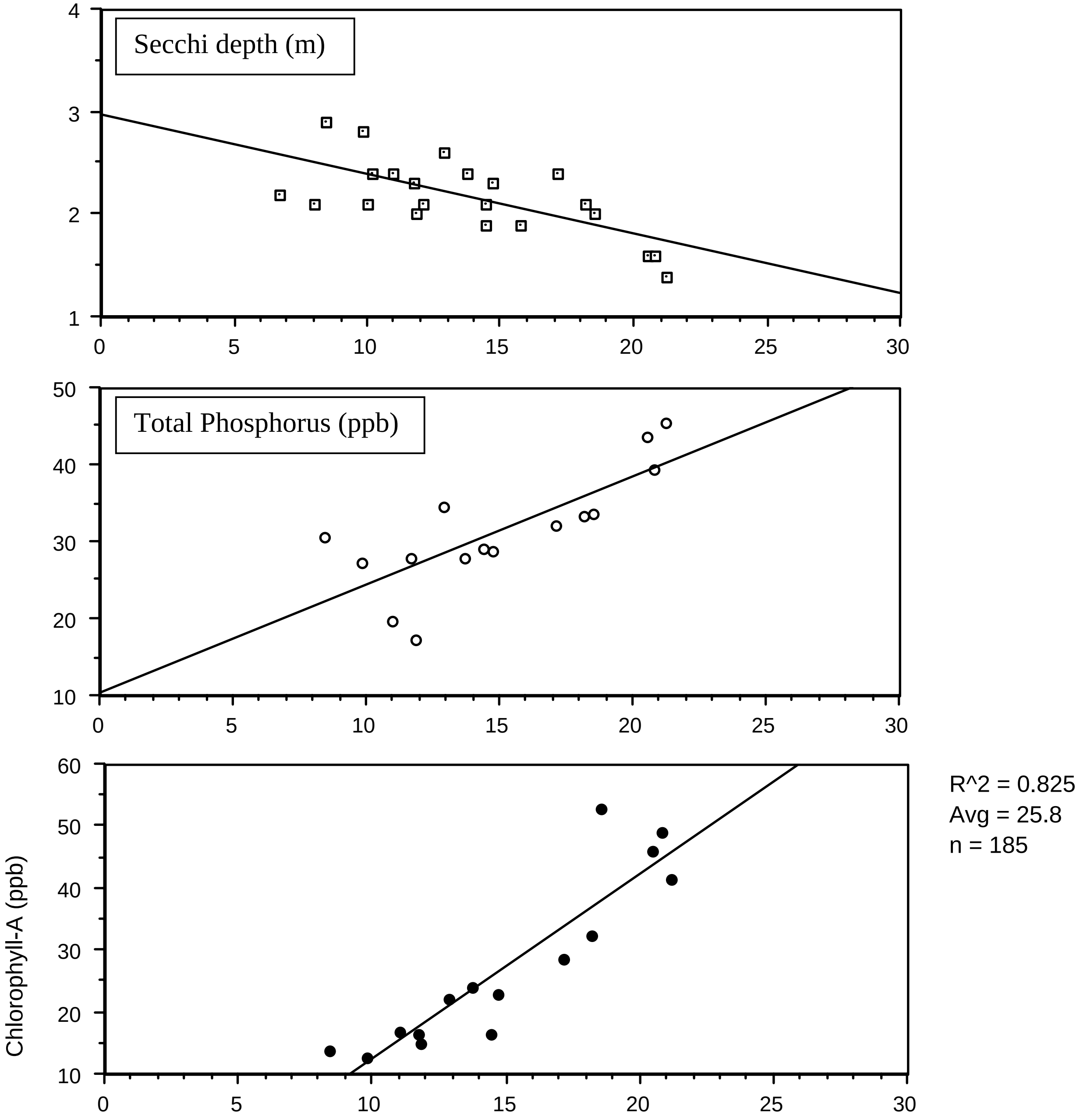

Figure 3. 1994 Blackwater River station average values versus miles to SML Dam.

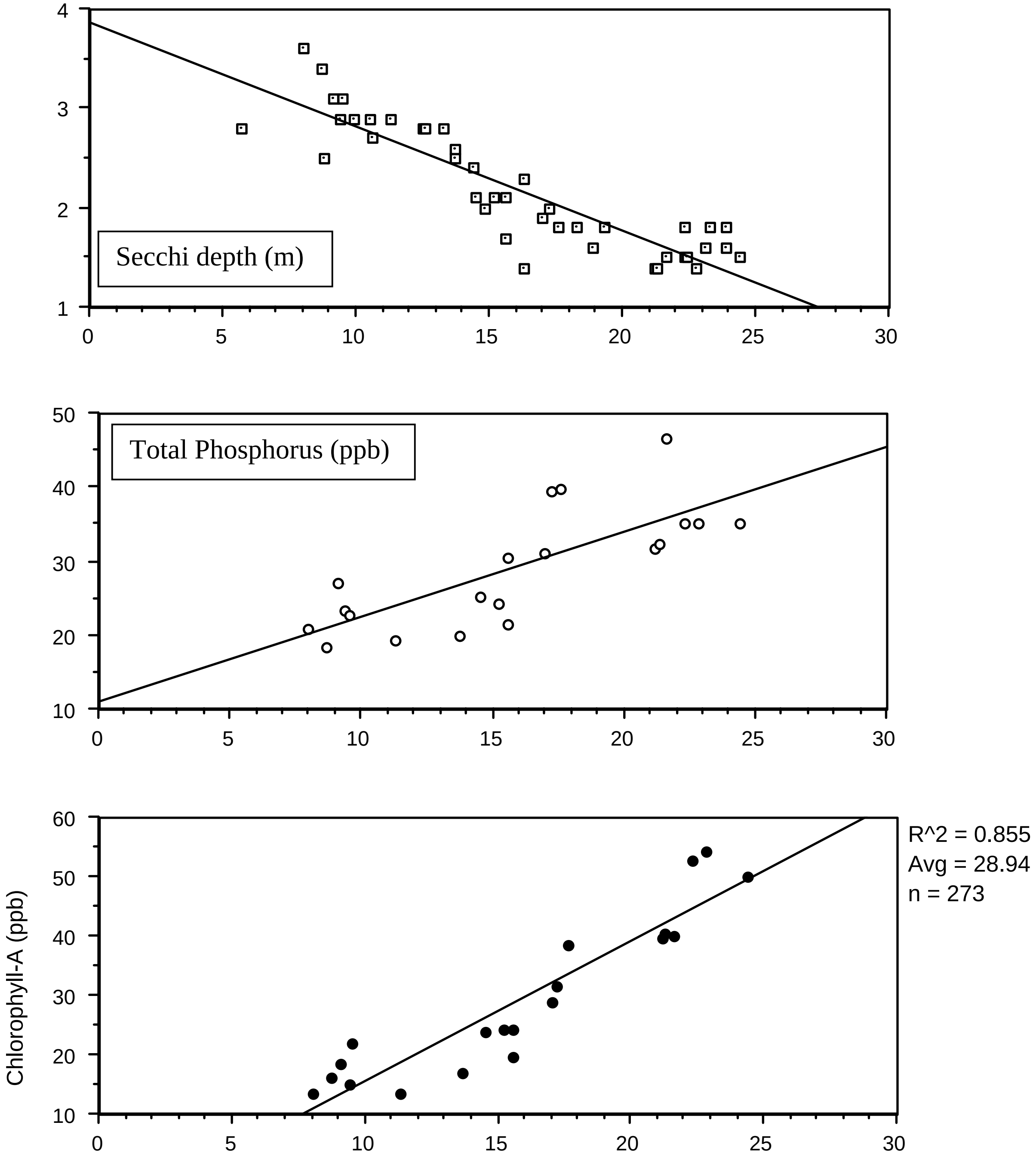

Figure 4. **1994 Roanoke River station average values versus miles to SML Dam.**

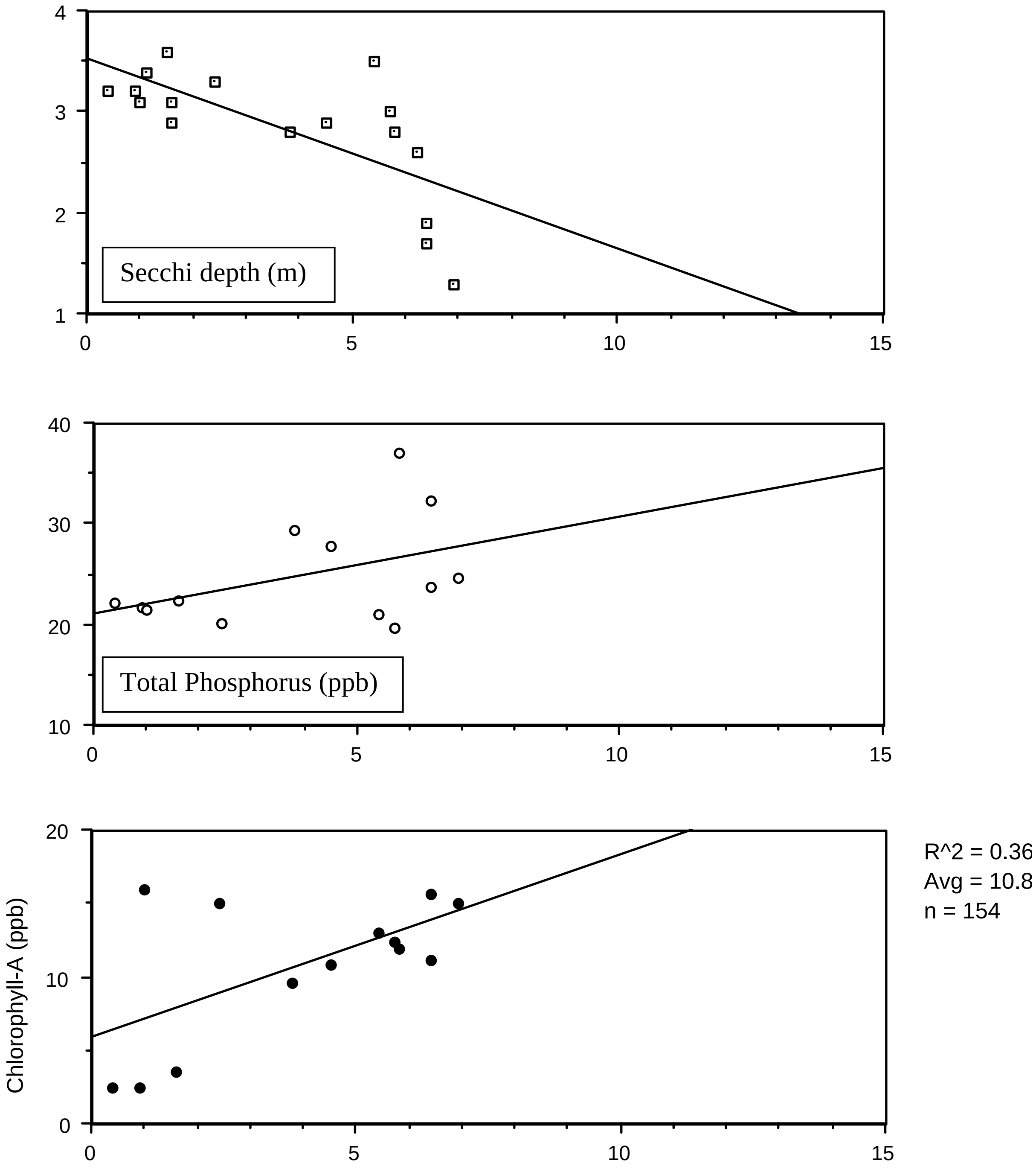

Figure 5. **1994 Main Basin station average values versus miles to SML Dam.**

4.2 Results for Leesville Lake

There is insufficient data on Leesville Lake for trend analysis but the results for 1993 and 1994 are summarized in Table 1. The raw data for Leesville Lake can be found in Table A4 in the Appendix.

Table 1. Summary of 1993 and 1994 results for Leesville Lake and station locations.

Station	Location	1993			1994
		SD (m)	CHA (ppb)	TP (ppb)	TP (ppb)
103	Tolei's Bridge, Rt. 608	0.8	12.2	54.6	38.7
104	Pigg River Bridge, Rt. 605	0.8	9.5	65.2	64.5
105	Bridge below SML Visitor Center	3.0	10.1	48.5	25.6

4.3 Discussion of Results

4.3.1 Total Phosphorus

The level of total phosphorus decreased this year by about 33%. During the first five years of the monitoring program, average levels of total phosphorus remained nearly constant. Changes in the number and location of sampling stations made it difficult to determine if the small differences observed were due to fluctuating water quality or an artifact of sampling. Since 1991, the network of sampling stations has been well established and the average total phosphorus concentration had increased between 10% to 60% each year. This increase in phosphorus levels must be attributed to nutrient enrichment. This year's decrease in phosphorus concentration could be attributed to the different rain pattern the watershed experienced in the spring of 1994.

Determination of total phosphorus went smoothly this past summer and preliminary analyses indicated good precision and accuracy. Table 1 gives the slopes and intercepts which are similar to those from previous years. The value of R^2 for the weekly calibration curves were all 0.98 or higher, an excellent result.

The surrogate samples for phosphorus, which are evaluated for quality control purposes, indicate a slightly higher concentration of phosphorus than the samples had added to them. The twenty ppb surrogate samples mean measured concentration of phosphorus was 35.3 ± 9.1 ppb and the forty ppb surrogate samples mean measured concentration of phosphorus was 44.7 ± 13.1 ppb.

This slightly higher concentration of phosphorus also was measured in the blank water samples. The field blank sample's mean measured phosphorus concentration was 16.3 ± 3.3 ppb. This additional phosphorus is attributed to the residual phosphorus adsorbed to sides and bottom of the sample bottles. The additional phosphorus is almost certainly a result of the manner in which the surrogate samples and field blanks are prepared. The QA/QC samples are placed in used sample bottles rinsed with distilled water, in the same way sample bottles are prepared for the monitor's lake samples. In the blanks and in the low concentration surrogate samples, some phosphorus is probably desorbed from the plastic sides and bottom of the bottle. To avoid adsorption/desorption problems with the monitor's samples, the same bottles are used for each sample site week after week and year after year. Next year all sample bottles will be acid washed again to remove some of the residual phosphorus in our field blanks and surrogate samples. Other QA/QC procedures went very well and the phosphorus results are reliable.

Table 2. Summary of calibration data for 1994 phosphate analysis.

WEEK	SLOPE	INTERCEPT	R^2
1	0.0020	0.0353	0.9820
2	0.0020	0.0130	0.9800
3	0.0020	0.0200	0.9800
4	0.0020	0.0440	0.9940
5	0.0020	0.0360	0.9940
6	0.0019	0.0210	0.9820
7	0.0026	0.0180	0.9970
8	0.0025	0.0125	0.9910
9	0.0019	0.0264	0.9880
10	0.0021	0.0079	0.9970
11	0.0023	-0.0006	0.9910
12	0.0022	0.0049	0.9990

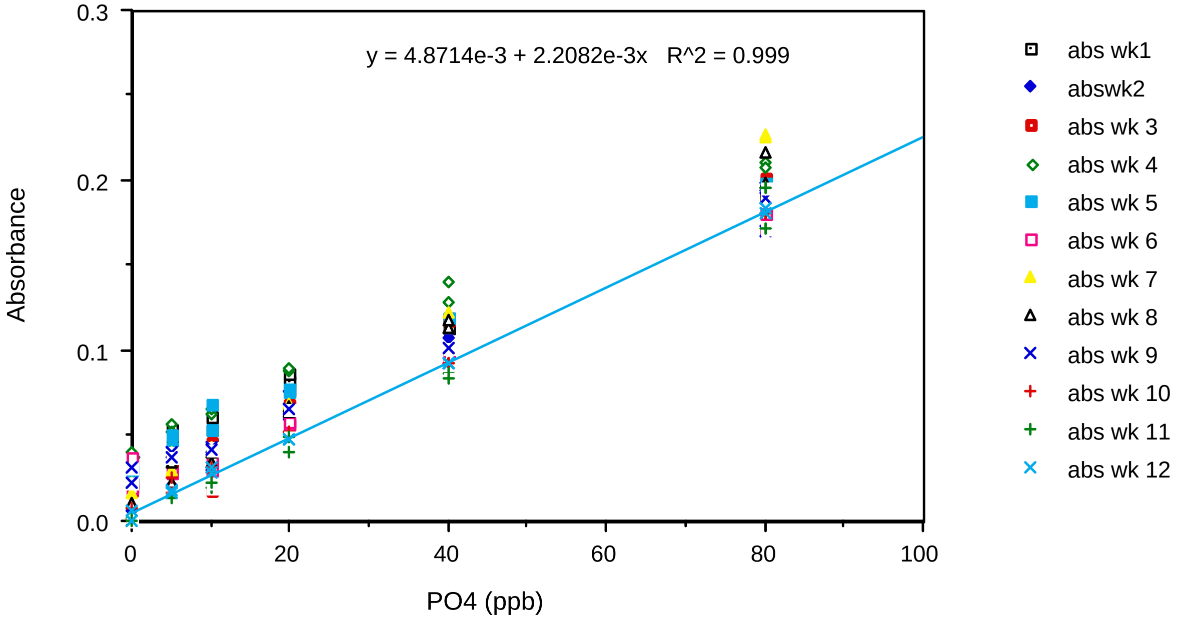

Figure 6. **Calibration Curve for 1994 Phosphate Analysis.**

4.3.2 Chlorophyll-*a*

Chlorophyll-*a* concentrations were high again this year, the average being very close to the same as last summer. (Note: Values for chlorophyll-*a* were calculated incorrectly. See Appendix Table A2a for corrected values). The difficulties inherent in quantifying chlorophyll-*a* were discussed in detail in the final report to the Virginia Environmental Endowment (1990). Because of the difficulty of the analysis, the instrument is calibrated each summer and student technicians practice their technique until adequate reproducibility is obtained. The instrument was calibrated three times during the summer. On July 21, the calibration was performed using a standard prepared from pure chlorophyll-*a* obtained from Sigma Chemical Company. On August 4 and again on August 26, EPA calibration standards were used. The results are shown in Table 3.

Table 3. Calibration data for the fluorimeter.

Date	Chlorophyll-*a* Level(ppb)	Fluorimeter Reading	Calibration Factor
21-Jul	4.4	6.0	0.73
	8.8	12.5	0.70
	17.6	25.0	0.70
	26.4	37.5	0.70
4-Aug	2.8	4.0	0.70
	14	21.0	0.67
	70	104.0	0.67
26-Aug	2.8	3.5	0.80
	14	19.0	0.74
	26.4	37.0	0.71
	70	105.0	0.67
			Avg = 0.71 **Stdev = 0.04**

To check the technique of the student technicians, a gallon of water was collected from Smith Mountain Lake and replicate analyses were performed. While keeping the sample well mixed, twenty 100 mL portions were filtered and analyzed using the standard procedure. Several extract blanks were prepared by treating an unused glass fiber filter in the same manner as a sample. In all cases the blank fluorescence reading was zero, indicating that light scattering by the glass fibers from the filters was not contributing to the fluorescence. The results are shown in Table 4 and indicate good reproducibility.

Table 4. Data from preliminary chlorophyll-*a* analysis to show variability of replicate analyses.

Fluorimeter Reading	Calibration Factor	Chlorophyll Concentration
9	0.75	6.8
9	0.75	6.8
10	0.75	7.5
10	0.75	7.5
10	0.75	7.5
11	0.75	8.3
7	0.75	5.3
8	0.75	6.0
12	0.75	9.0
10	0.75	7.5
6	0.75	4.5
10	0.75	7.5
7	0.75	5.3
11	0.75	8.3
10	0.75	7.5
11	0.75	8.3
9	0.75	6.8
7	0.75	5.3
7	0.75	5.3
8	0.75	6.0
		Avg = 6.4
		Stdev = 0.5

4.3.3 Secchi Depth

The average Secchi depth was almost identical to last year's value, indicating no change in water clarity. This year's mean Secchi depth (2.30 m) was nearly identical to the average of all yearly mean values since 1987 (2.4 m). This might seem inconsistent with the results for phosphorus and chlorophyll but is not necessarily so. From 1985-87 personnel from Ferrum College collected hundreds of suspended solids samples from Smith Mountain Lake and analyzed them for both volatile and nonvolatile content. The nonvolatile fraction was essentially suspended clay particles while the volatile fraction represented both algae and organic detritus. Taken as a whole, the samples indicated that about 60% of the suspended solids were nonvolatile. In many lakes and reservoirs, algae is primarily responsible for turbidity and Secchi depth correlates well with chlorophyll-*a* concentration. Smith Mountain Lake is surrounded by rugged terrain and its tributaries receive heavy runoff from agriculture. The counties surrounding the lake all display high rates of soil erosion. Thus, turbidity in Smith Mountain Lake may not correlate well with chlorophyll-*a* levels. This is especially true in the upper channels of the lake and in Leesville Lake. In these locations, phosphorus levels are very high and water clarity is very low, but chlorophyll-*a* concentration has been relatively low. There is plenty of phosphorus to support heavy algal growth but the water is so "muddy" that photosynthesis has been limited by lack of light. The last two summers have been relatively dry with few heavy downpours to wash soil into the lake and contribute to turbidity. This may be the reason that water clarity has not declined to the extent of the other two water quality indicators. It is expected that, sooner or later, heavy rains will lead to high levels of inorganic turbidity and combine with the high algal turbidity that has been seen in the last two years, greatly diminishing water clarity and the aesthetic appeal of Smith Mountain Lake.

5. WATER QUALITY TRENDS

Results of each water quality parameter measured have been discussed in the previous section. In this section, the water quality trends will be displayed in the manner that has been used for the past several years. Table 5 compares water quality in Smith Mountain Lake over the eight-year period of the monitoring program.

Table 5. Water quality data from Smith Mountain Lake 1987-1994.

	Annual Smith Mountain Lake Average							
Parameter	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
Total Phosphorus (ppb)	19.7	20.9	27.8	25.2	25.9	36.0	42.7	28.6
Chlorophyll-*a* (ppb)	3.8	2.6	3.7	4.5	3.0	5.5	23.7	23.4
Secchi Disk Depth (m)	2.4	2.7	2.2	2.4	2.6	2.0	2.3	2.3

Figures 7 and 8 show the average yearly values for each parameter; Figure 7 as a bar graph and Figure 8 as a line graph.

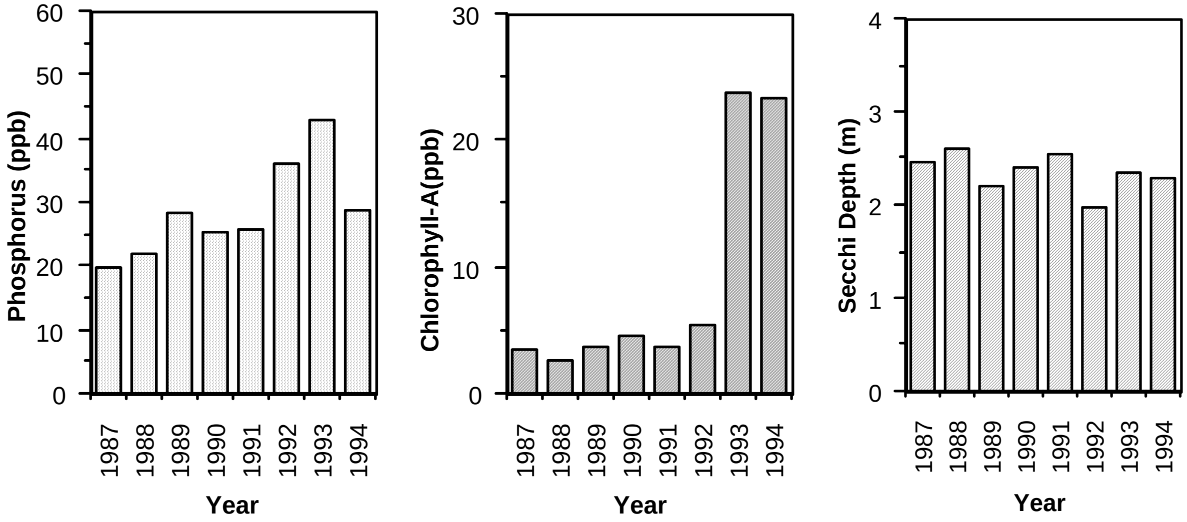

Figure 7. Bar graph comparison of water quality parameters by year.

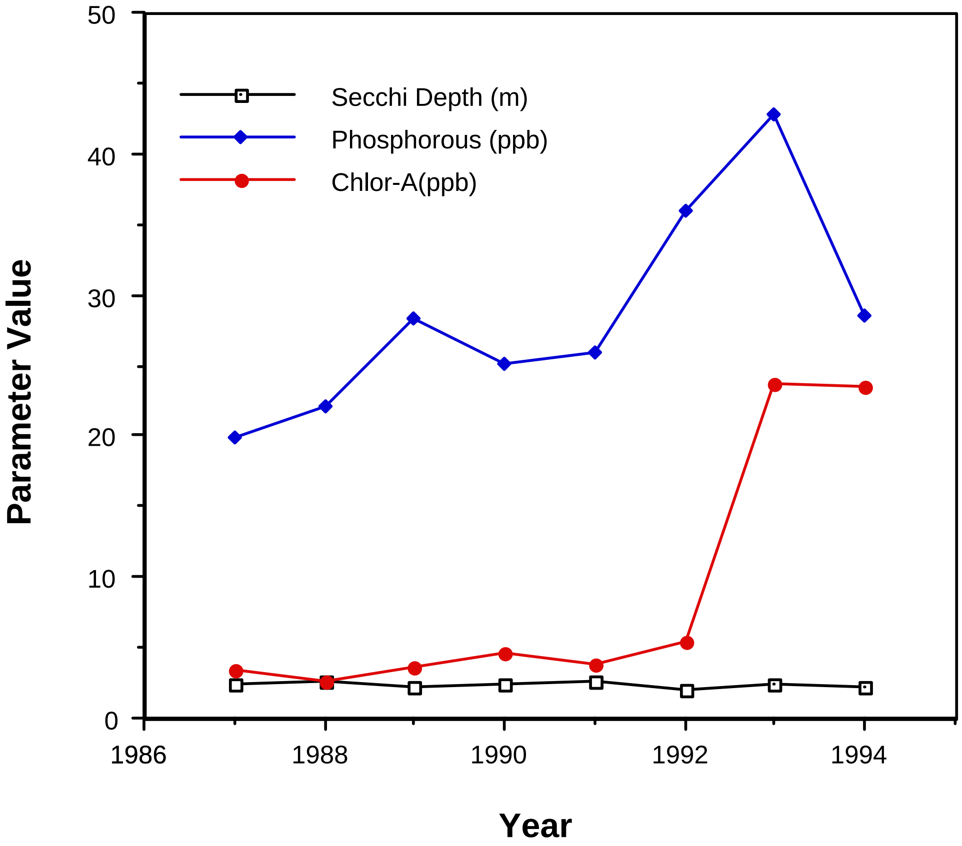

Figure 8. Line graph comparison of water quality parameters by year.

6. CARLSON’S TROPHIC STATE INDEX

The trophic status of a lake indicates the degree of nutrient enrichment and the resulting suitability of that lake for various uses. The process of eutrophication is described at the beginning of the Training Manual for the monitoring program. Phosphorus is most often the nutrient that limits algal production and attempts have been made to relate the trophic status of a lake to concentration of phosphorus. Table 6 shows one such effort. (Note that the relationships are for northern temperate lakes and will not represent southeastern lakes as well.)

The algal growth resulting from inputs of phosphorus can also be used to evaluate the trophic status of a lake. This is done by extracting the green pigment, chlorophyll-*a*, from algae and determining its apparent concentration. Table 7 shows the assignment of trophic status based on the concentration of chlorophyll-*a*. It also shows that the evaluation of trophic status is a matter of professional judgment, not a parameter to be exactly measured.

Table 6. Proposed relationships among phosphorus concentration, trophic state, and lake use for northern temperate lakes (Reckhow and Chapra, 1983).

Phosphorus (ppb)	Trophic State	Lake Use
< 10	Oligotrophic	Suitable for water-based recreation and cold water fisheries. Very high water clarity and aesthetically pleasing.
10-20	Mesotrophic	Suitable for recreation, often not for cold water fisheries. Clarity less than in oligotrophic lakes.
20-50	Eutrophic	Reduction in aesthetic properties reduces enjoyment from body contact recreation. Generally productive for warm water fish
> 50	Hypereutrophic	A typical "old-aged" lake in advanced succession. Some fisheries, but high levels of sedimentation and algae or macrophyte growth diminish open water surface area.

Table 7. Trophic status related to chlorophyll-*a* concentration in different studies (Reckhow and Chapra, 1983).

	Chlorophyll-*a* Concentration (ppb)			
Trophic Status	**Sakamoto**	**NAS**	**Dobson**	**EPA-NES**
Oligotrophic	0.3-2.5	0-4	0-4.3	<7
Mesotrophic	1-15	4-10	4.3-8.8	7-12
Eutrophic	5-140	>10	>8.8	>12

Trophic status can also be evaluated from Secchi disk measurements since algal growth decreases water clarity. Researchers have also attempted to relate water quality parameters such as conductivity and total organic nitrogen to trophic status. Regardless of how trophic status is evaluated, a particular status is used to summarize the water quality in a lake with respect to certain uses. The particular summary term, such as mesotrophic, is assigned to a lake based on a summary statistic, such as the average total phosphorus concentration. Further, researchers have devised water quality indices based on one or more summary statistics to better communicate water quality information to the general public. Using an index, water quality can be placed on a scale from 1 to 100, with 1 being the best. An index can be derived from any summary statistic by means of a mathematical transformation and provides a way of directly comparing various parameters that are measured in very different units. For example, without indexing, most people would have a hard time comparing the water quality significance of a 14 ppb total phosphorus concentration with a 3.5 meter Secchi depth.

The State of Virginia makes use of one of the best-known trophic state indices (TSI), called the Carlson Trophic State Index after the researcher who developed it. This index is also used to help interpret the water quality data collected on Smith Mountain Lake. Carlson's TSI may be calculated from any of the parameters that are monitored: total phosphorus concentration (TP), chlorophyll-*a* concentration (CA), or Secchi disk depth (SD). The index obtained from each of these parameters can be averaged to give a combined TSI. This is important because any of the individual parameters can be misleading in some situations. Secchi disk readings are a misleading indicator of trophic status in lakes with non-algal turbidity caused by soil erosion, such as in the upper river channels and near shore areas of Smith Mountain Lake. Phosphorus will not be a good indicator in lakes where algal growth is not limited by availability of phosphorus (algal growth in Smith Mountain Lake is phosphorus limited). Chlorophyll-*a* may be the best indicator during the growing season and the worst at other times.

The following equations are used for the calculation of TSI's:

$$\mathrm{TSI(TP)} = 14.42 \ln \mathrm{TP} + 4.15$$
$$\mathrm{TSI(CA)} = 9.81 \ln \mathrm{CA} + 30.6$$
$$\mathrm{TSI(SD)} = 60 - 14.41 \ln \mathrm{SD}$$
$$\mathrm{TSI(C)} = \{\mathrm{TSI(TP)} + \mathrm{TSI(CA)} + \mathrm{TSI(SD)}\}/3$$

TSIs are given for each year of the Smith Mountain Lake Volunteer Water Quality Monitoring Program in Table 8 and Figure 9.

Table 8. Trophic State Index in Smith Mountain Lake by year.

Year	TSI-TP	TSI-CA	TSI-SD	TSI-C
1987	47	43	47	46
1988	49	40	46	45
1989	52	43	49	48
1990	51	45	47	48
1991	51	45	47	47
1992	56	47	50	51
1993	58	62	48	56
1994	53	62	48	54

Note that figure 9 shows the same data at two scales. On the right, only a portion of the trophic state index is shown to more clearly indicate variation over time.

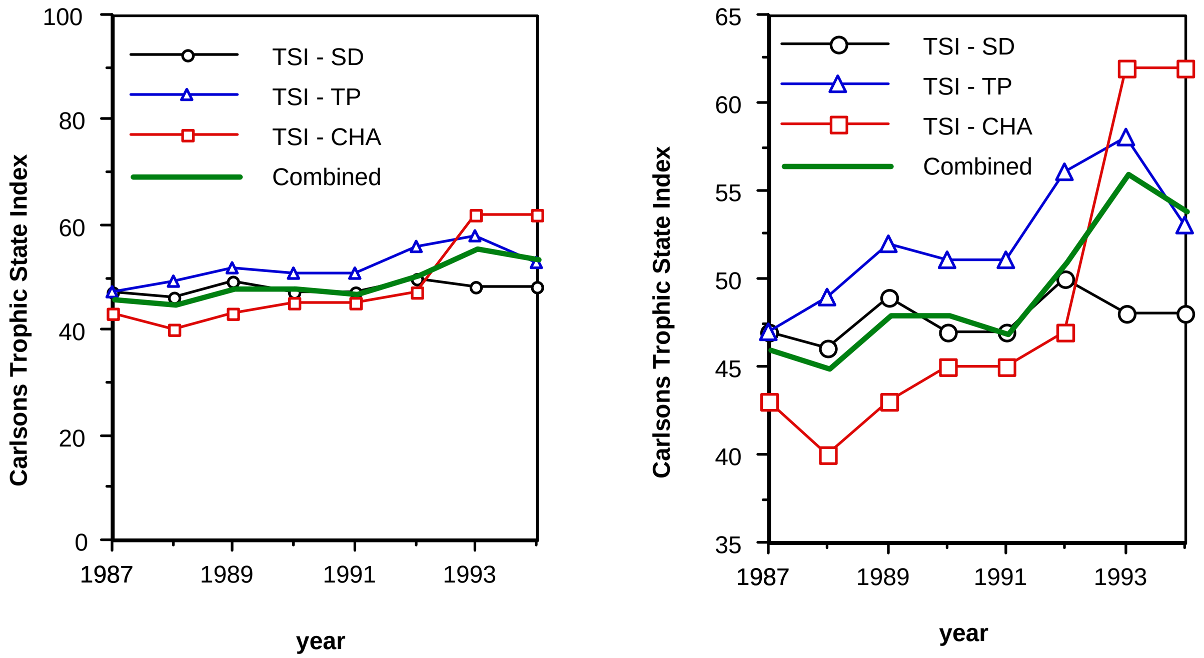

Figure 9. **Carlson's Trophic State Index for Smith Mountain Lake (1987-94).**

7. SAMPLING EFFICIENCY

The monitoring program depends on volunteers for sample collection and one measure of success for the program is the consistency with which these volunteers attend to their stations. Table 9 presents the collection efficiencies for 1991, 1992, 1993 and 1994. The figures show that the volunteer monitors are very conscientious about sample collection. Advanced monitors collected 98-99% of the samples possible in 1994 and 93% of the samples possible for basic monitors. These sampling efficiencies are higher than any year so far, and this sampling efficiency is remarkably high for volunteer sampling programs. Their sampling efficiency is as good or better than that of professionals in agencies responsible for environmental sampling. This degree of commitment no doubt carries over to the care with which samples are collected and is evidence of their dedication to the program.

Table 9. Comparison of sampling efficiencies for 1991, 1992, 1993, and 1994.

	Sampling Efficiencies			
	1991	1992	1993	1994
Secchi Disk Measurements	86%	90%	80%	93%
Total Phosphorus Samples	96%	93%	90%	99%
Chlorophyll-*a* Samples	95%	93%	90%	98%

8. CONCLUSIONS AND SUMMARY

Results from this year's monitoring program indicate little change in water quality. Average values for Secchi depth and chlorophyll-*a* concentration are almost exactly the same while the average concentration of total phosphorus has decreased by a third. This means that water clarity and algal production are unchanged and nutrient levels have gone down. This is good news and bad news. The downward trend in water quality has not been reversed, but neither has the condition continued to decline. That the rapid increase in chlorophyll-*a* (values for chlorophyll-*a* were calculated incorrectly. See Appendix Table A2a for corrected values) has leveled off while the phosphorus concentration decreased is reason for guarded optimism. As eutrophication progresses, increased nutrient inputs will lead to increased algal production. The rising algal population leads, in turn, to decreased water clarity and larger fluctuations in dissolved oxygen. The lower phosphorus level seen this past summer may translate to lower algal production in the future. However, very little has changed with respect to watershed management and so there is no reason to expect a dramatic change in water quality. Short-term variations in water quality reflect changes in precipitation patterns. In 1994, for the first time in several years, there was no severe flooding in the spring and this could be the reason for the lower phosphorus levels observed this past summer.

We are more convinced than ever that watershed protection is the key to maintaining water quality in Smith Mountain Lake. The initiatives being taken to protect the Smith Mountain Lake Watershed are also cause for optimism. Some of the initiatives are described below:

> -The Fifth Planning District has finished a study of the Roanoke River Corridor and developed plans for overlay zoning to protect critical habitat. Some localities have already approved and begun implementing an overlay zoning ordinance and the process needs to be supported in localities all along the corridor.
>
> -The SMLA and Ferrum College are working on a GIS (Geological Information System) to map the SML watershed and identify areas with high potential for non-point source pollution due to soil erosion.
>
> -The Franklin County Office of the Natural Resources Conservation Service continues the Blackwater Hydrologic Unit project to demonstrate how BMPs (Best Management Practices on agricultural land) can improve water quality in streams receiving agricultural runoff. In addition, EPA has tentatively approved funding for a second demonstration project. This project will demonstrate how

building alternative animal watering systems and getting the animals out of streams and off of stream banks decreases silt and nutrient loading.

None of the initiatives are producing big water quality dividends at this point but they are moving us in the right direction and laying the groundwork for continued progress. In conclusion, the list of positive actions from last year's report (to prevent continued decline of water quality) are reiterated:

1. Finding out about the regulatory implications of the "nutrient enriched" designation and supporting the DEQ in their effort to protect water quality in Smith Mountain Lake.
2. Encouraging lake residents to use lawn and garden chemicals conservatively and maintain optimal functioning of septic tanks.
3. Closely following the progress and results from the Blackwater Demonstration Project and other efforts being made by the Blue Ridge Soil and Water Conservation District to prevent soil loss from the SML watershed.
4. Insisting on effective erosion control at all construction sites in the SML watershed and supporting enforcement efforts by the counties surrounding the lake.
5. Actively seeking funds at the local, state and national level to develop a dynamic model of water quality in Smith mountain Lake, beginning with existing resource information from GIS and satellite imagery.
6. Exploring the feasibility of engineering approaches to sediment trapping in the upper channels.

9. ACKNOWLEDGEMENTS

We would like to acknowledge the hard work and effectiveness of our student technicians, Christine Carr and Tracy Rakes this past summer. They were responsible for making the long trek around the lake collecting the volunteers' samples every week, and for doing the weekly analyses for total phosphorus and chlorophyll-*a*. We would also like to acknowledge the hard work and unfailing support of John Barr as Past President and Karl Lerz as President of the SMLA. We would like to especially thank Bob Halsted for his hard work and enthusiasm. His efficient and effective leadership has made our job easier, and his expertise in soil conservation has been valuable to the program.

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APPENDIX

Table A1. 1994 Total phosphorus data.

STA/WK	94/1	94/2	94/3	94/4	94/5	94/6	94/7	94/8	94/9	94/10	94/11	94/12	Sta Avg	Stdev
ST 1	20.5	35.0	32.0	16.1	25.1	27.1	42.0	45.8	0.0	15.9	55.0	18.6	27.8	15.2
ST 2	11.5	33.0	23.0	17.1	25.1	26.1	24.1	22.4	5.6	7.5	25.9	16.7	19.8	8.3
ST 3	15.0	32.0	6.0	13.3	21.2	26.1	15.6	20.0	7.2	15.0	20.6	16.7	17.4	7.3
ST 4	32.5	29.6	11.0	21.8	23.2	33.5	23.0	26.4	18.8	24.3	25.4	21.3	24.2	6.1
ST 5	26.5	28.8	46.0	22.7	37.9	29.3	37.0	28.9	22.0	33.6	32.0	23.1	30.6	7.1
ST 6	35.0	20.6	36.0	27.5	22.2	30.3	22.2	26.0	15.7	25.2	23.2	18.6	25.2	6.2
ST 7	30.5	67.0	37.0	25.6	26.1	32.4	22.6	22.4	18.7	14.1	11.7	17.6	27.1	14.6
ST 8	24.5	37.8	21.0	24.6	24.1	36.7	21.4	23.2	16.9	15.0	12.2	15.8	22.8	7.9
ST 9	27.5	22.7	32.0	22.7	25.1	29.3	24.5	25.6	17.8	20.6	16.2	14.0	23.2	5.3
ST 16	48.5	58.8	45.5	36.0	45.2	43.1	26.1	24.4	36.0	28.0	47.0	36.7	39.6	10.3
ST 17	43.5	44.2	25.6	27.5	43.1	43.1	50.2	48.2	24.3	44.8	54.5	29.4	39.9	10.3
ST 18	38.5	36.1	27.5	20.9	41.0	34.6	35.4	32.9	16.9	21.5	35.6	32.1	31.1	7.6
ST 31	31.5	25.3	26.0	0.9	26.1	30.3	26.5	21.6	9.5	17.8	19.2	24.0	21.6	8.8
ST 32	17.5	30.5	21.0	15.2	24.1	26.1	22.2	24.8	8.5	15.0	16.6	18.6	20.0	6.0
ST 33	18.5	23.6	24.0	14.2	19.7	26.1	23.7	25.6	9.5	14.1	18.8	14.9	19.4	5.4
ST 37	36.5	24.5	32.0	19.7	25.1	30.3	24.5	26.4	7.4	17.0	23.1	19.5	23.8	7.6
ST 38	22.5	38.6	24.5	17.7	23.2	30.3	26.5	21.6	5.3	8.2	18.6	18.6	21.3	8.9
ST 39	20.5	27.0	26.0	15.8	20.2	22.9	27.2	23.2	5.3	18.8	24.0	22.2	21.1	6.0
ST 40	30.5	35.6	31.0	32.0	29.1	56.9	28.0	29.7	20.1	22.3	38.5	33.9	32.3	9.3
ST 41	23.5	33.5	27.0	31.5	21.2	38.8	17.9	21.6	15.9	21.4	22.2	21.3	24.6	6.8
ST 42	17.5	25.3	24.0	29.0	33.0	44.1	23.3	17.6	12.7	15.8	24.0	18.1	23.7	8.7
ST 43	22.5	27.0	25.0	13.3	29.1	34.6	22.2	22.0	7.4	14.9	18.1	14.5	20.9	7.6
ST 44	25.5	35.6	11.0	18.0	22.2	30.3	25.3	18.4	6.3	15.8	26.0	18.1	21.0	8.2
ST 45	13.6	31.8	28.5	11.4	20.2	31.4	22.6	14.7	6.3	14.9	11.9	13.7	18.4	8.4
ST 49	35.2	33.5	39.0	22.7	35.0	41.0	31.1	24.4	15.9	53.0	42.3	39.2	34.4	9.9
ST 50	38.0	34.3	37.0	18.0	23.2	31.4	21.0	28.9	21.2	26.0	29.1	26.9	27.9	6.5
ST 51	60.6	30.5	37.0	16.1	24.1	32.4	24.5	22.8	20.1	23.3	27.3	28.6	28.9	11.4
ST 55	66.2	95.7	53.0	41.7	53.7	48.4	49.0	27.2	14.8	38.1	30.0	41.0	46.6	20.6
ST 56	28.6	58.8	40.0	22.7	34.0	44.1	37.0	23.2	13.8	28.8	26.9	28.6	32.2	11.7
ST 57		39.1	44.0	27.5	27.1	42.0	42.4	29.7	14.8	27.9	24.2	31.3	31.8	9.1
ST 64		23.6	28.0	15.2	18.2	23.9	20.2	21.6	6.3	17.9	22.2	20.4	19.8	5.6
ST 65	16.4	17.6	26.0	16.1	18.2	27.1	26.8	20.8	12.7	20.1	20.4	18.6	20.1	4.5
ST 66	16.0	26.2	33.0	18.0	19.2	31.4	21.4	20.8	10.6	22.7	21.3	16.8	21.4	6.4
ST 67		38.6	33.0	21.8	23.2	36.7	38.9	24.8	26.5	22.3	39.6	48.9	32.2	9.0
ST 68		30.9	31.0	22.7	24.1	37.8	48.2	28.5	36.0	26.0	37.0	42.7	33.2	8.0
ST 69		37.8	39.5	25.6	24.1	39.9	31.1	27.2	22.2	22.3	38.8	59.5	33.5	11.2
ST 70		19.3	48.9	47.0	36.9	38.8	33.9	35.7	19.0	26.0	50.7	31.3	35.2	10.9
ST 71		33.5	48.1	45.0	33.5	39.9	30.0	32.9	16.9	33.5	35.2	38.3	35.2	8.2
ST 72		32.5	38.2	41.0	29.1	38.8	35.8	35.3	29.6	35.3	41.4	30.4	35.2	4.4
ST 76	14.6	29.6	145.0	42.0	32.4	33.5	40.5	29.7	19.0	18.6	14.1	25.6	37.1	35.2
ST 77	23.1	33.9	37.0	28.0	29.3	37.8	22.6	27.2	18.0	17.7	33.0	26.0	27.8	6.8
ST 78	28.8	27.9	34.5	31.0	28.2	36.7	30.7	24.0	15.9	27.0	29.5	37.4	29.3	5.8
ST 79	14.6	25.8	28.0	14.2	31.4	29.3	25.7	19.2	9.5	15.8	30.0	23.3	22.2	7.3
ST 80	13.7	24.9	27.0	14.2	26.1	29.3	34.2	21.6	10.6	14.9	22.9	22.5	21.8	7.2
ST 81	18.4	36.5	29.0	15.2	26.6	29.3	26.1	21.6	9.5	15.8	17.6	21.6	22.3	7.5
ST 82	24.1	34.8	33.0	25.6	30.3	42.0	35.4	24.8	16.9	22.3	31.3	30.4	29.2	6.8
ST 83	25.9	30.0	35.0	19.4	26.1	37.8	37.4	24.0	14.8	23.3	26.0	27.8	27.3	6.9
ST 84	22.2	27.0	34.0	19.9	29.3	33.5	47.5	30.1	11.1	19.5	27.3	67.4	30.7	14.7
ST 85	36.3	36.9	38.0	29.4	36.7	54.8	66.1	41.8	50.8	44.7	41.9	44.5	43.5	9.9
ST 86	25.9	41.6	39.5	31.3	39.9	46.3	53.7	31.7	42.3	29.8	44.9	46.3	39.4	8.2
ST 87	24.1	43.8	53.0	31.3	41.9	55.9	67.3	53.5	39.2	34.4	48.9	54.2	45.6	12.2
ST 200	26.9	48.5	67.0	28.4	49.8	68.6	81.3	61.1	49.7	37.2	44.1	48.9	51.0	16.3
Per Avg	27.1	34.6	35.0	23.6	28.9	36.2	32.6	27.5	17.3	23.2	29.2	28.4	**Gr Avg**	**28.6**
Stdev	11.7	12.9	18.9	9.3	8.2	9.2	13.4	8.9	11.1	9.3	11.3	12.5	**Stdev**	**12.8**

Table A2. 1994 Chlorophyll-*a* data.

(Corrected CHA data on next page)

STA/WK	94/1	94/2	94/3	94/4	94/5	94/6	94/7	94/8	94/9	94/10	94/11	94/12	St Avg	Stdev
ST 1	29.3	11.3	13.5	14.3	20.3	6.0	24.0	18.0	12.8	12.0	12.0	22.5	16.3	6.6
ST 2	20.3	17.3	21.8	22.5	15.0	7.5	9.8	15.0	12.8	6.0	21.0	35.3	17.0	8.0
ST 3	19.5	24.0	15.8	10.5	19.5	9.8	12.8	14.3	15.8	8.3	15.8	15.8	15.1	4.5
ST 4	33.8	31.5	33.8	35.3	8.3	20.3	18.0	20.3	19.5	12.8	29.3	30.8	24.4	9.1
ST 5	29.3	47.3	43.5	20.3	9.0	12.8	22.5	26.3	18.8	13.5	20.3	27.0	24.2	11.6
ST 6	37.5	50.3	53.3	24.8	13.5	12.0	14.3	20.3	14.3	8.3	9.8	30.0	24.0	15.6
ST 7	26.3	25.5	27.8	31.5	12.0	8.3	15.0	18.8	0.8	2.3	19.5	31.5	18.3	10.8
ST 8	24.0	36.0	32.3	24.0	6.8	10.5	18.0	21.0	5.3	32.3	12.0	42.0	22.0	12.0
ST 9	20.3	30.0	27.0	20.3	13.5	9.0	12.8	17.3	3.0	6.8	9.0	9.8	14.9	8.2
ST 16	50.3	51.0	23.3	87.8	28.5	20.3	19.5	16.5	18.8	27.0	21.0	16.5	31.7	21.3
ST 17	42.0	75.0	49.5	22.5	33.0	49.5	36.0	21.8	31.5	29.3	22.5	49.5	38.5	15.6
ST 18	57.0	50.3	15.0	18.0	16.5	16.5	30.8	15.0	19.5	28.5	24.8	54.8	28.9	16.1
ST 31	31.5	27.8	28.5	27.8	15.0	9.8	27.0	18.0	5.3	15.8	10.5	19.5	19.7	8.7
ST 32	15.8	37.5	18.8	18.8	6.8	9.0	13.5	18.8	21.0	9.8	15.8	16.5	16.8	7.9
ST 33	8.3	38.3	29.3	15.0	1.5	6.0	8.3	5.3	10.5	12.8	14.3	13.5	13.6	10.4
ST 37	34.5	50.3	22.5	16.5	14.3	23.3	24.0	18.0	12.0	21.0	29.3	60.0	27.1	14.6
ST 38	42.8	59.3	33.0	17.3	12.8	31.5	14.3	18.8	18.0	42.0	33.0	52.5	31.3	15.5
ST 39	25.5	53.3	27.0	18.0	11.3	28.5	19.5	36.0	16.5	20.3	30.8	71.3	29.8	17.0
ST 40	18.0	30.8	26.3	14.3	6.8	13.5	11.3	8.3	12.0	9.8	17.3	20.3	15.7	7.2
ST 41		39.0	40.5	21.8	0.8	13.5	11.3	6.0	5.3	10.5	7.5	9.8	15.1	13.3
ST 42	17.3	30.0	12.0	16.5	1.5	6.8	6.8	7.5	8.3	1.5	6.0	20.3	11.2	8.4
ST 43	17.3	27.0	29.3	12.8	9.8	10.5	14.3	11.3	9.0	7.5	1.5	11.3	13.4	7.9
ST 44	21.0	24.0	22.5	13.5	6.0	12.8	15.8	10.5	10.5	3.0	6.8	10.5	13.1	6.7
ST 45	14.3	23.3	26.3	23.3	9.8	17.3	16.5	12.0	8.3	6.8	10.5	24.8	16.1	6.9
ST 49	21.8	29.3	17.3	16.5	10.5	18.0	22.5	11.3	16.5	11.3	49.5	41.3	22.1	12.2
ST 50	14.3	43.5	18.0	16.5	5.3	12.0	23.3	30.8			25.5	51.0	24.0	14.3
ST 51	17.3	44.3	18.0	21.8	12.0	12.0	16.5	28.5	24.8	8.3	31.5	41.3	23.0	11.5
ST 55	34.5	75.0	75.0	28.5	18.8	19.5	19.5	48.8	23.3	11.3	49.5	76.5	40.0	24.3
ST 56	62.3	72.8	27.0	32.3	24.8	20.3	45.0	24.0	30.0	45.8	45.8	56.3	40.5	16.9
ST 57	48.8	75.0	24.0	45.0	21.0	18.0	66.0	23.3	42.0	36.8	33.0	42.8	39.6	17.7
ST 64	11.3	23.3	18.8	13.5	15.0	6.8	6.8	16.5	4.5	7.5	15.8	9.0	12.4	5.7
ST 65	27.8	25.5	21.8	17.3	5.3	8.3	8.3	20.3	6.0	1.5	28.5	11.3	15.1	9.5
ST 66	17.3	21.0	25.5	10.5	10.5	10.5	10.5	48.0	6.8	14.3	9.8	6.8	15.9	11.6
ST 67		26.3	17.3	27.0	9.0	21.0	32.3	17.3	31.5	24.8	55.5	50.3	28.4	13.9
ST 68		30.0	17.3	18.8	13.5	50.3	46.5	42.0	11.3	19.5	43.5	63.0	32.3	17.5
ST 69		42.0	21.0	23.3	8.3	43.5	277.5	14.3	27.0	22.5	29.3	72.0	52.8	76.5
ST 70		47.3	75.0	48.0	60.8	39.0	42.0	51.0	55.5	87.0	44.3	30.8	52.8	16.3
ST 71		45.0	75.0	38.3	74.3	49.5	27.0	40.5	46.5	51.8	56.3	91.5	54.1	18.9
ST 72		45.8	75.0	33.8	51.8	72.0	33.8	10.5	63.0	78.0	53.3	32.3	49.9	21.2
ST 76	16.5	22.5	20.3	12.8	6.0	6.8	14.3	7.5	6.0	7.5	13.5	9.8	11.9	5.7
ST 77	23.3	27.0	9.8	18.0	7.5	10.5	9.8	9.8	3.8	3.0	0.8	8.3	10.9	8.0
ST 78	18.8	27.8	15.0	15.0	5.3	5.3	12.8	2.3	3.8	0.8		8.3	10.4	8.2
ST 79		14.3	1.5	3.0	1.5		2.3	2.3	0.8	0.8		1.5	3.1	4.3
ST 80	3.0	6.0	3.8	1.5		0.8	5.3	1.5	4.5	2.3		1.5	3.0	1.8
ST 81	3.0	12.0	6.8	1.5		0.8	2.3	12.0	0.8	0.0	1.5	1.5	3.8	4.4
ST 82	15.8	21.8	19.5	21.8	3.0	11.3	24.0	9.8	17.3	21.0	4.5	28.5	16.5	7.9
ST 83	16.5	25.5	21.0	15.0	9.0	12.0	14.3	6.0	7.5	3.8		21.8	13.8	7.0
ST 84	18.0	35.3	14.3	16.5	3.8	14.3	8.3	22.5	8.3	11.3	3.0	11.3	13.9	8.8
ST 85	38.3	43.5	30.0	59.3	27.8	38.3	21.8	35.3	90.0	109.5	25.5	31.5	45.9	27.3
ST 86		59.3	30.8	130.5	63.0	30.0	28.5	32.3	17.3	31.5	70.5	47.3	49.2	31.8
ST 87		30.8	54.8	115.5	26.3	6.0	18.0	33.8	16.5	64.5	49.5	40.5	41.5	30.2
ST 200	7.5	13.5	5.3	8.3	18.8	9.0	4.5	6.8	9.0	3.0	6.8	1.5	7.8	4.7
Avg	25.0	36.0	27.5	26.1	16.1	17.8	24.2	19.3	17.3	20.1	23.9	30.5	**Gr Avg**	**23.7**
Stdev	13.7	16.8	17.7	24.2	15.8	14.6	37.8	12.2	16.9	23.1	17.3	22.0	**Stdev**	**21.2**

Table A2-a. Corrected 1994 chlorophyll-*a* data.

STA/WK	94/1	94/2	94/3	94/4	94/5	94/6	94/7	94/8	94/9	94/10	94/11	94/12	Sta Avg	Stdev
ST 1	4.4	1.7	2.0	2.1	3.0	0.9	3.6	2.7	1.9	1.8	1.8	3.4	2.4	1.0
ST 2	3.0	2.6	3.3	3.4	2.3	1.1	1.5	2.3	1.9	0.9	3.2	5.3	2.6	1.2
ST 3	2.9	3.6	2.4	1.6	2.9	1.5	1.9	2.1	2.4	1.2	2.4	2.4	2.3	0.7
ST 4	5.1	4.7	5.1	5.3	1.2	3.0	2.7	3.0	2.9	1.9	4.4	4.6	3.7	1.4
ST 5	4.4	7.1	6.5	3.0	1.4	1.9	3.4	3.9	2.8	2.0	3.0	4.1	3.6	1.7
ST 6	5.6	7.5	8.0	3.7	2.0	1.8	2.1	3.0	2.1	1.2	1.5	4.5	3.6	2.3
ST 7	3.9	3.8	4.2	4.7	1.8	1.2	2.3	2.8	0.1	0.3	2.9	4.7	2.7	1.6
ST 8	3.6	5.4	4.8	3.6	1.0	1.6	2.7	3.2	0.8	4.8	1.8	6.3	3.3	1.8
ST 9	3.0	4.5	4.1	3.0	2.0	1.4	1.9	2.6	0.5	1.0	1.4	1.5	2.2	1.2
ST 16	7.5	7.7	3.5	13.2	4.3	3.0	2.9	2.5	2.8	4.1	3.2	2.5	4.8	3.2
ST 17	6.3	11.3	7.4	3.4	5.0	7.4	5.4	3.3	4.7	4.4	3.4	7.4	5.8	2.3
ST 18	8.6	7.5	2.3	2.7	2.5	2.5	4.6	2.3	2.9	4.3	3.7	8.2	4.3	2.4
ST 31	4.7	4.2	4.3	4.2	2.3	1.5	4.1	2.7	0.8	2.4	1.6	2.9	3.0	1.3
ST 32	2.4	5.6	2.8	2.8	1.0	1.4	2.0	2.8	3.2	1.5	2.4	2.5	2.5	1.2
ST 33	1.2	5.7	4.4	2.3	0.2	0.9	1.2	0.8	1.6	1.9	2.1	2.0	2.0	1.6
ST 37	5.2	7.5	3.4	2.5	2.1	3.5	3.6	2.7	1.8	3.2	4.4	9.0	4.1	2.2
ST 38	6.4	8.9	5.0	2.6	1.9	4.7	2.1	2.8	2.7	6.3	5.0	7.9	4.7	2.3
ST 39	3.8	8.0	4.1	2.7	1.7	4.3	2.9	5.4	2.5	3.0	4.6	10.7	4.5	2.6
ST 40	2.7	4.6	3.9	2.1	1.0	2.0	1.7	1.2	1.8	1.5	2.6	3.0	2.4	1.1
ST 41		5.9	6.1	3.3	0.1	2.0	1.7	0.9	0.8	1.6	1.1	1.5	2.3	2.0
ST 42	2.6	4.5	1.8	2.5	0.2	1.0	1.0	1.1	1.2	0.2	0.9	3.0	1.7	1.3
ST 43	2.6	4.1	4.4	1.9	1.5	1.6	2.1	1.7	1.4	1.1	0.2	1.7	2.0	1.2
ST 44	3.2	3.6	3.4	2.0	0.9	1.9	2.4	1.6	1.6	0.5	1.0	1.6	2.0	1.0
ST 45	2.1	3.5	3.9	3.5	1.5	2.6	2.5	1.8	1.2	1.0	1.6	3.7	2.4	1.0
ST 49	3.3	4.4	2.6	2.5	1.6	2.7	3.4	1.7	2.5	1.7	7.4	6.2	3.3	1.8
ST 50	2.1	6.5	2.7	2.5	0.8	1.8	3.5	4.6	0.0	0.0	3.8	7.7	3.0	2.4
ST 51	2.6	6.6	2.7	3.3	1.8	1.8	2.5	4.3	3.7	1.2	4.7	6.2	3.5	1.7
ST 55	5.2	11.3	11.3	4.3	2.8	2.9	2.9	7.3	3.5	1.7	7.4	11.5	6.0	3.6
ST 56	9.3	10.9	4.1	4.8	3.7	3.0	6.8	3.6	4.5	6.9	6.9	8.4	6.1	2.5
ST 57	7.3	11.3	3.6	6.8	3.2	2.7	9.9	3.5	6.3	5.5	5.0	6.4	5.9	2.7
ST 64	1.7	3.5	2.8	2.0	2.3	1.0	1.0	2.5	0.7	1.1	2.4	1.4	1.9	0.9
ST 65	4.2	3.8	3.3	2.6	0.8	1.2	1.2	3.0	0.9	0.2	4.3	1.7	2.3	1.4
ST 66	2.6	3.2	3.8	1.6	1.6	1.6	1.6	7.2	1.0	2.1	1.5	1.0	2.4	1.7
ST 67		3.9	2.6	4.1	1.4	3.2	4.8	2.6	4.7	3.7	8.3	7.5	4.3	2.1
ST 68		4.5	2.6	2.8	2.0	7.5	7.0	6.3	1.7	2.9	6.5	9.5	4.8	2.6
ST 69		6.3	3.2	3.5	1.2	6.5	41.6	2.1	4.1	3.4	4.4	10.8	7.9	11.5
ST 70		7.1	11.3	7.2	9.1	5.9	6.3	7.7	8.3	13.1	6.6	4.6	7.9	2.4
ST 71		6.8	11.3	5.7	11.1	7.4	4.1	6.1	7.0	7.8	8.4	13.7	8.1	2.8
ST 72		6.9	11.3	5.1	7.8	10.8	5.1	1.6	9.5	11.7	8.0	4.8	7.5	3.2
ST 76	2.5	3.4	3.0	1.9	0.9	1.0	2.1	1.1	0.9	1.1	2.0	1.5	1.8	0.8
ST 77	3.5	4.1	1.5	2.7	1.1	1.6	1.5	1.5	0.6	0.5	0.1	1.2	1.6	1.2
ST 78	2.8	4.2	2.3	2.3	0.8	0.8	1.9	0.3	0.6	0.1		1.2	1.6	1.2
ST 79		2.1	0.2	0.5	0.2		0.3	0.3	0.1	0.1		0.2	0.5	0.6
ST 80	0.5	0.9	0.6	0.2	0.0	0.1	0.8	0.2	0.7	0.3		0.2	0.4	0.3
ST 81	0.5	1.8	1.0	0.2	0.0	0.1	0.3	1.8	0.1	0.0	0.2	0.2	0.5	0.7
ST 82	2.4	3.3	2.9	3.3	0.5	1.7	3.6	1.5	2.6	3.2	0.7	4.3	2.5	1.2
ST 83	2.5	3.8	3.2	2.3	1.4	1.8	2.1	0.9	1.1	0.6	0.0	3.3	1.9	1.2
ST 84	2.7	5.3	2.1	2.5	0.6	2.1	1.2	3.4	1.2	1.7	0.5	1.7	2.1	1.3
ST 85	5.7	6.5	4.5	8.9	4.2	5.7	3.3	5.3	13.5	16.4	3.8	4.7	6.9	4.1
ST 86		8.9	4.6	19.6	9.5	4.5	4.3	4.8	2.6	4.7	10.6	7.1	7.4	4.8
ST 87		4.6	8.2	17.3	3.9	0.9	2.7	5.1	2.5	9.7	7.4	6.1	6.2	4.5
ST 200	1.1	2.0	0.8	1.2	2.8	1.4	0.7	1.0	1.4	0.5	1.0	0.2	1.2	0.7
Per Avg	3.8	5.4	4.1	3.9	2.3	2.7	3.6	2.9	2.5	3.0	3.5	4.6	**Gr Avg**	**3.5**
Stdev	2.1	2.5	2.7	3.6	2.4	2.2	5.7	1.8	2.5	3.5	2.6	3.3	**Stdev**	**3.2**

Table A3. 1994 Secchi depth data.

STA/WK	94/1	94/2	94/3	94/4	94/5	94/6	94/7	94/8	94/9	94/10	94/11	94/12	Sta Avg	Stdev
ST 1	2.00	2.50	2.00	2.00	2.00	3.00	2.50	2.50	2.25	2.00	2.75	2.00	2.29	0.35
ST 2	2.00	2.50	2.00	2.00	2.00	2.75	2.50	2.75	2.25	2.50	3.00	2.00	2.35	0.36
ST 3	1.50	2.00	2.00	2.00	1.50	2.50	2.50	2.00	2.00	2.00	2.50	2.00	2.04	0.33
ST 4	1.50	2.25	2.12	2.50	2.65	2.70	2.50	2.00	2.10	2.00	1.90	1.25	2.12	0.44
ST 5	1.50	1.75	2.25	2.65	2.70	2.35	2.40	2.00	1.75	1.75	1.90	1.75	2.06	0.40
ST 6	1.50	1.75	2.25	2.25	2.55	2.45	2.25	2.30	2.25	2.00	2.00	2.10	2.14	0.29
ST 7	2.00	2.75	3.50	4.00	3.00	3.75	3.50	3.50	2.75	2.50	3.50	3.00	3.15	0.58
ST 8	2.13	2.50	3.25	4.00	3.00	3.50	3.50	3.50	2.50	3.00	2.75	3.00	3.05	0.53
ST 9	2.00	3.00	3.25	3.00	3.00	2.75	3.25	3.00	2.50	3.00	3.00	2.75	2.88	0.35
ST 10	2.00	2.50	2.75		2.75	3.25	3.50	3.50		3.00	2.75	2.25	2.83	0.50
ST 11	2.50	2.50	2.75		2.50	3.00	3.25	3.25		3.00	3.00	2.25	2.80	0.35
ST 12	2.50	2.50	2.75		2.50	3.00	3.25	3.25		2.75	3.25	2.50	2.83	0.33
ST 13	2.00	2.00	2.50	2.75	2.75	3.25	2.75	3.00	2.50	2.50		2.25	2.57	0.39
ST 14	1.75	2.00	2.50	2.75	2.50	3.00	2.75	2.75	2.50	2.25		2.00	2.43	0.39
ST 15	1.75	2.00	2.25	2.75	2.25	2.75	2.50	2.50	2.50	2.25		1.75	2.30	0.35
ST 16	1.80		1.90	2.40	2.00	1.90	2.30	2.00	2.00	1.80	2.00	1.80	1.99	0.20
ST 17	1.70		1.65	2.00	1.80	1.70	2.10	2.00	1.80	1.80	1.50	1.80	1.80	0.17
ST 18	1.70		1.75	2.10	2.30	1.80	2.20	1.90	1.80	1.90	1.80	2.00	1.93	0.20
ST 25	2.50	2.50		3.00	2.75	2.75	3.50	3.50	3.00	2.50	3.00	3.00	2.91	0.36
ST 26	2.50	2.50		2.75	2.75	2.50	4.00	3.25	2.75	2.50	2.75	3.50	2.89	0.49
ST 27	2.50	2.50		3.00	2.75	2.25	3.25	3.50	2.50	2.50	2.50	2.50	2.70	0.38
ST 28			3.00	3.50	4.25	4.00			3.00				3.55	0.57
ST 29			3.00	3.75	3.75	3.50			2.75				3.35	0.45
ST 30			2.00	3.25	3.50	3.00			2.75				2.90	0.58
ST 31	1.50	1.75	1.75	2.00	1.75	1.50	2.00	2.00	1.75	1.75	1.75	1.25	1.73	0.23
ST 32	2.00	2.50	2.50	2.75	2.75	2.75	3.00	2.75	2.50	2.50	2.00	2.50	2.54	0.30
ST 33	2.00	2.75	3.00	2.75	3.00	3.00	3.25	3.00	2.75	3.00	3.00	2.75	2.85	0.31
ST 37	1.90		2.25	2.50	2.80	3.20	3.00	2.70	2.10	2.10	2.50	2.00	2.46	0.43
ST 38	2.00		2.40	2.90	3.00	3.00	3.00	2.80	2.10	2.20	2.60	2.00	2.55	0.42
ST 39	1.80		2.70	3.00	3.00	3.60	3.50	3.50	2.20	2.50	3.00	2.20	2.82	0.60
ST 40	1.25	1.50		1.50	1.50		2.00	1.75	1.50	1.88	2.00	1.75	1.66	0.25
ST 41	1.50	1.50		1.25	1.25		1.50	1.50	1.25	1.13	1.50	1.00	1.34	0.19
ST 42	1.75	1.63		2.25	1.75		2.00	1.75	1.50	2.00	2.00	2.00	1.86	0.22
ST 43	2.25	3.00	3.50	3.50	3.25	4.00	4.25	4.00	3.50	4.00	4.00	3.75	3.58	0.56
ST 44	2.00	3.00	3.00	3.75	3.25	3.75	3.50	4.00	3.25	4.25	4.25	3.75	3.48	0.63
ST 45	2.00	2.75	3.50	3.50	3.00	3.00	4.00	3.75	3.50	3.75	3.75	3.75	3.35	0.57
ST 49	2.25	3.00	3.00	2.50	2.50	2.50	2.50		2.63		2.50	2.50	2.59	0.24
ST 50	2.00	3.50	2.50	2.00	2.50	2.50	2.50		2.25		2.50	2.00	2.43	0.44
ST 51	2.00	3.25	2.50	2.00	2.50	2.00	2.00		2.75		2.25	2.00	2.33	0.43
ST 52		1.50	1.75	1.75	2.00	2.50	2.00	1.50	1.75	1.50	1.75	1.50	1.77	0.31
ST 53		1.25	1.25	1.75	1.50	2.25	2.25	1.50	1.50	1.50	1.50	1.50	1.61	0.34
ST 54		1.25	2.00	2.00	2.00	2.25	2.00	1.75	1.50	1.50	1.50	1.50	1.75	0.32
ST 55	1.25	1.00	1.50	1.50	1.50	1.50	2.00		1.50	1.50	1.25	1.50	1.45	0.25
ST 56	1.25	1.00	1.50	1.75	1.50	1.25	1.75		1.50	1.50	1.25	1.50	1.43	0.23
ST 57	1.25	1.00	1.50	1.75	1.50	1.50	1.75		1.50	1.25	1.25	1.50	1.43	0.23
ST 58	2.00	2.25		2.25	2.00	2.50	2.50	1.75	2.00	2.00	2.50	2.50	2.20	0.27
ST 59	2.00	2.25		2.25	2.00	2.50	3.00	2.25	2.50	2.25	2.75	3.00	2.43	0.36

(Table A3 continued on next page)

Table A3 1994 Secchi depth data(cont'd).

STA/WK	94/1	94/2	94/3	94/4	94/5	94/6	94/7	94/8	94/9	94/10	94/11	94/12	Sta Avg	Stdev
ST 60	2.00	2.50		3.25	2.50	2.75	2.75	2.50	2.25	2.50	2.75	3.00	2.61	0.34
ST 60.5	2.00	2.50		2.25	2.00	1.75	2.25	2.00	1.75	2.00	2.25	2.50	2.11	0.26
ST 61	1.50	1.75	1.75	1.75	1.50	1.50	1.50	1.25	1.25	1.50	1.50	1.50	1.52	0.17
ST 62	1.75	1.50	1.75	1.75	1.75	1.50	1.50	1.25	1.50	1.50	1.75	1.75	1.60	0.17
ST 63	1.50	1.75	1.75	1.75	1.50	1.50	1.50	1.25	1.50	1.75	1.75	1.75	1.60	0.17
ST 64	1.70	2.40	2.80	3.50	3.25	3.00	3.25	3.00	3.25	2.80	3.50	3.00	2.95	0.50
ST 65	1.80	2.50	3.00	3.50	4.00	3.60	3.50	3.50	3.50	4.00	3.50	3.00	3.28	0.63
ST 66	1.80	2.20	2.75	3.50	3.75	3.50	3.50	3.00	3.50	3.75	3.50	2.80	3.13	0.63
ST 67			2.75	2.25	2.50	2.75	2.50	2.50	2.25	2.25	2.00	1.75	2.35	0.32
ST 68			2.00	2.25	2.25	2.25	2.25	2.25	2.00	2.00	1.75	1.75	2.08	0.21
ST 69			1.75	2.25	2.00	2.50	2.00	2.25	1.75	2.00	1.75	1.75	2.00	0.26
ST 70		1.25	1.00	1.75	1.50	1.50	1.75	1.50	1.50	1.50	1.50	1.75	1.50	0.22
ST 71		1.25	1.00	1.50	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.41	0.17
ST 72		1.50	1.00	1.75	1.25	1.50	1.75	1.50	1.50	1.50	1.50	1.50	1.48	0.21
ST 73	1.50	1.75	2.00	2.00	2.00	1.75	2.00	2.00	1.50	2.00	1.75	1.25	1.79	0.26
ST 74	1.50	1.75	2.00	2.00	1.75	1.75	2.00	2.00	1.50	1.75	1.75	1.25	1.75	0.24
ST 75	1.50	1.75	2.00	2.00	2.00	1.75	2.00	2.00	1.50	1.75	1.75	1.25	1.77	0.25
ST 76	1.88	2.38		3.50	3.75	2.50	3.00	2.00	2.00	3.00	3.65	3.00	2.79	0.68
ST 77	2.38	2.75		3.00	3.50	3.00	3.00	2.50	2.00	3.25	3.25	3.25	2.90	0.45
ST 78	2.13	2.38		3.50	3.50	3.00	3.00	2.50	2.00	3.00	3.25	3.00	2.84	0.52
ST 79		2.70	2.90	3.10	3.50	4.00	3.50	3.25	3.10		2.50	3.00	3.16	0.43
ST 80		2.90	2.80	3.00	3.20	3.10	3.50	3.45	3.50		3.50	3.00	3.20	0.27
ST 81		3.00	2.80	2.80	3.00	3.10	3.50	3.20	3.00		3.10	3.50	3.10	0.24
ST 82	2.00	2.75		2.00	1.50	2.50	2.75	2.50	1.75	2.00	2.00	1.50	2.11	0.45
ST 83	2.00	2.88		3.00	2.50	3.50	3.00	2.50	2.50	3.00	3.00	3.00	2.81	0.40
ST 84	2.00	2.88		3.50	2.50	3.50	3.00	2.50	2.50	3.00	3.00	3.00	2.85	0.45
ST 85	1.50	1.75	2.00	2.00	1.50	1.75		2.00	1.00	1.00	2.00	1.50	1.64	0.38
ST 86	1.50	1.75	2.00	2.00	1.50	1.75		2.00	1.00	1.00	2.00	1.25	1.61	0.39
ST 87	1.25	1.50	1.75	1.75	1.25	1.75		1.50	0.75	1.00	1.75	1.25	1.41	0.34
ST 88	1.50	1.50	2.75	2.50		2.50	3.00	2.25	2.25	2.75	3.50	3.25	2.52	0.64
ST 89	2.00	2.00	2.50	2.75		3.00	3.00	2.75	2.50	3.00	3.50	3.25	2.75	0.47
ST 90	1.25	1.25	2.50	2.75		2.75	3.00	2.50	2.25	3.25	3.50	3.50	2.59	0.78
ST 91	2.00	1.75	2.00		2.00	2.50	2.00	2.00	1.50	1.75	2.00	1.75	1.93	0.25
ST 92	1.75	2.00	2.00		2.00	2.25	2.25	1.75	1.75	1.50	1.75	1.75	1.89	0.23
ST 93	2.00	2.00	2.50		2.00	2.50	2.25	1.75	2.00	1.75	2.00	2.00	2.07	0.25
ST 94	1.10	1.25	1.75		1.25	1.75		1.25	1.75		1.50	1.00	1.40	0.29
ST 95	1.50	1.75	1.75		2.00	2.00		2.00	2.00		2.00	1.75	1.86	0.18
ST 96	1.40	1.75	2.25		2.25	2.50		2.50	2.00		2.00	1.75	2.04	0.37
Per Avg	1.81	2.12	2.28	2.52	2.38	2.56	2.64	2.42	2.15	2.24	2.40	2.20	**Gr Avg**	**2.32**
Stdev	0.34	0.61	0.60	0.68	0.74	0.70	0.68	0.72	0.64	0.74	0.75	0.73	**Stdev**	**0.70**

Table A4. 1994 Leesville Lake data (total phosphorus only).

STA/WK	94/5	94/6	94/7	94/8	94/9	94/10	94/11	94/12	Sta Avg	Stdev
ST 103	50.0	37.4	36.9	41.0	35.6	36.3	31.1	41.4	38.7125	5.5848
ST 104	92.0	55.3	95.0	74.6	50.3	75.3	33.3	40.5	64.5375	23.117
ST 105	22.0	31.1	25.0	22.2	20.8	23.9	25.0	35.0	25.625	4.9248
Per Avg	54.7	41.3	52.3	45.9	35.6	45.2	29.8	39.0	**Gr Avg**	**43.0**
Stdev	35.2	12.6	37.5	26.5	14.8	26.8	4.3	3.5	**Stdev**	**21.3**

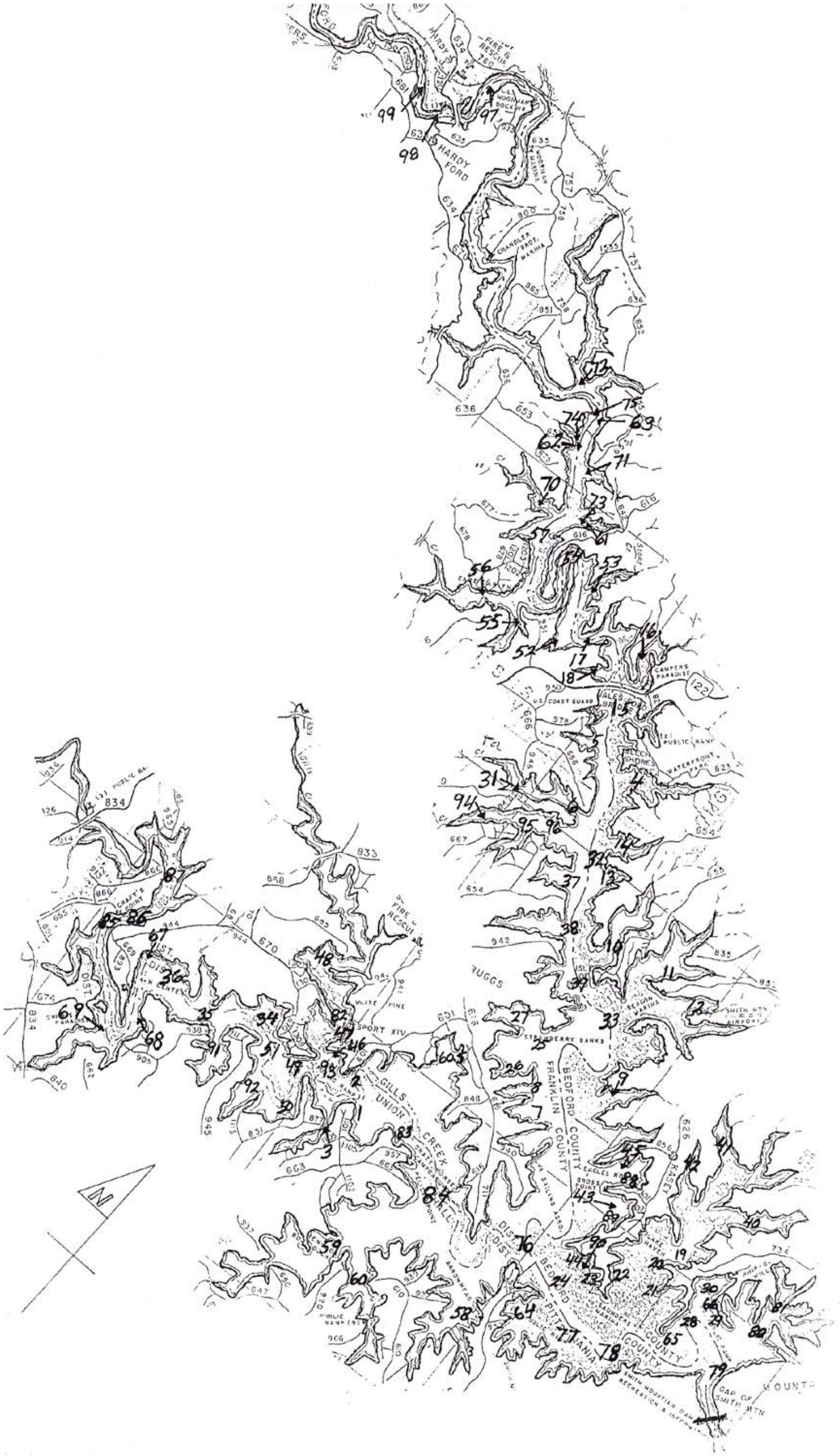

Figure A1. SMLAVWQMP Sampling stations