WATER QUALITY DATABASE EVALUATION AND TREND ANALYSIS FOR: REND LAKE

Prepared for

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1.0 EXECUTIVE SUMMARY

The purpose of this report is to provide a statistical analysis of water quality conditions within Rend Lake during the period 2001-2005. In so far as possible, these conditions are related to those described in a previous similar report dated January, 2001.

Statistical evaluations were performed using water quality data values acquired during the referenced period on a wide variety of organic, inorganic and biological parameters from a number of sampling points spread throughout the lake. Analytical data reviewed consisted of Rend Lake water quality data has been collected from a total of nine (9) distinct sites sampled by the Corps of Engineers, St. Louis District, Environmental Quality Section. Statistical analysis and trend results were evaluated for seventeen (17) parameters for all sites that contained sufficient data (i.e. more than two years data and/or a sufficient number of data points above the detection limit) on a combined and individual basis.

Data collected during the period 1989 through 2000 and evaluated during the previous study referenced above suggested an generally improving to stable water quality within Rend Lake. The most recent data discussed herein indicates that that trend is continuing.

2.0 INTRODUCTION

Water quality monitoring within the lakes and rivers under the control of the U.S. Army Corps of Engineers is essential to assure that environmental conditions are safe for human and wildlife contact and general usage. The Corps of Engineers, St. Louis District, Environmental Quality Section has maintained a database of monitoring sites within Rend Lake since 1989. The data as collected is reviewed to assure that immediate environmental conditions are within acceptable ranges. The data is then archived within a database file.

The values regarding water quality in Rend Lake which are presented herein were acquired during the calendar years 2001 to 2005. Statistical analysis of the data was performed on data sets from individual sampling sites within Rend Lake. All data for each parameter was also analyzed for trends for the entire lake system. The statistical results are compared to applicable water quality standards currently in force by regulation (State and/or Federal) or generally accepted as a good water quality range for parameters with no regulatory limit. Illinois regulations for general use waters appear in 35 Illinois Administrative Code, Section 302, Subpart B and in Illinois Integrated Water Quality Report, 2006.

Statistical analysis was performed on seven (7) surface or near surface monitoring sites within Rend Lake. A total of seventeen (17) parameters were reviewed statistically. Additional parameters were analyzed on various occasions at several of the sites but were deemed an insufficient quantity and/or time span (less than five data points or less than 2 year time span) for statistical trend analysis.

3.0 REND LAKE WATER QUALITY DATA EVALUATION

3.1 Data Sets

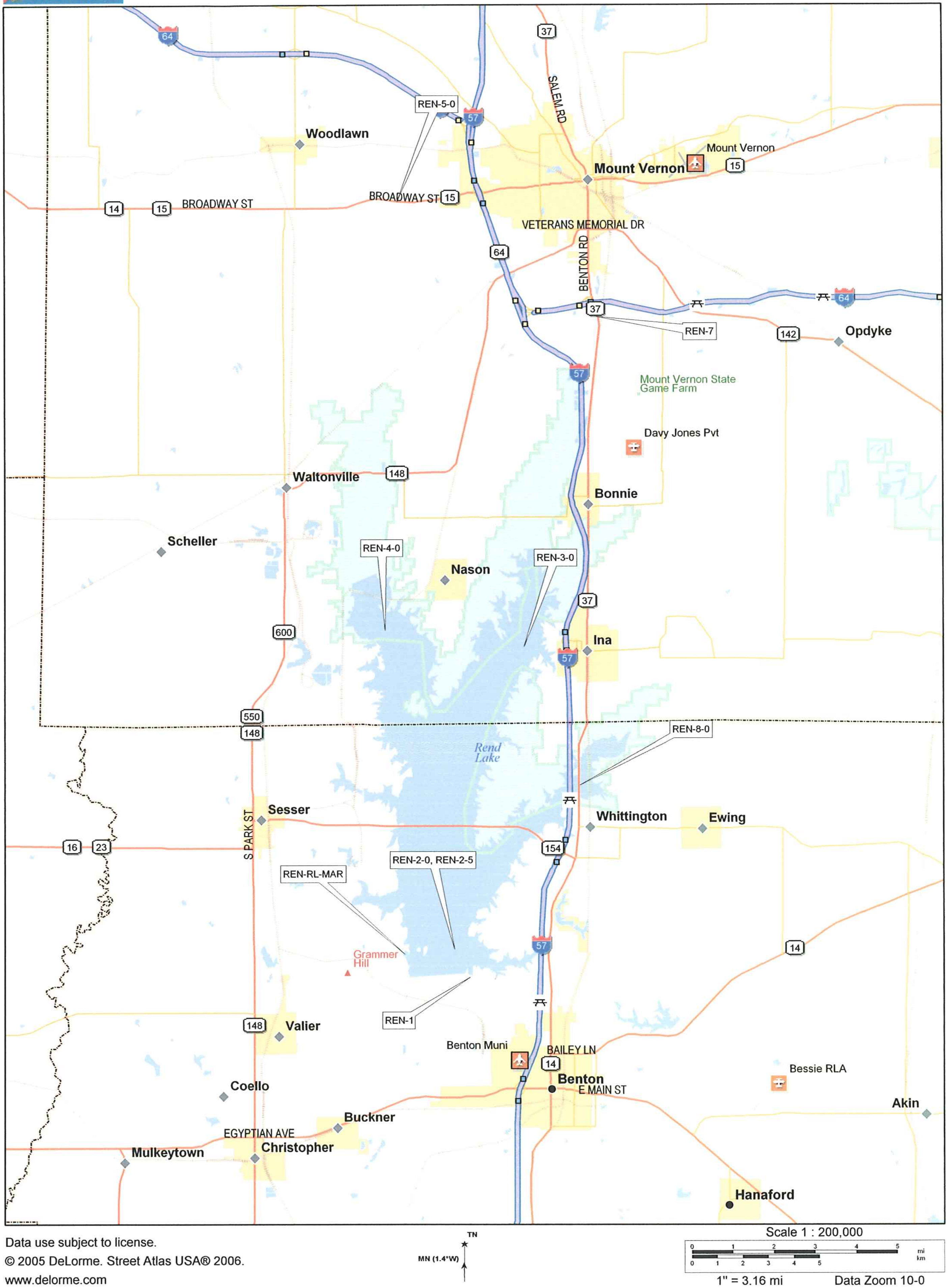
Data sets evaluated for Rend Lake originated from field sampling by the St. Louis District Corps of Engineers Environmental Quality Section at nine (9) sites. Figure 1 shows the locations of these sites.

3.2 Evaluation

Evaluation of data was performed on nine (9) sites individual sites/sets and as a whole single set for each of the sites. A descriptive statistical summary of each parameter for all sites taken as a whole and for each site individually appears in Sections 3.3 and 3.4, below. The current levels are compared to State and/or Federal regulatory limits where such limits have been set. Trend analysis plots and descriptive statistics for all sites combined are provided in the various figures and tables the referenced sections. The equation for the trendline appears in the upper right hand corner of all plots. All data utilized from the monitored sites for this evaluation is provided in electronic format on CD which is attached hereto as an Appendix.. The files on the disk can be accessed with Microsoft Excel.

Figure 1 - Rend Lake Site Location Map

Street Atlas USA® 2006



3.2.1 Trend and Descriptive Statistics Analysis Summary

The descriptive statistics calculated and reviewed for the combined data sets are defined in Table 1.

3.3 Data From All Sites

3.3.1 Dissolved Oxygen

Figure 2 shows the data from all sites for Dissolved Oxygen (DO). The descriptive statistics for those data appear in the table below the plotted values.

Dissolved oxygen levels depend on temperature and atmospheric pressure as well as on the chemical and biological activities occurring in an aqueous system. Review of the figure will show that in general the observed values are in an approximate range of 5 to 10 mg/L. Most of the readings were taken in surface waters during the warmer months of late spring and early fall and approximately 75% were at or slightly above 5 mg/L, a level which is hostile to occurrences of algal blooms and which is well-recognized as favorable for fish and other aquatic life. The data indicates that the levels of DO are stable with a slight upward trend.

Note: Neither the plotted values or statistical evaluations include a grouping of nearly 50 inexplicably high values (range approximately 50 - >200 mg/L) that were reported for DO in summer of 2003 for a number of sites. The values were excluded from the plot as erroneous since they substantially exceeded the maximum possible solubility for oxygen in water at standard pressure and ambient temperatures,

A minimum quality standard of 5.0 mg dissolved oxygen/L has been established for general purpose waters Illinois.

3.3.2 pH

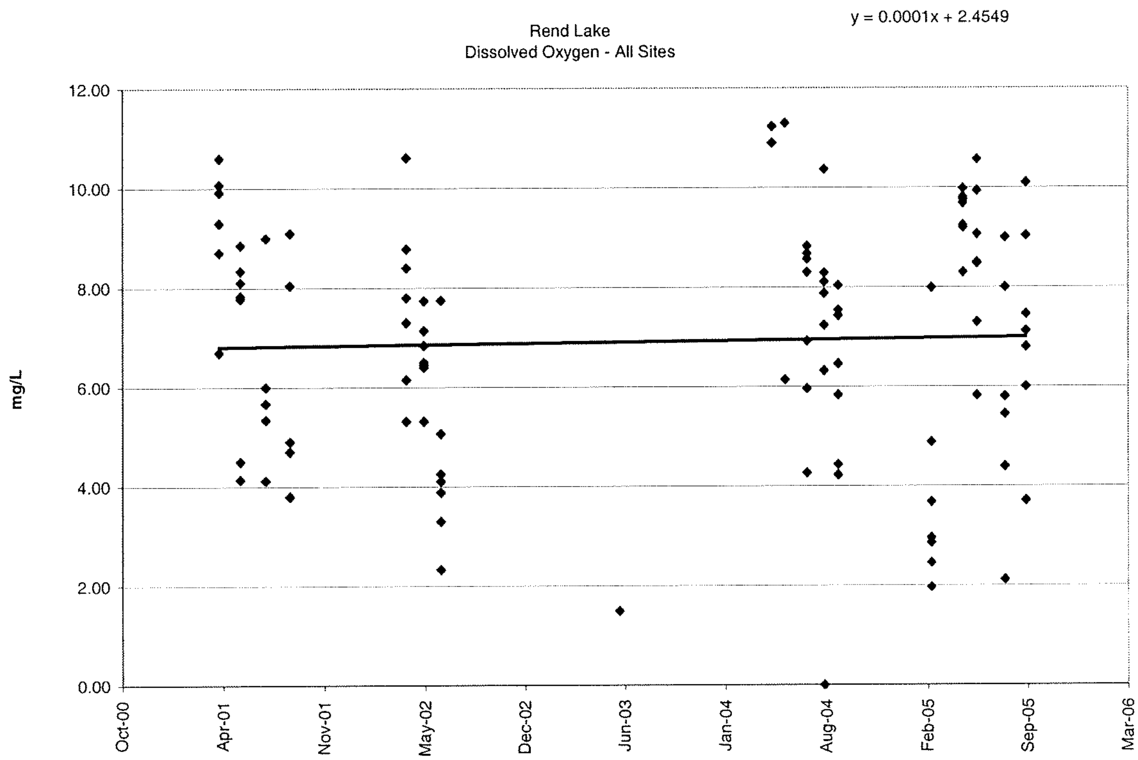
The value for pH is a logarithmic expression of the concentration of hydrogen ions. It is governed by the combined effects of dissolved gases (principally carbon dioxide) and the levels of the various salts which are present. A "neutral" system is pH 6 to 8. The pH of an acidic system is less than 6 and that of a basic system is greater than 8.

Review of the Figure 3 and the statistics in accompanying table shows that, when plotted on a logarithmic scale, individual measurements were closely similar in all sites at all times. The values, however, can be strongly influenced temporarily by local conditions associated with unusual temperatures, flooding, increased runoff, and/or erosion resulting from agricultural activities or land development. Illinois regulations specify a pH in the range 6.5 to 9 for general purpose waters. Although the some observed values fall outside that range, the mean, median and mode are at or near to neutrality and well within state guidelines. The trendline for the parameter over the five year period reflected in the plot is virtually flat, indicating that the current general conditions will remain stable in the future.

Table 1 – Definitions for Descriptive Statistics

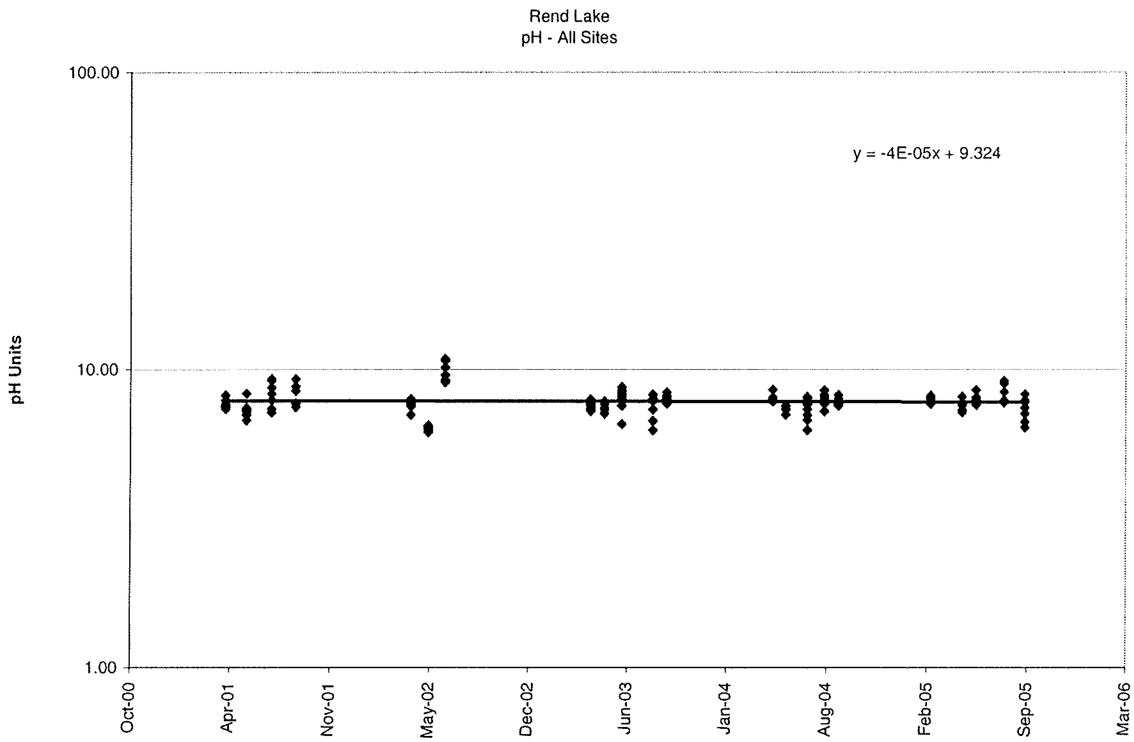
Statistic	Definition
Mean	Arithmetic average of all the data points.
Standard Error	Measure of the amount of error in the prediction of the Y(parameter of interest) data point for an individual X data point. A function of standard deviation and the number of measurements made.
Median	Number in the middle of a set of numbers; that is, half the numbers have values that are greater than the median, and half have values that are less.
Mode	Most frequently occurring, or repetitive, value in an array or range of data.
Standard Deviation	Measure of how widely values are dispersed from the average value
Variance	Calculation of potential difference from the norm/mean.
Kurtosis	Characterizes the relative peakedness or flatness of a distribution compared with the normal distribution. Positive kurtosis indicates a relatively peaked distribution. Negative kurtosis indicates a relatively flat distribution
Skewness	Characterizes the degree of asymmetry of a distribution around its mean. Positive skewness indicates a distribution with an asymmetric tail extending toward more positive values. Negative skewness indicates a distribution with an asymmetric tail extending toward more negative Values

Figure 2



Statistic	Value
Mean	7.0
Standard Error	0.232
Median	7.30
Mode	6
Standard Deviation	2.36
Sample Variance	5.6
Kurtosis	-0.68
Skewness	-0.32
Range	9.8
Minimum	1.5
Maximum	11.30
Sum	719
Count	103

Figure 3



Statistics	**Values**
Mean	7.4
Standard Error	0.149
Median	7.64
Mode	8
Standard Deviation	1.61
Sample Variance	2.6
Kurtosis	0.40
Skewness	-0.48
Range	8.4
Minimum	6.2
Maximum	10.8
Sum	870
Count	117

3.3.3 ORP (Oxidation Reduction Potential)

Figure 4 shows the data from all sites for ORP. The descriptive statistics for those data appear in the table below the plotted values.

ORP is a logarithmic function dependent upon the net effects and the balance of the complex interactions of dissolved components, pH, temperature and other variables. A positive ORP indicates an excess of oxidizing components and a negative ORP indicates an excess of reducing agents. In general terms, a positive ORP is considered beneficial since the system is healthy and operating aerobically. A negative ORP, however, indicates that the system is operating anaerobically, a condition which sometimes leads to generation of objectionable odors through putrefaction.

Linear and logarithmic values of ORP data are plotted in Figures 4A and 4B. The linear plot of ORP determinations (Figure 4A) emphasizes the variability in the individual measurements and tends to mask the reason for the relatively strong decline in the trendline over the period studied. Plotted logarithmically (Figure 4B), the negative slope of the line is better defined. Review of the figures will show that during the period studied, the mean of the values observed for ORP decreased steadily from a high of approximately 350 to a low of about 125. The data indicate that this trend will continue. An excess of oxygen (and, consequently, a positive ORP) is ensured by the observed rate of oxygen transfer from the atmosphere into lake waters and the low to moderate oxygen demand imposed by the levels of organic materials present in those wares.

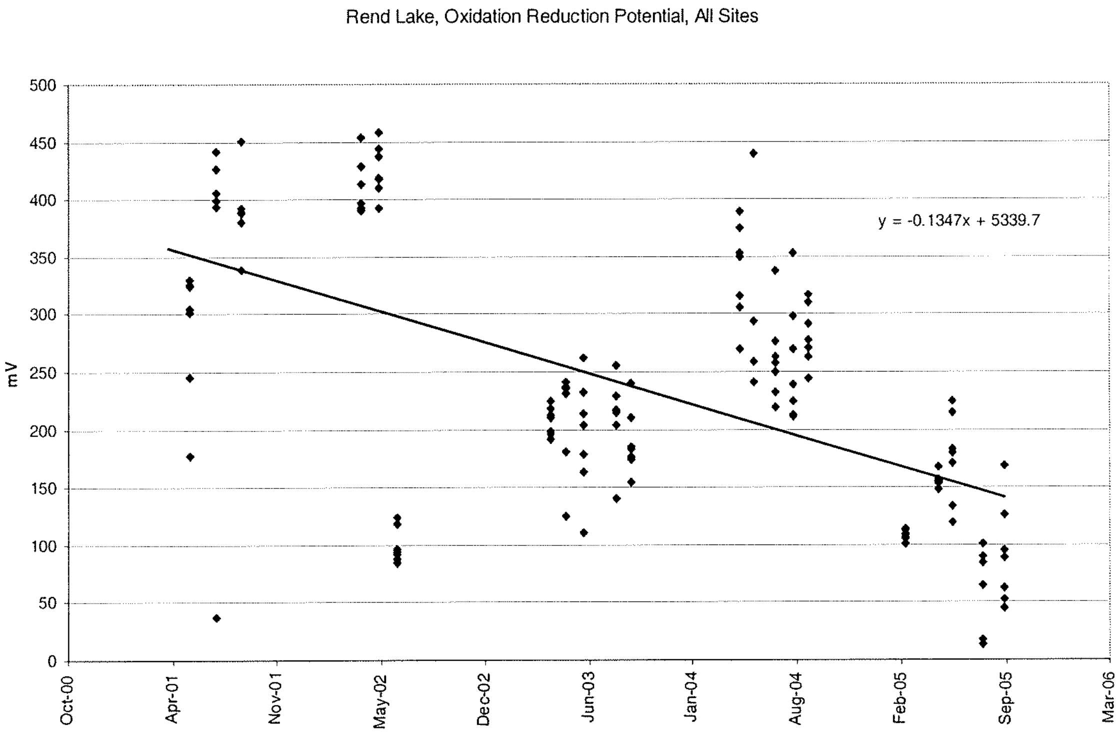
No specific regulations for ORP in general purpose waters have been generated by the states or federal government.

3.3.4 Conductivity

The data for conductivity appear in Figure 5.. The descriptive statistics for those data are in the table below the plotted values.

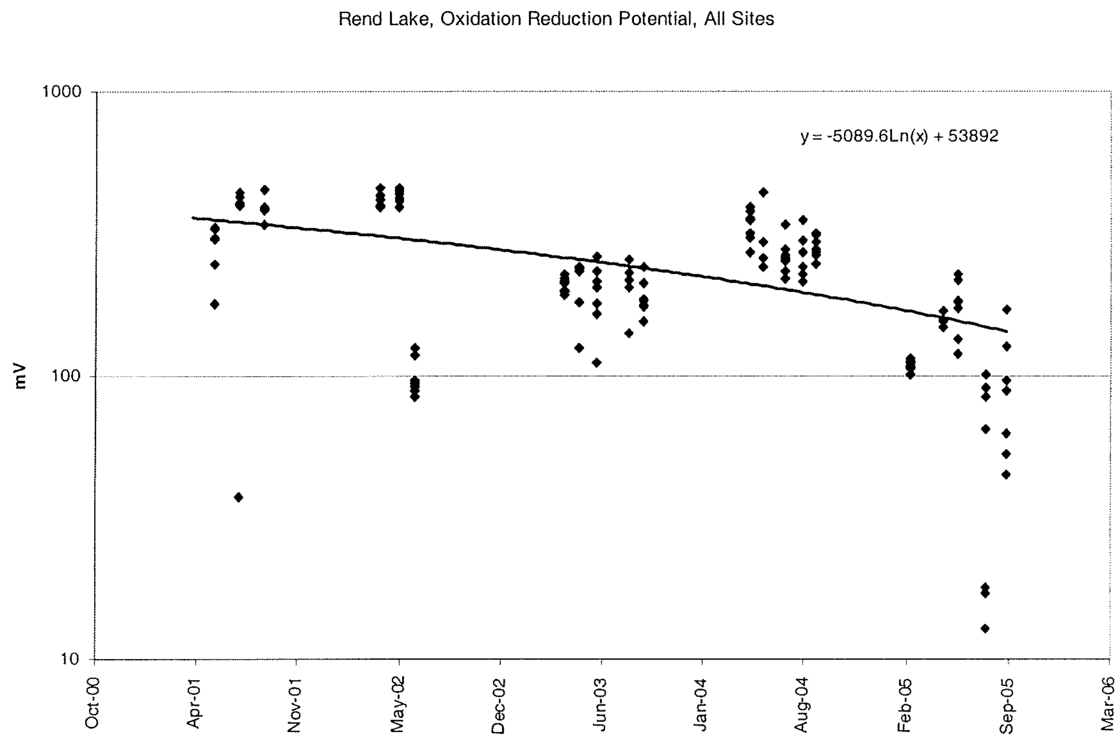
Conductivity in an aqueous system is governed by the concentrations, mobility, oxidation state and other properties of dissolved ionized substances. Conductivity is also directly proportional to temperature and an approximate 2% rise in conductance of water occurs for every 1° C rise in temperature in the system. Many of the ionized substances present in natural waters (especially carbonates which also impact system pH) are leached from local and watershed soil and rocks and many more are introduced by runoff from agricultural and land development activities. Most of the nutrients from agricultural runoff are ionized.

Figure 4a



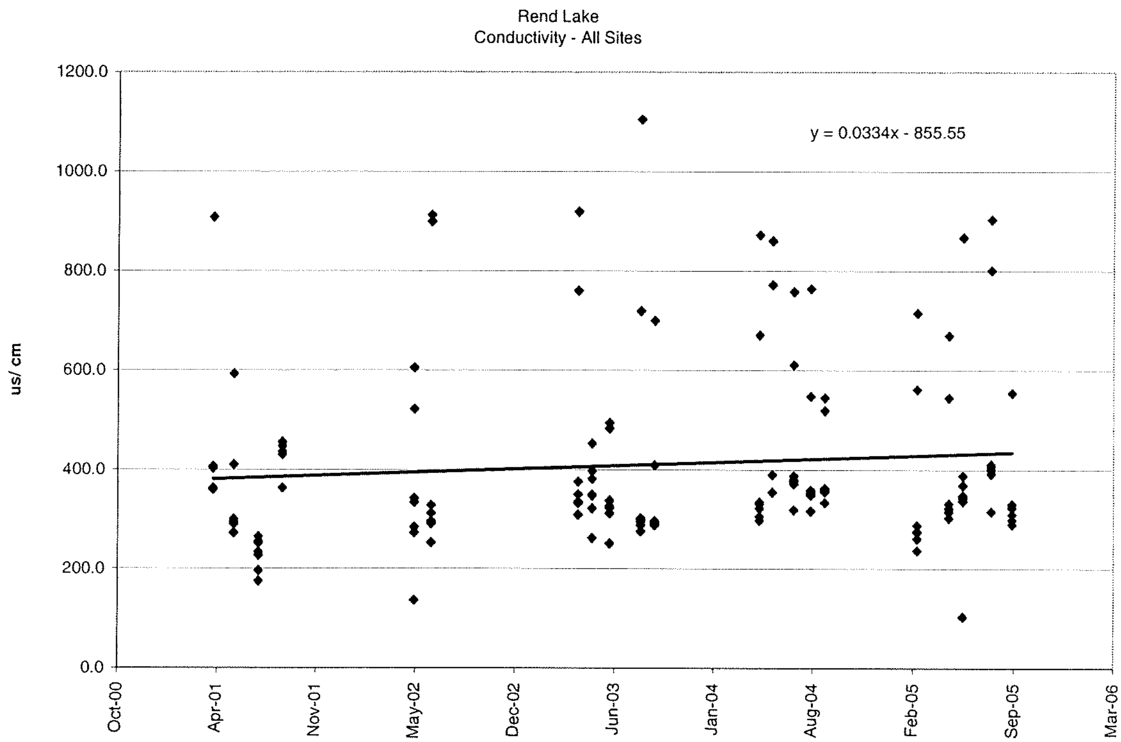
Statistics	**Values**
Mean	236.0
Standard Error	9.605
Median	225.00
Mode	406
Standard Deviation	114.85
Sample Variance	13191.3
Kurtosis	-0.87
Skewness	0.21
Range	445.1
Minimum	12.9
Maximum	458.00
Sum	33749
Count	143

Figure 4B



Statistics	Values
Mean	236.0
Standard Error	9.605
Median	225.00
Mode	406
Standard Deviation	114.85
Sample Variance	13191.3
Kurtosis	-0.87
Skewness	0.21
Range	445.1
Minimum	12.9
Maximum	458.00
Sum	33749
Count	143

Figure 5



Statistics	Values
Mean	411.1
Standard Error	15.566
Median	348.00
Mode	363
Standard Deviation	185.49
Sample Variance	34405.4
Kurtosis	2.10
Skewness	1.62
Range	1001.3
Minimum	103.7
Maximum	1105.00
Sum	58375
Count	142

The complex of interactions which determines conductivity tends to make individual readings highly variable. The data acquired during the subject study reflect that variability. The mean, mode and median of the values, however, are all within a reasonable range and there is a slight upward trend in those values. The data suggest that future values for this property will be within the range found during the current study.

A standard for conductivity of 1667 uS/cm has been established for general purpose waters in Illinois,

3.3.5 Total Suspended Solids

The data for total suspended solids appear in Figure 6.. The descriptive statistics for those data are in the table below the plotted values.

Suspended solids affect the clarity and appearance of water. In general, these solids are soil and/or plant particulates introduced to the system by local or watershed erosion or biomaterials produced by aquatic flora and fauna. Individual measurements taken at separate sites in the system are quite often highly variable because of localized effects. Except for a single value, however, the data acquired during the subject study are similar to those collected previously except that the trend of the most recent data is downward. The value not shown (139 mg/L observed in July, 2001) was excluded from the plot in Figure 6 as an outlier since it was more than twice as large as the largest of the remaining values and 7 times the average value.

No quality standard has been set by Illinois for suspended solids in general purpose waters.

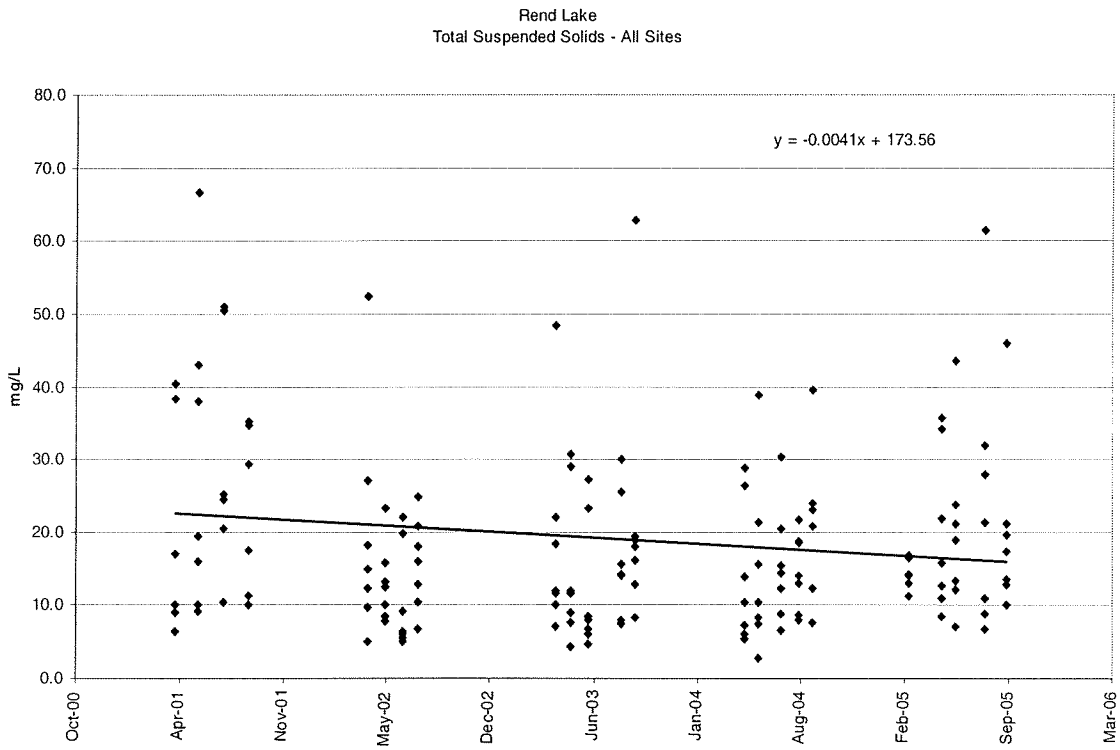
3.3.6 Volatile Suspended Solids

The data for volatile suspended solids appears in Figure 7.. The descriptive statistics for those data appear in the table below the plotted values.

Volatile suspended solids are usually organic and impact on the oxygen levels as they degrade. In general, those materials were found in low concentration at levels that were approximately one quarter of total solids. The trendline is flat, indicating that the current values are stable and that future determinations will be similar in distribution and magnitude.

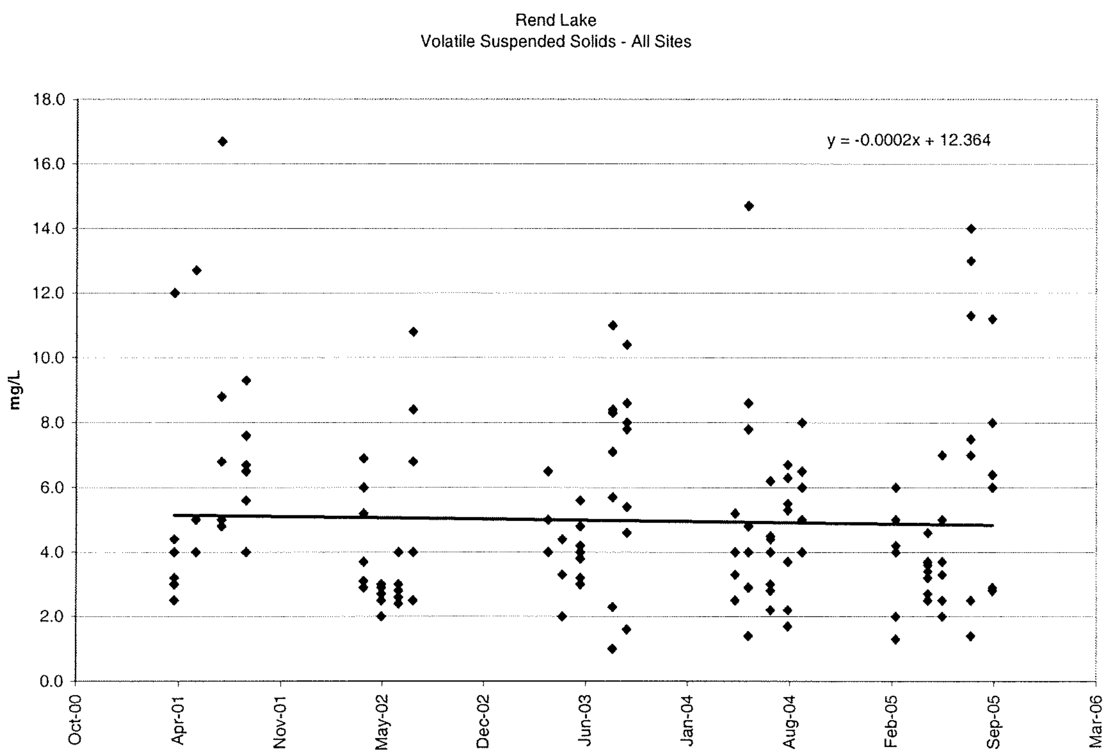
There is no standard set by Illinois for volatile suspended solids in general purpose waters

Figure 6



Statistics	Values
Mean	19.07
Standard Error	1.232
Median	14.65
Mode	10
Standard Deviation	15.58
Sample Variance	242.7
Kurtosis	22.05
Skewness	3.62
Range	136.3
Minimum	2.7
Maximum	139.00
Sum	3051
Count	160

Figure 7



Statistics	Values
Mean	4.98
Standard Error	0.220
Median	4.00
Mode	4
Standard Deviation	2.78
Sample Variance	7.7
Kurtosis	3.00
Skewness	1.59
Range	15.7
Minimum	1.0
Maximum	16.70
Sum	797
Count	160

3.3.7 Total Phosphorus

The data for total phosphorus appear in Figure 8. The descriptive statistics for those data are in the table below the plotted values.

Phosphorus is an active nutrient. Elevated levels of the element in virtually any form (and other nutrients as well) add to the risk of algal blooms and other problems associated with eutrophication-related water quality problems. The principal source of these materials is runoff from agricultural activities. The data presented here is similar in average, median value and modal value to that acquired during previous studies. The trendline is flat indicating that the characteristic is stable and that future data will parallel the values shown in Figure 8.

The average of these data exceeds the current quality standard for general use waters in Illinois (0.05 mg/L) by a factor of approximately 3 and the maximum values observed are in the order of 8 to 9 times the prescribed level. Based on the considerations outlined on page 32 of the 2006 Illinois Water Quality Report referenced above (see section 2.0). however, the lake remains acceptable as a Category 2 water since the none of the other uses are impaired.

3.3.8 Soluble Phosphorus (ortho Phosphate)

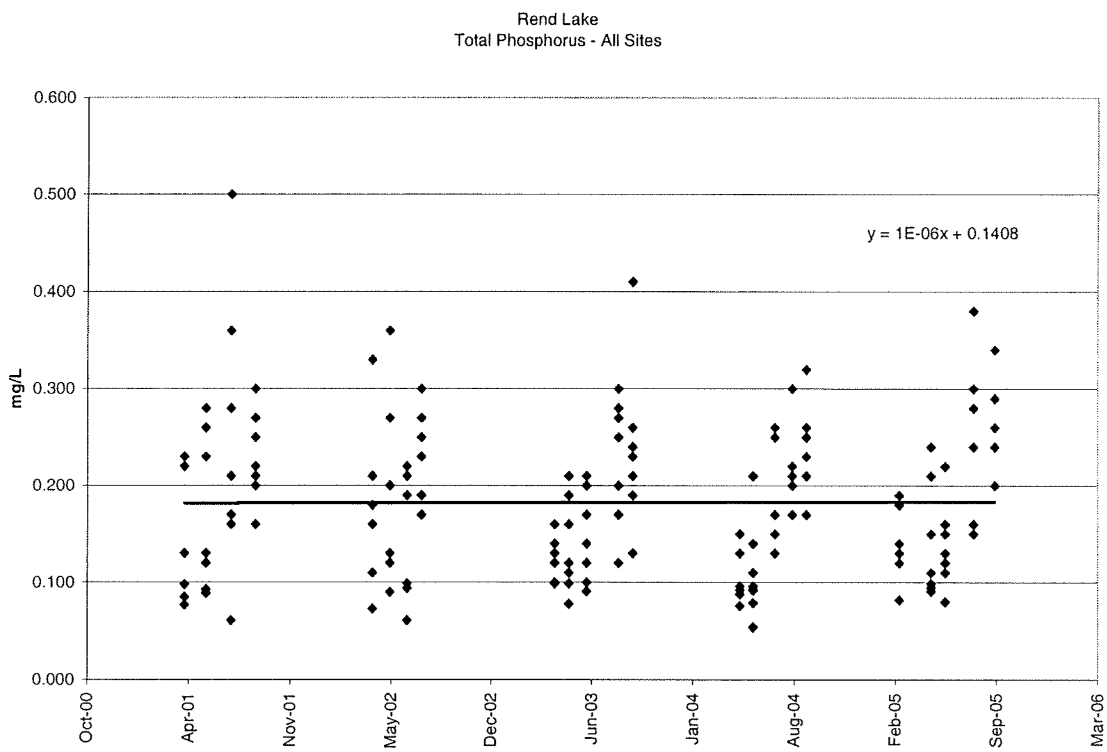
The data for ortho-phosphate appears in Figure 9. The descriptive statistics for those data appear in the table below the plotted values.

The data plotted in Figure 9 show the proportion of total phosphorus which is in soluble form. The remarks relative to the action, environmental threat potential and origin of total phosphorus given in the previous section apply to soluble forms as well.

Although slightly higher, the mean and range of the most recent data is similar to that collected previously. Evaluation of the data shows that the annual average for soluble phosphorus at all sites rose slightly to a peak in 2003 and thereafter began to decline. In a significant proportion of the data pairs, soluble phosphorus is approximately one-fourth total phosphorous, a value indicating that the profile of the nutrient in lake waters is stable.

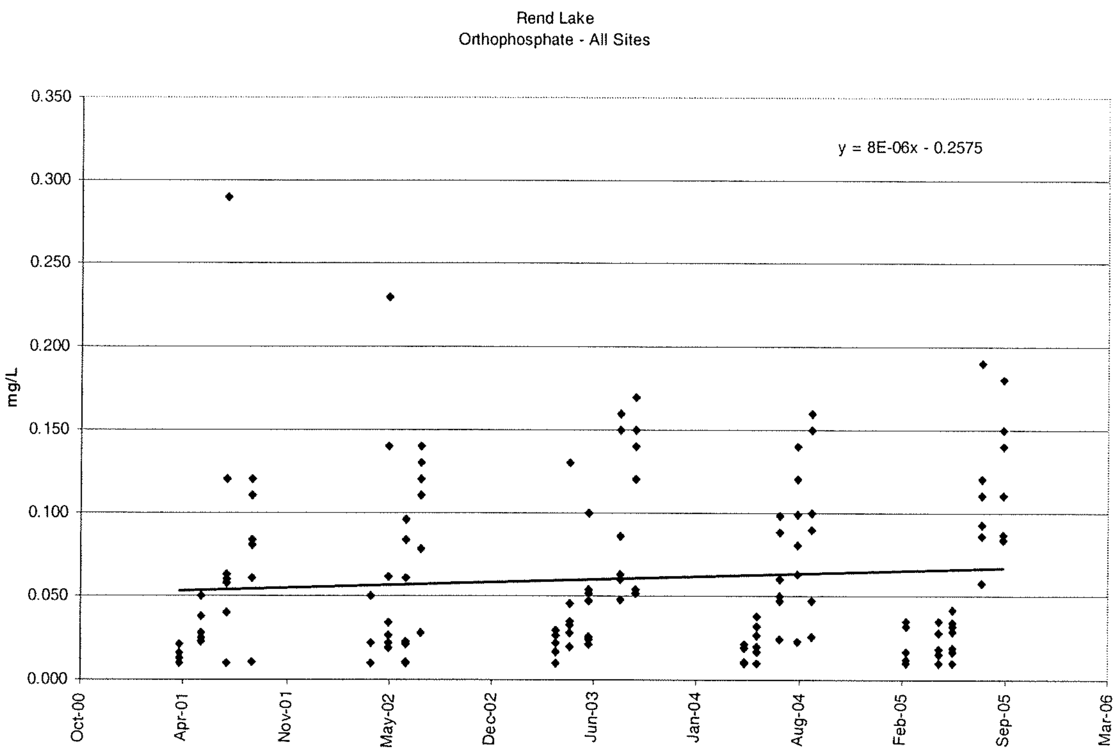
There is no water quality standard for this characteristic published by Illinois.

Figure 8



Statistics	Values
Mean	0.18
Standard Error	0.006
Median	0.17
Mode	0.21
Standard Deviation	0.08
Sample Variance	0.0
Kurtosis	0.71
Skewness	0.76
Range	0.4
Minimum	0.1
Maximum	0.50
Sum	29
Count	160

Figure 9



Statistics	Values
Mean	0.06
Standard Error	0.004
Median	0.04
Mode	0.01
Standard Deviation	0.05
Sample Variance	0.0
Kurtosis	1.66
Skewness	1.28
Range	0.3
Minimum	0.0
Maximum	0.29
Sum	10
Count	160

3.3.9 Nitrate

The data for nitrate appear in Figure 10. The descriptive statistics for those data are in the table below the plotted values.

Nitrate, like phosphorus, is an active nutrient and can have a detrimental environmental effect when it degrades to nitrite, a nutrient for algae. Nitrates may be introduced into water systems by the decay of nitrogenous organic matter or runoff from both agricultural or industrial sites.

The mean nitrate level at all sites found in previous work was slightly above 6 mg/L. Although some values in that approximate range were observed during current study, however, the mean value of 0.35 mg/L was significantly lower. These new data show that, in this regard, there has been a substantial, relatively recent improvement in the quality of the lake waters. The more recent data, however, were acquired using an analytical method with a lower detection limit. The effect of that reduction may be the cause of the apparent improvement in water quality in the system.

There is no water quality standard for nitrate on record in Illinois. The limit for finished water, however, is 10 mg/L.

3.3.10 Ammonia

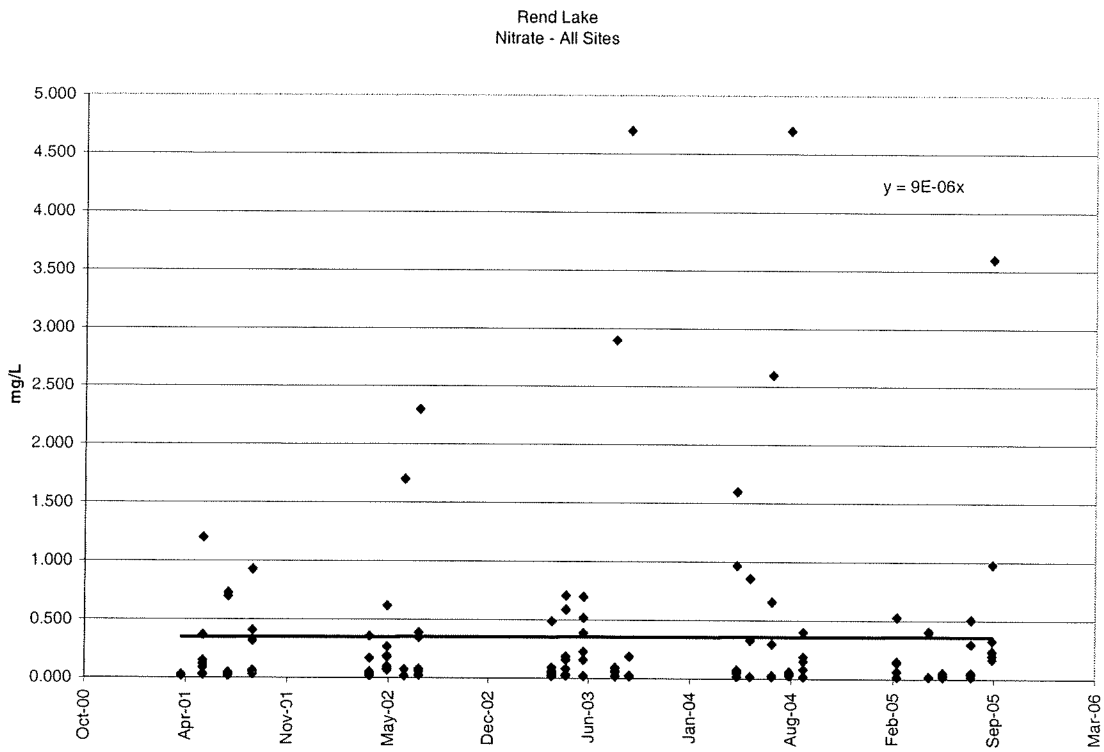
The data for ammonia appear in Figure 11. The descriptive statistics for those data are in the table below the plotted values.

Like phosphorus and nitrate, ammonia is an active nutrient. It may be present in runoff from agricultural or industrial sites, may form in aqueous systems from the decay of nitrogenous wastes or may indicate the presence of improperly treated discharges from waste treatment plants.

The mean and median levels of ammonia observed in both the current and previous studies are closely similar. The data show that the profile of ammoniacal entities in the lake is stable.

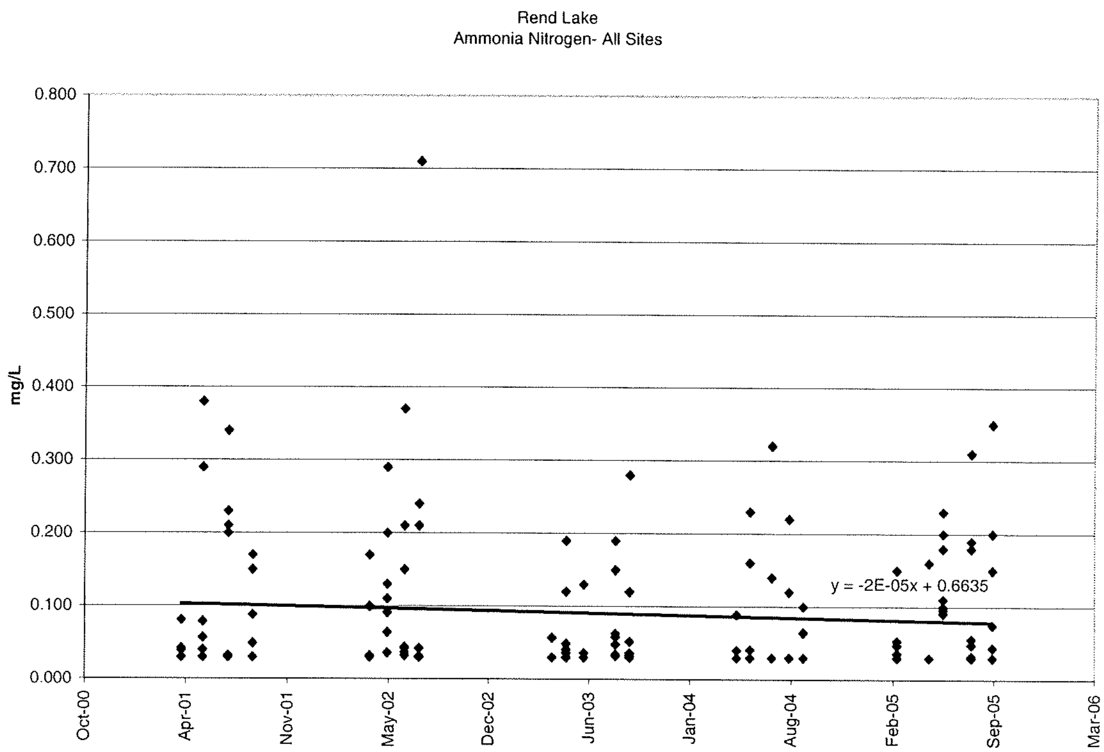
The current level of ammoniacal components in Rend Lake water is well below the water quality standard of 15 mg/L for total ammonia in general purpose waters in Illinois. For unionized ammonia, however, the statutory level is far lower (0.10 mg/L). This does not apply to Rend Lake waters (pH 6 to 10) found in Rend Lake since the ionization constant of ammonia ($pK_b = 4.74$) ensures that all of the compound present will be completely ionized.

Figure 10



Statistics	Values
Mean	0.35
Standard Error	0.073
Median	0.06
Mode	0.02
Standard Deviation	0.91
Sample Variance	0.8
Kurtosis	29.34
Skewness	5.00
Range	7.36
Minimum	0.04
Maximum	7.40
Sum	56
Count	157

Figure 11



Statistics	Values
Mean	0.09
Standard Error	0.008
Median	0.04
Mode	0.03
Standard Deviation	0.10
Sample Variance	0.0
Kurtosis	10.50
Skewness	2.63
Range	0.68
Minimum	0.03
Maximum	0.71
Sum	14
Count	160

3.3.11 Alachlor

The data for Alachlor at all sites appear in Figure 12.

A total of 160 samples were evaluated for the pre-emergence herbicide, Alachlor. All values observed were less than the detection limit (approximately 0.05 ug/L. The plotted data are the reporting limits. These varied from sample to sample between 1.0 and 1.4 ug/L dependent on the volume available for analysis. The data did not support use of a trendline and no descriptive statistics appear below the plotted values.

Because this compound is suspected to be carcinogenic a low regulatory limit of 2 ug/L has been set by the USEPA for drinking waters. No standard has been set by Illinois for general use waters.

3.3.12 Atrazine

The data for Atrazine at all sites appears in Figure 13. The descriptive statistics for those data appear in the table below the plotted values.

A total of 160 samples were analyzed for the herbicide, Atrazine. The reporting limit for this compound varied from sample to sample between 1.0 and 1.4 ug/L. A total of 95 of the values were below the detection limit. By convention, such values are usually plotted at the reporting limit. In this report, however, that convention was not followed. Instead only the 65 observations above the detection limit are plotted. Values less than the reporting limit (there were about 50 of these) are, by convention, estimated. One exceedingly high value (25 ug/L) was observed in a sample taken from Site 5 in June, 2004. This value is excluded from the plot (but not the statistics) to simplify scale selection. The presence of the compound has had no significant effect on water quality in Rend Lake

Because this compound is suspected to be carcinogenic a low regulatory limit of 3 ug/L has been set by the USEPA for drinking waters. No standard has been set by Illinois for general use waters.

3.3.13 Chlorophyll

The data for chlorophyll at all sites appears in Figure 14. The descriptive statistics for those data appear in the table below the plotted values.

Chlorophyll is the photosynthetic pigment present in all plant except the fungi and bacteria. There are three forms of the pigment, chlorophyll A, B and C. The concentration of chlorophyll is an indicator of the rate of formation of organic carbon from atmospheric carbon dioxide by aquatic life forms.

Figure 12

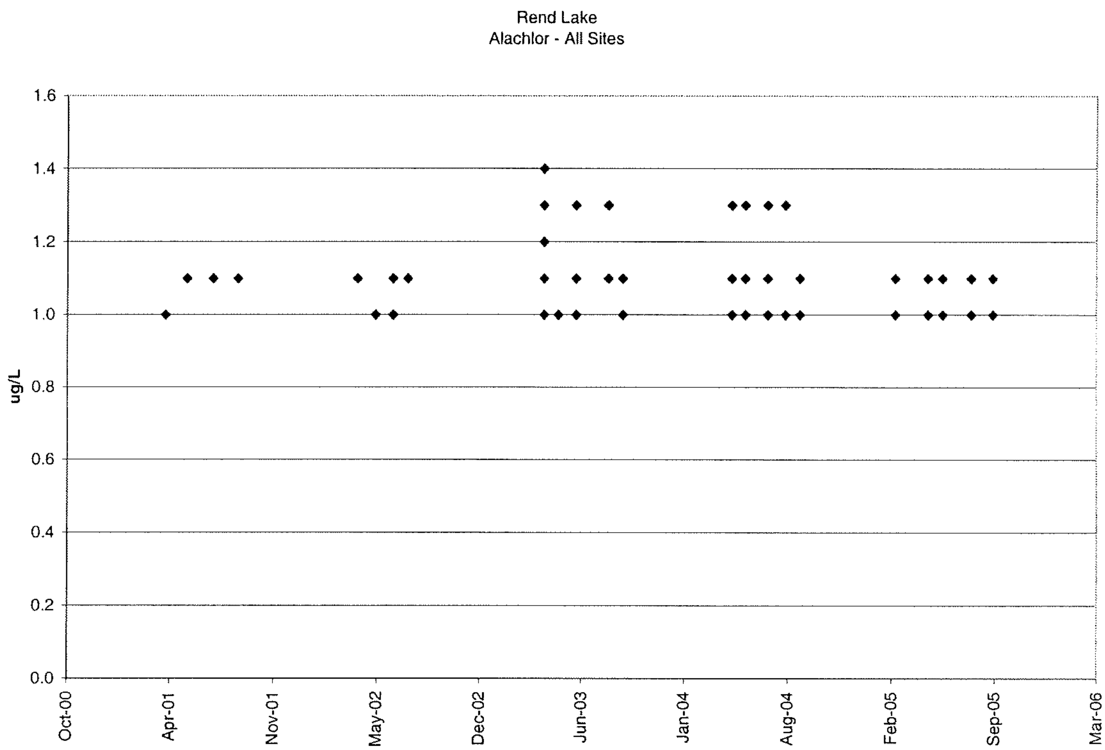
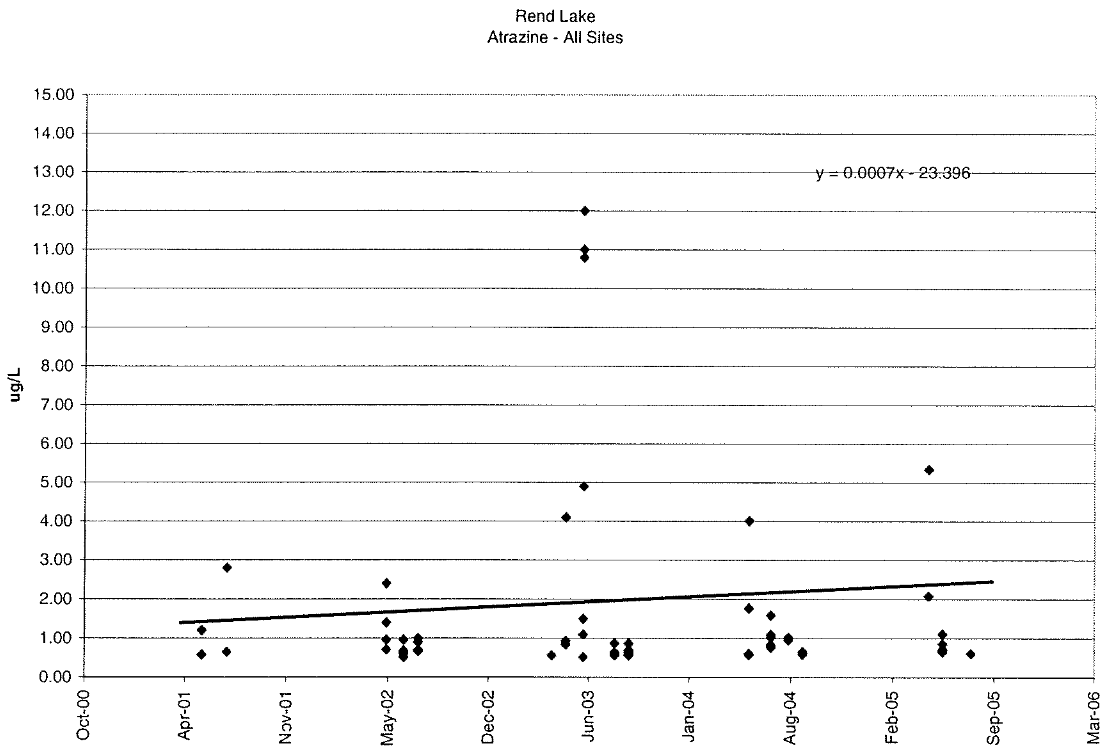
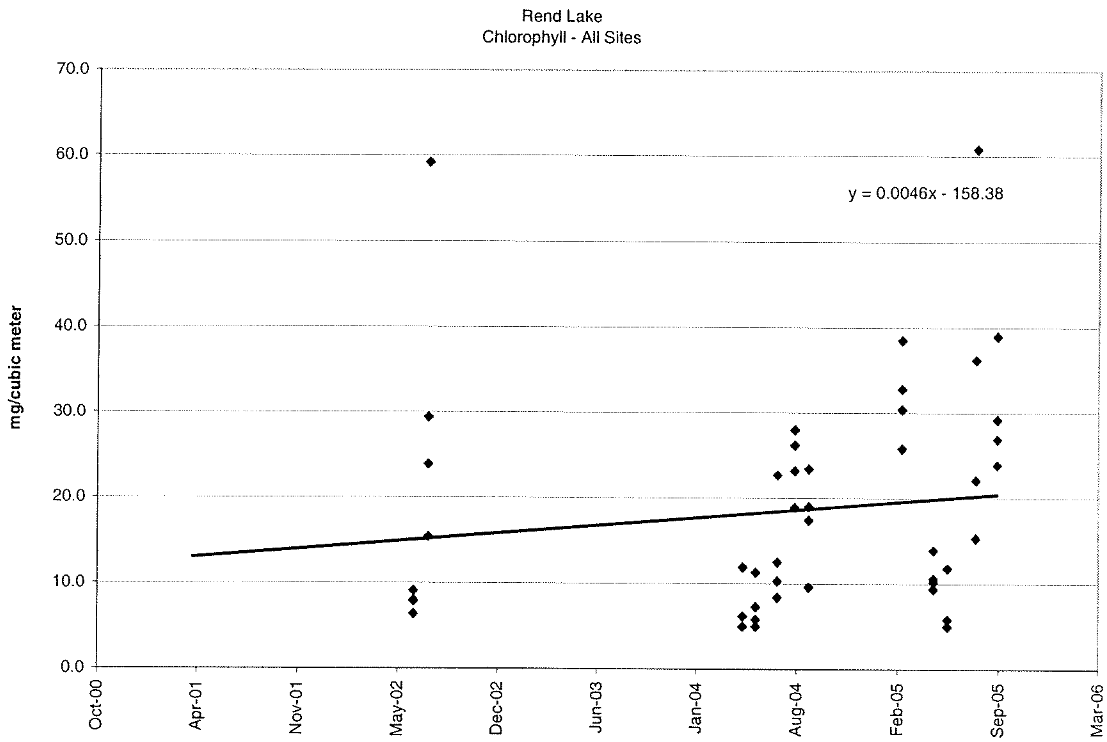

Rend Lake
Alachlor - All Sites
ug/L
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Oct-00
Apr-01
Nov-01
May-02
Dec-02
Jun-03
Jan-04
Aug-04
Feb-05
Sep-05
Mar-06

Figure 13



Statistics	Values
Mean	1.97
Standard Error	0.464
Median	0.78
Mode	0.61
Standard Deviation	3.74
Sample Variance	14.0
Kurtosis	23.46
Skewness	4.50
Range	24.5
Minimum	0.51
Maximum	25.00
Sum	128
Count	65

Figure 14



Statistics	Values
Mean	18.52
Standard Error	1.908
Median	14.60
Mode	5
Standard Deviation	13.22
Sample Variance	174.8
Kurtosis	2.21
Skewness	1.39
Range	55.8
Minimum	5.00
Maximum	60.80
Sum	889
Count	48

There is no regulatory limit for chlorophyll. The values from previous studies and the one described herein are highly similar. The mean and median values for the property were within a few points and there was an increasing trendline in the data. Evaluation of data indicates an increase in primary productivity in lake waters.

3.3.14 Pheophytin

The data for pheophytin at all sites appears in Figure 15. The descriptive statistics for those data appear in the table below the plotted values.

Pheophytin is a photosynthetic pigment and degradation product of chlorophyll. It is a general indicator of the health of the chlorophyll available in the system. There is no regulatory limit for the compound.

As with chlorophyll, data from the current and previous studies are highly similar with the average and median values in good agreement. The data strongly indicate that the life cycles in lake wasters utilizing photosynthesis are stable and healthy.

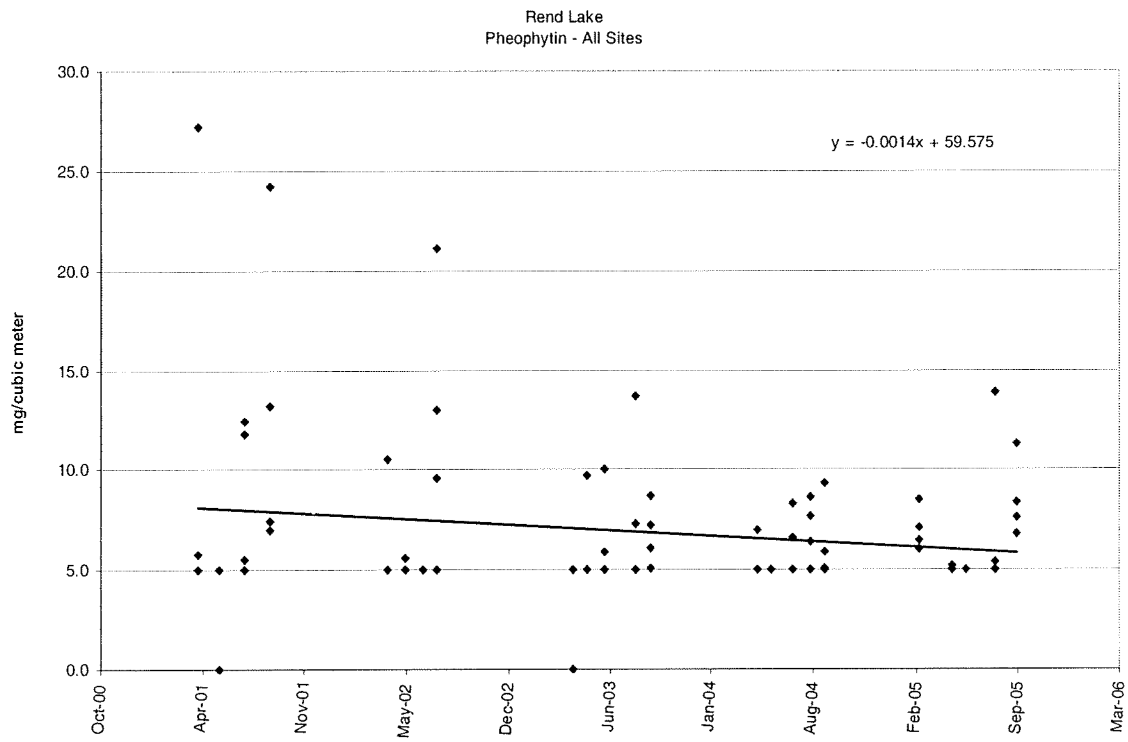
3.3.15 Total Organic Carbon

The data for total organic carbon at all sites appears in Figure 16. The descriptive statistics for those data appear in the table below the plotted values.

Total organic carbon measurements are important in water quality monitoring. The measurement provides an index for estimating the levels of toxins, teratogens and other organic materials which may increase the demand for available oxygen in the system.

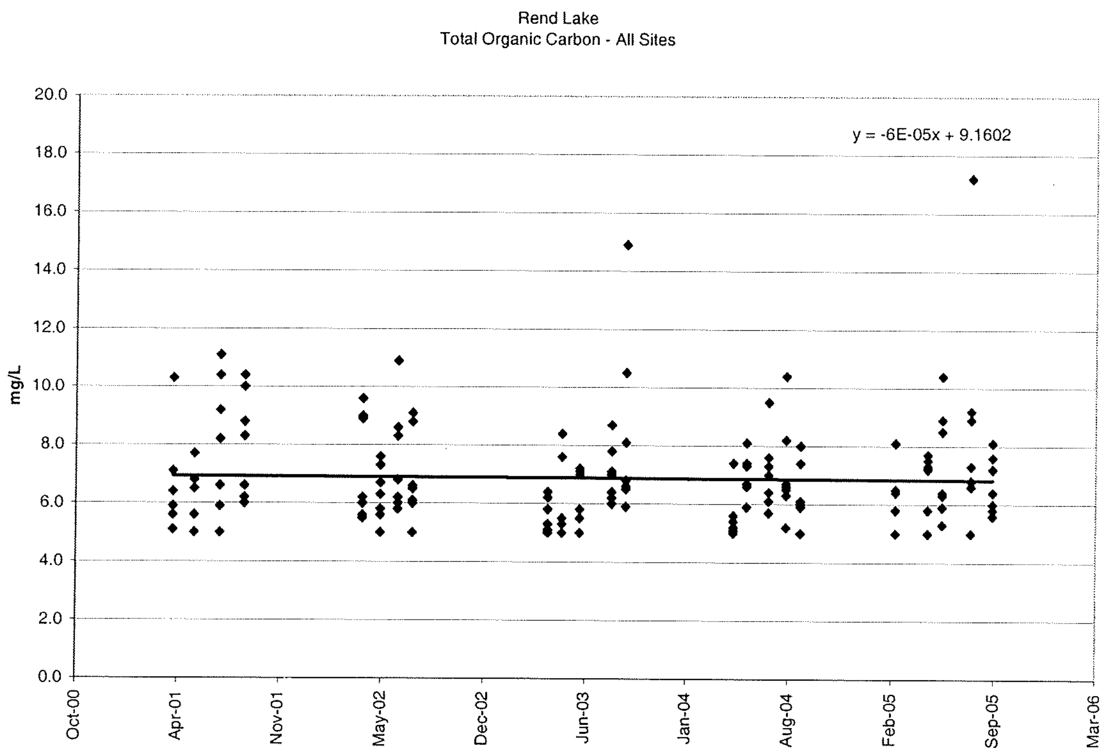
The values for total organic carbon observed in previous studies and the current effort are in excellent agreement. The average and median values at all sites in the previous study were 7.8 and 6.6 mg/L, respectively. The values observed at all sites during the current study were an average of 6.9 and a median of 6.4 mg/L. These data strongly suggest that all aspects of dealing with organic materials in Rend Lake are stable and healthy.

Figure 15



Statistics	Values
Mean	6.92
Standard Error	0.428
Median	5.00
Mode	5
Standard Deviation	4.08
Sample Variance	16.7
Kurtosis	10.34
Skewness	2.84
Range	27.2
Minimum	0.00
Maximum	27.20
Sum	630
Count	91

Figure 16



Statistics	Values
Mean	6.88
Standard Error	0.143
Median	6.40
Mode	5
Standard Deviation	1.81
Sample Variance	3.3
Kurtosis	7.75
Skewness	2.13
Range	12.2
Minimum	5.00
Maximum	17.20
Sum	1100
Count	160

3.4 Individual Sites

3.4.1 Overview

Surface waters from eight sites and subsurface water from one site were evaluated during performance of the subject study. The locations of these sites are shown in Figure 1, above. As noted REN-5-0 and REN-7 are off-lake in areas where major runoff occurs. REN-5-0 is on Highway 15 (Broadway), due west of Mount Vernon. REN-7 is on Highway 37 (Benton Road) just south of I-64. No information was available regarding the location of site REN-15-0.

In the text below the data are compared between sites and to the values found at all sites. Plots of the levels found for properties evaluated at each site appear in Appendix 6.1.

As review of that table and the plots of the data acquired during the study shows water quality values in samples taken from the body of the lake were generally nominal. The exceptions were scattered problems observed in samples taken at REN-8 and the prevalence of undesirably high levels of total phosphorus in all samples. Results on samples taken in off lake sites (REN-5-0 and REN 7) demonstrated that, in general, the run off in these locations has a negative impact on water quality in the lake.

3.4.2 Chemical/Physical Properties

Only a few data points for these properties were from site REN-15. These results are not considered in the remarks in the text below.

3.4.2.1 Dissolved Oxygen

The profile of dissolved oxygen was similar at all sites. Mean and median levels and trend lines were essentially flat The mean and median levels of water taken at depth (REN-2-5), however, were somewhat lower than the values found in surface waters and individual readings tended to be less variable.

3.4.2.2 pH

Although occasional excursions above 10 and between 6 and 7 were observed, the profile of pH was reasonably constant at all sites. The highest average and median values were observed at site REN-3, -4 and -8. In all cases, trend lines were flat.

3.4.2.3 Oxidation-Reduction Potential (ORP)

At all sites there was a substantial, time related reduction in ORP of approximately 10 to 15% for each 5 months of the study period. The mean and median of observed values were in general agreement at all sites.

3.4.2.4 Conductivity

Trend lines, mean and median values were similar in samples taken from all sites except for the high average and median levels (approximately 600 uS/cm) found at REN-5 and REN-7. The high values and the differences in the slopes of the trend lines at these two sites are almost certainly due to their off-lake location. Trend lines at all sites located on the lake were essentially flat.

3.4.3 Suspended Solids

Suspended solids values were reasonable and in general agreement at all on-lake sites except REN-8-0 where elevated levels of both total and volatile suspended solids were noted. In general, the ratio of total to volatile suspended solids is regarded as an indicator of the ratio of inorganic and organic materials in natural waters. In samples taken from all on-lake sites (including Ren-8-0) that ratio was in the range of 2:1 and 4:1, regardless of the absolute values found. In samples taken from the off-lake sites of REN-5-0 and REN-7, however, average values for total suspended solids were over 20 mg/L and the ratio of total to volatile suspended materials was approximately 6 or 7:1

3.4.4 Nutrients

As shown in tables below, date related patterns of variation in the observed levels of some nutrients were noted in the data acquired during the study. These variations may be related to agricultural activity in the area.

3.4.4.1 Phosphorus

As already noted, total phosphorus values in all locations in the lake are above Illinois regulations for general use waters by factors of two to almost 4. Of all sites, the highest average for total phosphorus was at REN-5 and the lowest at REN-2-0.

As shown in the tables below there was: 1) a continuing trend of slight deceases (approximately 5 to 10% per year) in the average values over the period of the study; and 2) there was a pattern to the levels found with respect to the month when samples were collected.

Year	2001	2002	2003	2004	2005
mg/L, average	0.204	0.181	0.174	0.168	0.191

Month Collected	Feb	Apr	May	Jun	Jul	Aug	Sep
mg/L, average	0.15	0.13	0.15	0.15	0.24	0.23.	0.26

3.4.4.2 Nitrate

Levels of this compound in lake pose no threat to overall water quality. It is noteworthy, however, that the overall average of the nutrient observed in samples from REN-7 are six times the average at all sites. Further, as shown in the tables below, there were date related patterns to those levels.

Year	2001	2002	2003	2004	2005
mg/L, average	0.207	0.280	0.371	0.389	0.498

Month Collected	Feb	Apr	May	Jun	Jul	Aug	Sep
mg/L, average	0.14	0.16	0.20	0.38	0.67	0.28.	0.78

3.4.4.3 Ammonia

Levels of this compound in lake pose no threat to overall water quality. It is noteworthy, however, that the overall average of the nutrient observed in samples from REN-5 and REN-7 are twice the average at all sites. Further, as shown in the tables below, there were date related patterns to those levels.

Year	2001	2002	2003	2004	2005
mg/L, average	0.108	0.123	0.065	0.066	0.102

Month Collected	Feb	Apr	May	Jun	Jul	Aug	Sep
mg/L, average	0.05	0.05	0.11	0.09	0.14	0.07.	0.10

3.4.5 Organics

3.4.5.1 Herbicides

The levels of the nitrogen-phosphorus herbicides Atrazine and Alachlor were evaluated in samples collected from Rend Lake sites.

No concentrations of Alachlor above the detection limit of 0.5 ug/L were detected in any of the samples collected.

Atrazine, however, was observed in samples from several sites at concentrations above the detection limit of 0.5 ug/L but below the reporting limit of approximately 1 ug/L. Additionally, some of these observations were at levels substantially above 1 ug/L, notably the occasional values in the range 5 to 25 ug/L observed in samples from REN-3, -4, -5, -8 and -15. The sporadic occurrence of elevated levels in samples from REN-5 collected in May and June of both 2004 and 2005 and in April of 2005 raised the average of observations at that site to 2.5 times the average at all sites.

3.4.5.2 Chlorophyll/Pheophytin

Excepting observed values in sample collected at REN-8-0 which were approximately half again the levels at all other sites for both of these organics, there were no significant differences in the concentrations of these materials which were date or location related.

3.4.5.3 Total Organic Carbon (TOC)

Levels of TOC were somewhat higher in samples collected from REN-5, -7 and -8 than other sites but there were no other patterns in the data. The average value at all sites and the average values at individual sites are consistent with those observed during the previous study. The slightly lower levels found during the current study indicate that an improvement in water quality has been acheived.

4.0 CONCLUSIONS AND RECOMMENDATIONS

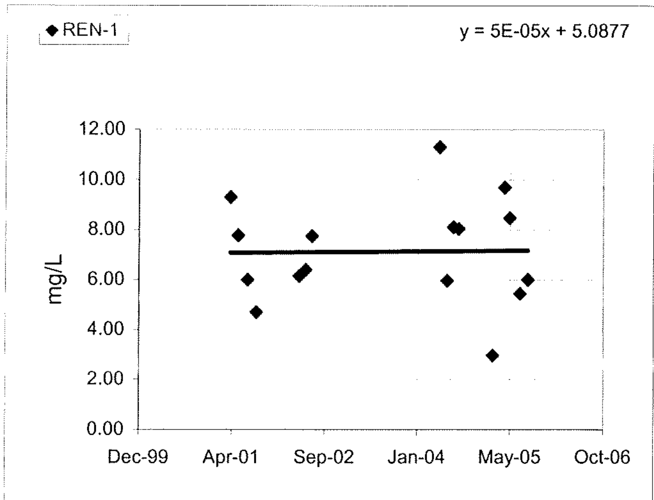
The result of the evaluations in this document are compared in the table below to those described in the referenced previous report

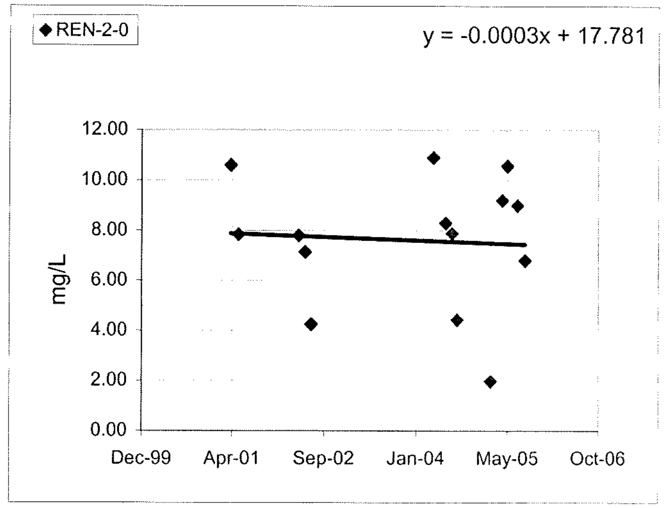
PARAMETER	TREND 1989-2000	TREND 2001-2005
Dissolved Oxygen	Degrading	Stable
pH	Stable	Stable
Alkalinity	Degrading	---
Oxidation Reduction Potential	---	Improving
Conductivity	---	Stable
Total Suspended Solids	Stable	Stable
Volatile Suspended Solids	Improving	Stable
Total Phosphorus	Degrading	Stable but high
Soluble Phosphorous (ortho-Phosphate)	Improving	Stable
Nitrate	Degrading	Stable
Ammonia	Improving	Improving
Silica	Degrading	---
Manganese	Stable	---
Iron	Stable	---
Alachlor	Stable	Stable
Atrazine	Degrading	Stable
Chlorophyll	Stable	Stable
Pheophytin	Stable	Stable
Total Organic Carbon (TOC)	Improving	Stable

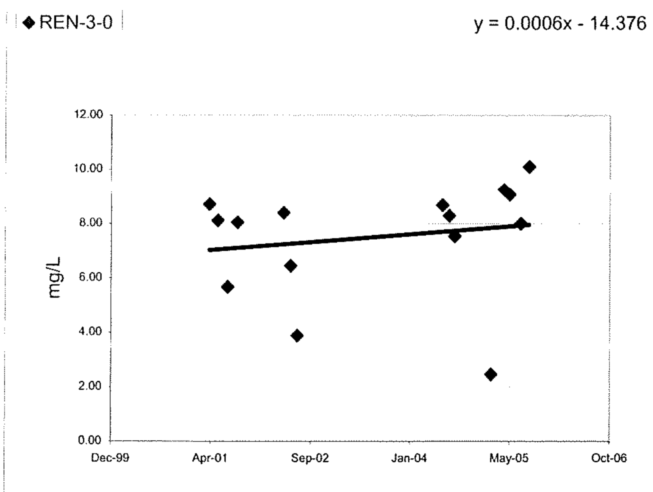
The trends noted suggest that the condition of Rend Lake has improved and stabilized. Efforts to achieve better control of and lower the phosphate levels in the system should be considered.

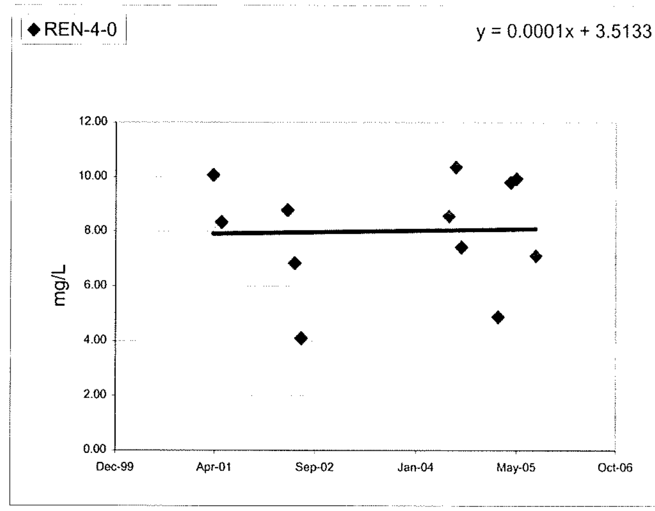
Appendix 1 – Plots of Data Collected from Individual Sample Sites

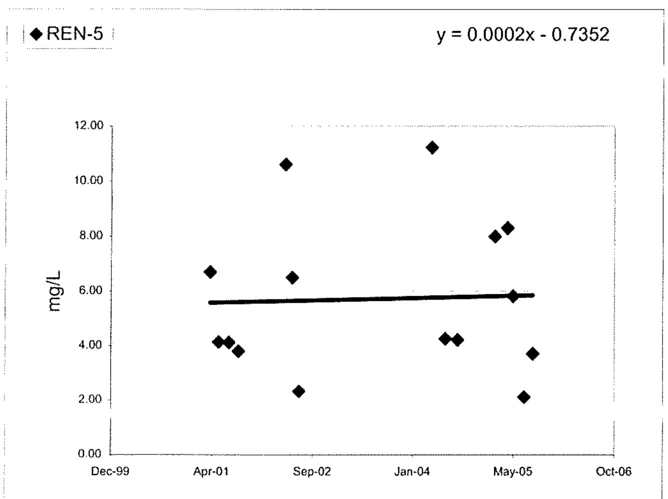
Dissolved Oxygen (DO)

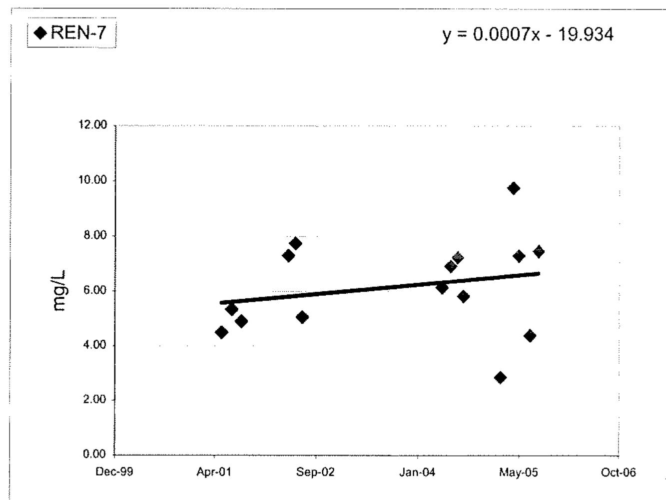


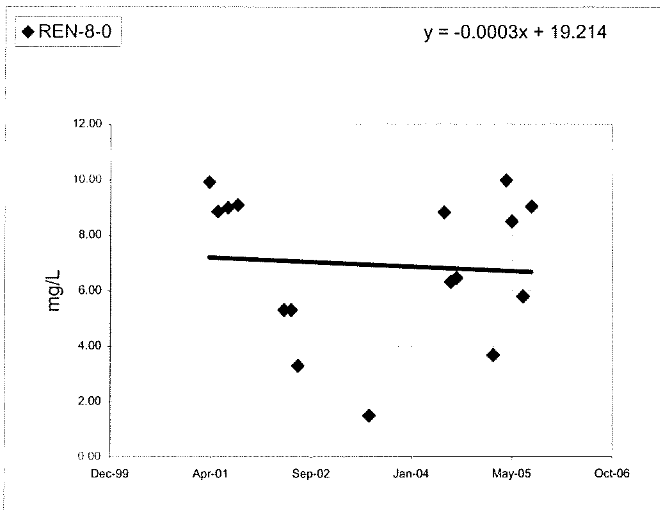




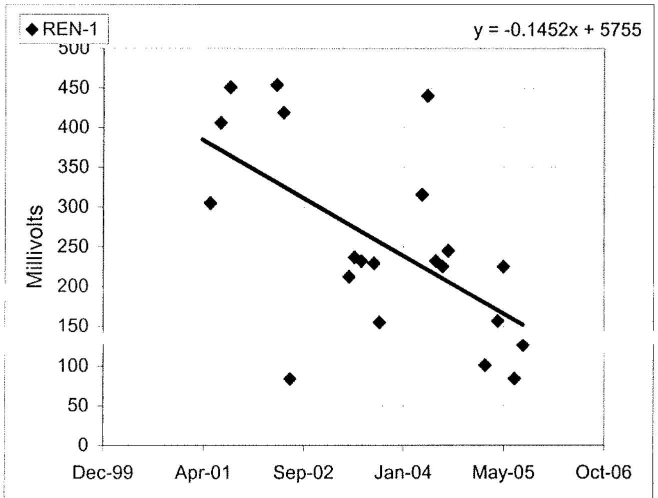


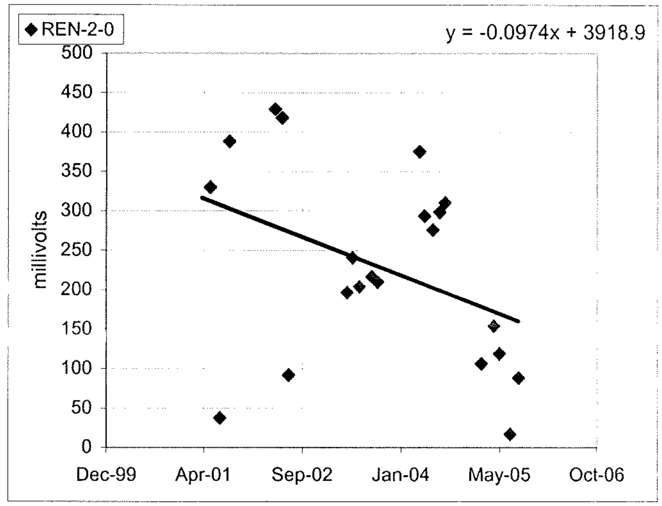


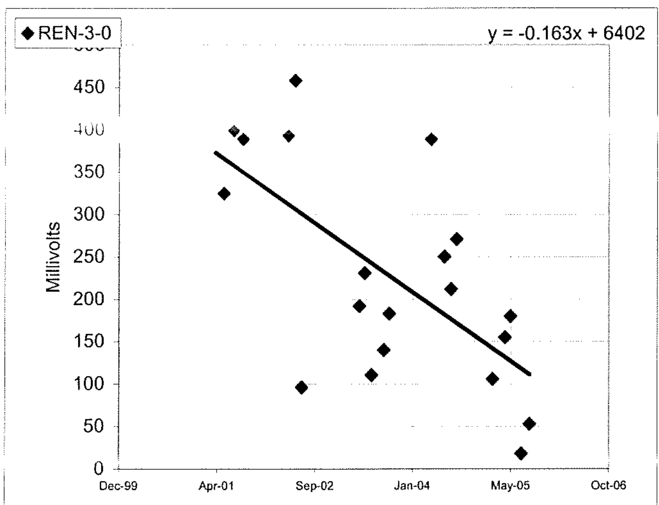


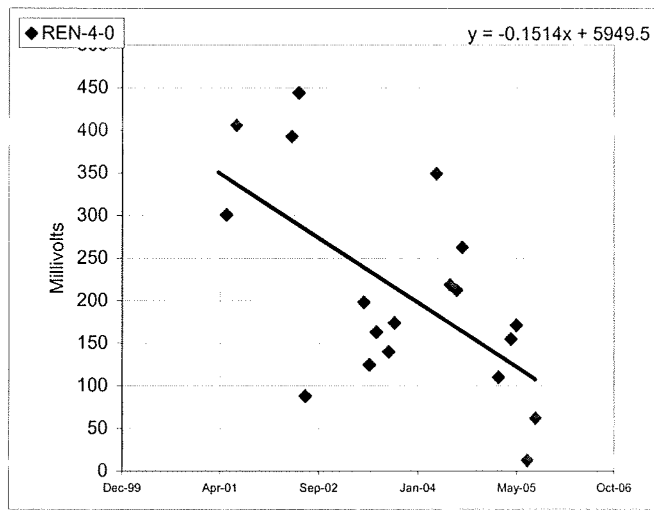

◆ REN-8-0
y = -0.0003x + 19.214
12.00
10.00
8.00
6.00
4.00
2.00
0.00
mg/L
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

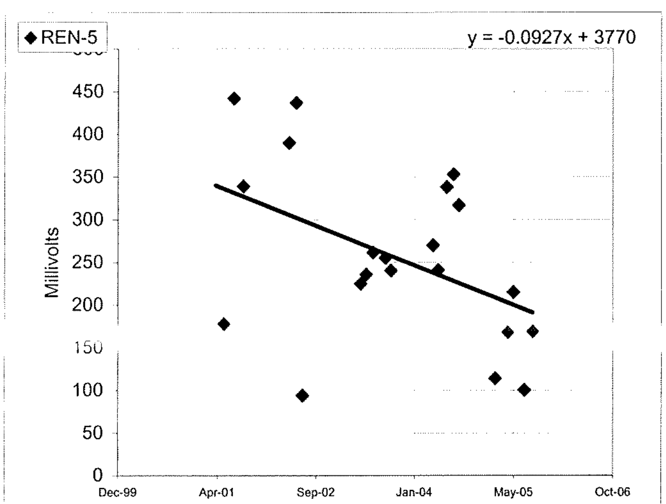
Oxidation Reduction Potential (ORP)

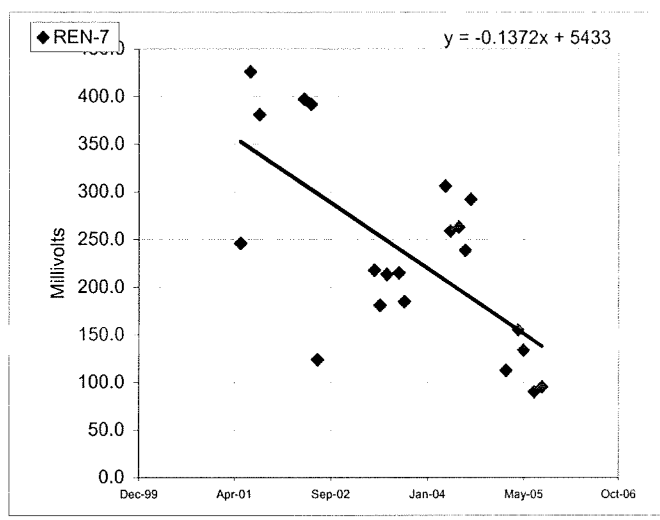


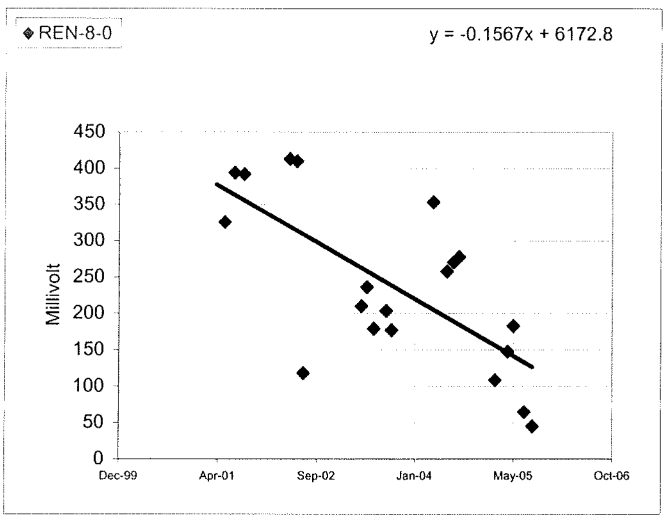




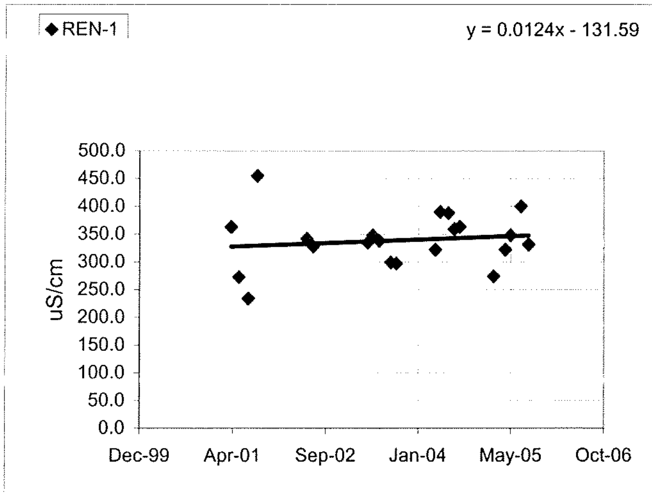


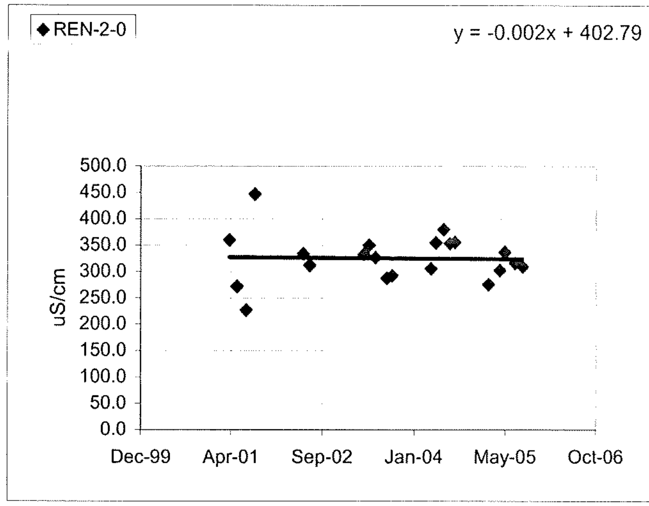


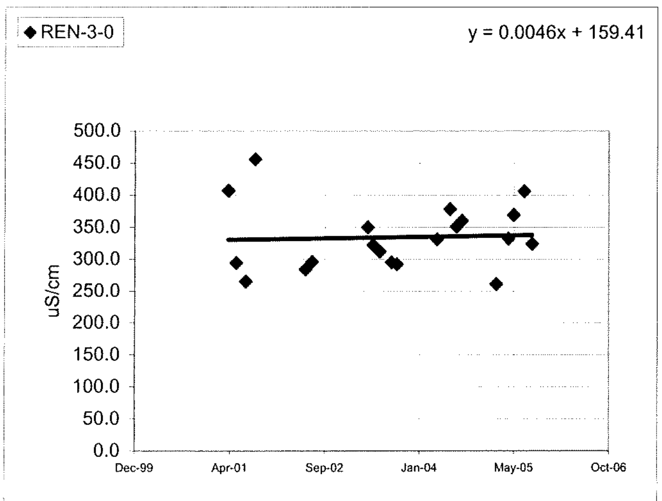


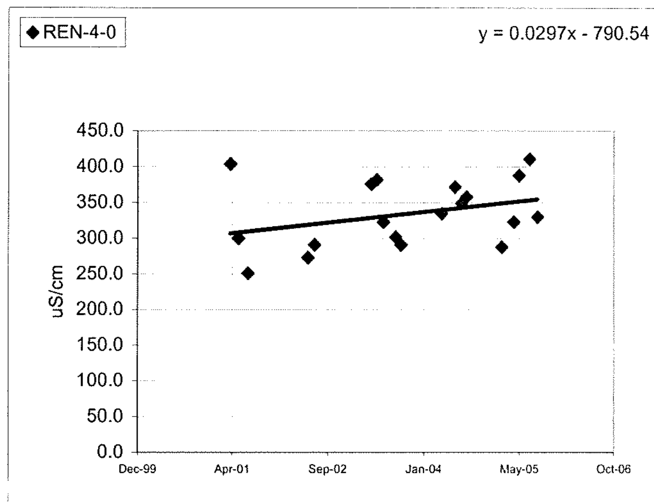

REN-8-0
y = -0.1567x + 6172.8
450
400
350
300
250
200
150
100
50
0
Millivolt
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

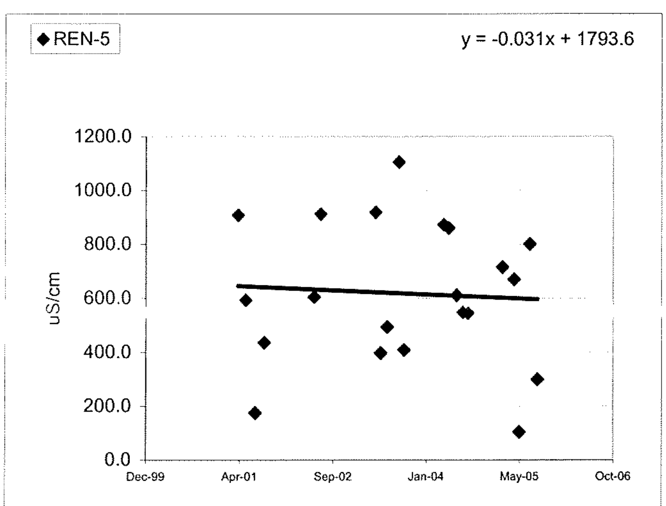
Conductivity

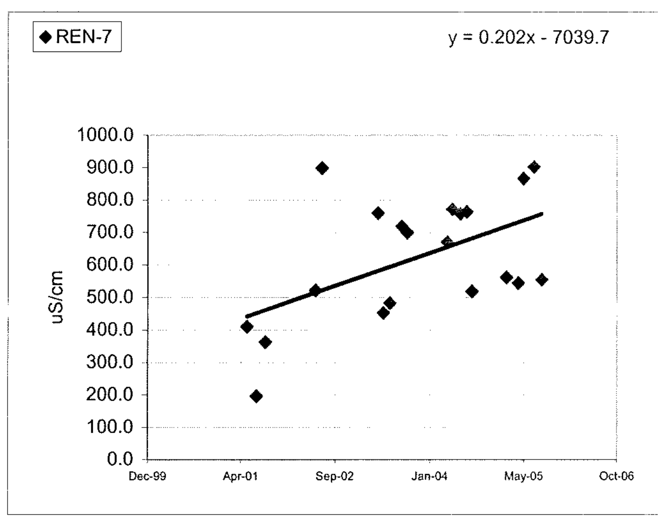




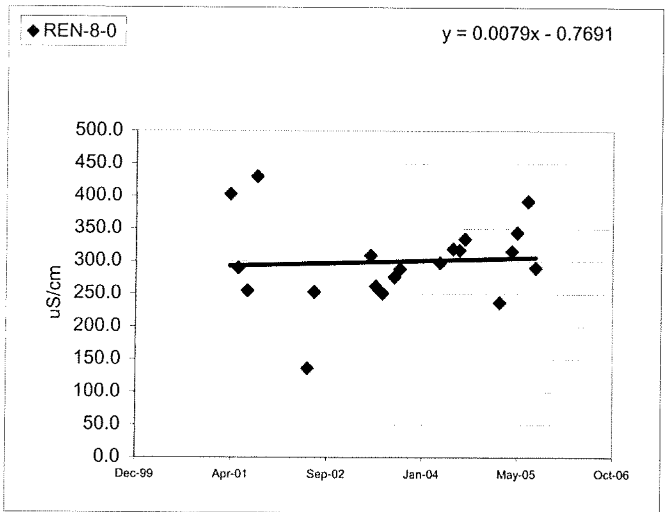




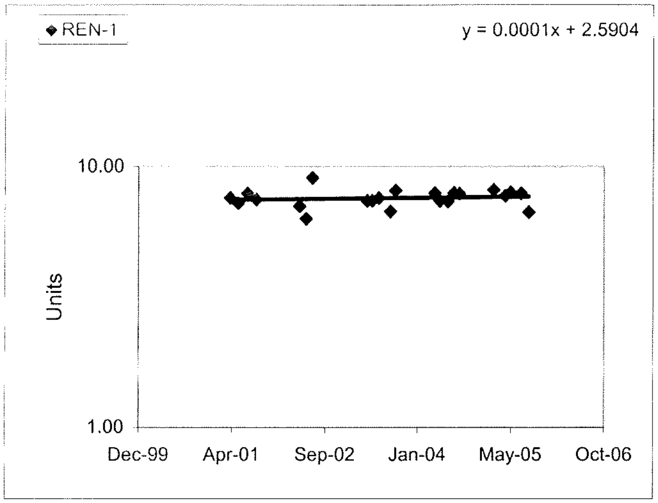




Conductivity



pH


REN-1
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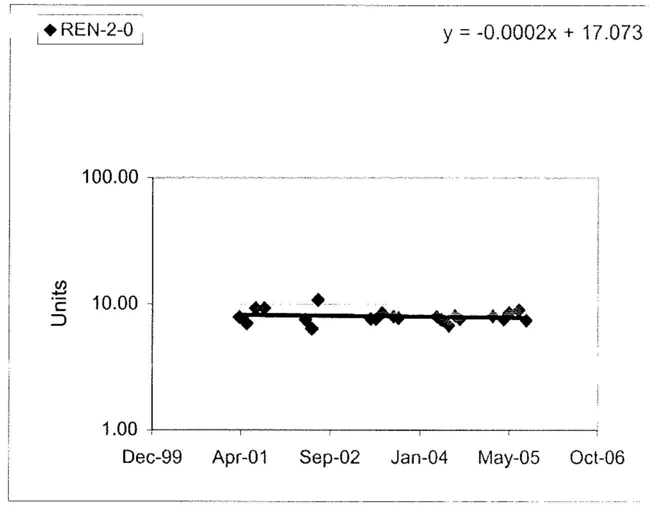
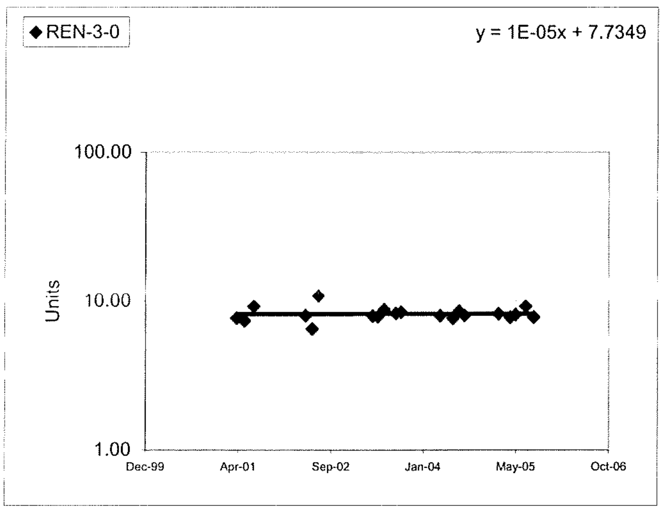
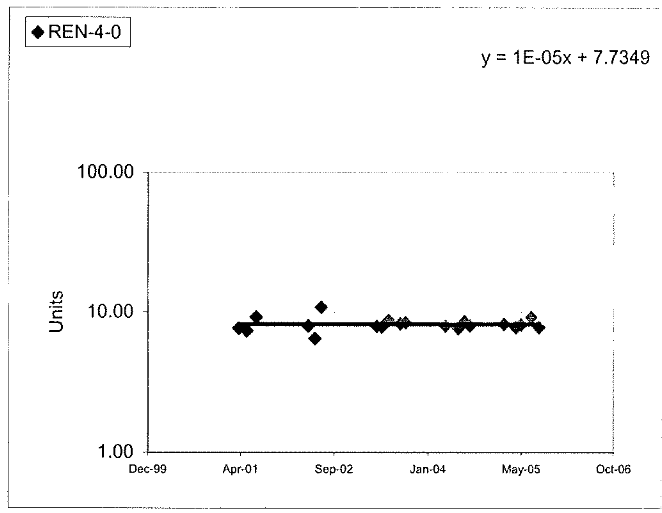
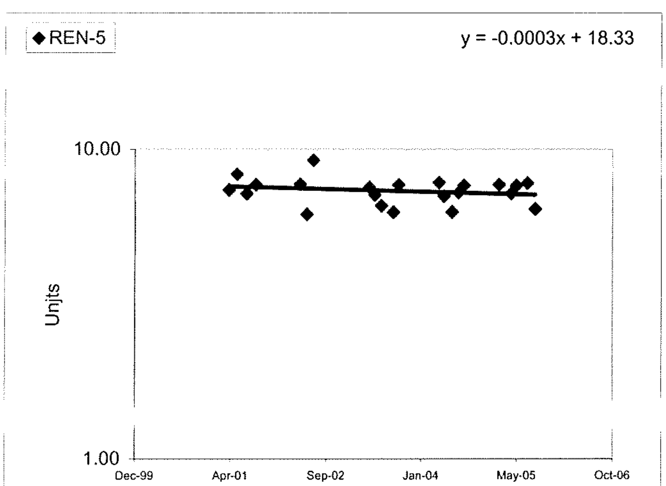
1.00
Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-2-0
y = -0.0002x + 17.073
100.00
10.00
1.00
Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-3-0
y = 1E-05x + 7.7349
100.00
10.00
1.00
Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-4-0
y = 1E-05x + 7.7349
100.00
10.00
1.00
Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06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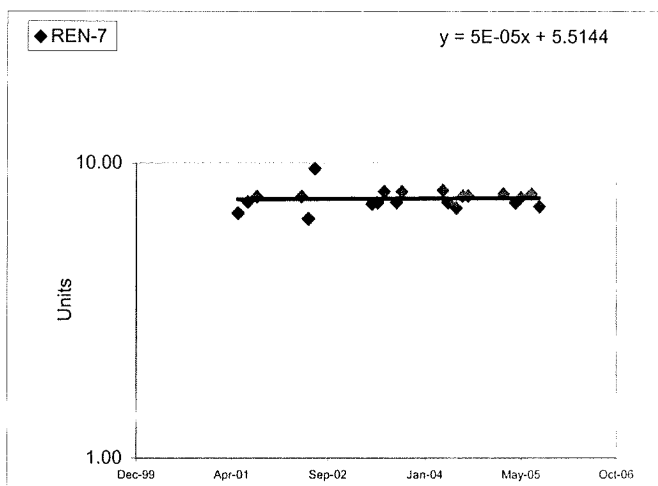
1.00
Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-7
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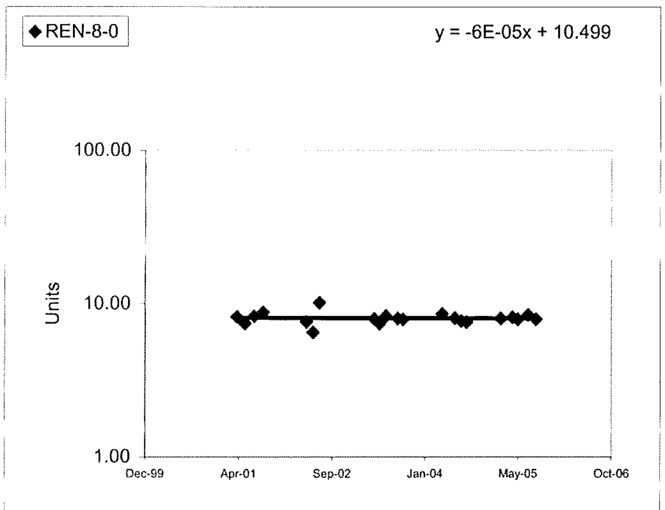
1.00
Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



REN-8-0
y = -6E-05x + 10.499
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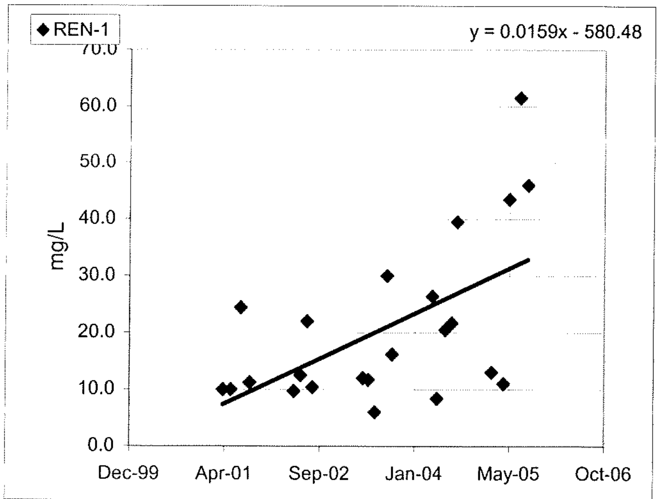
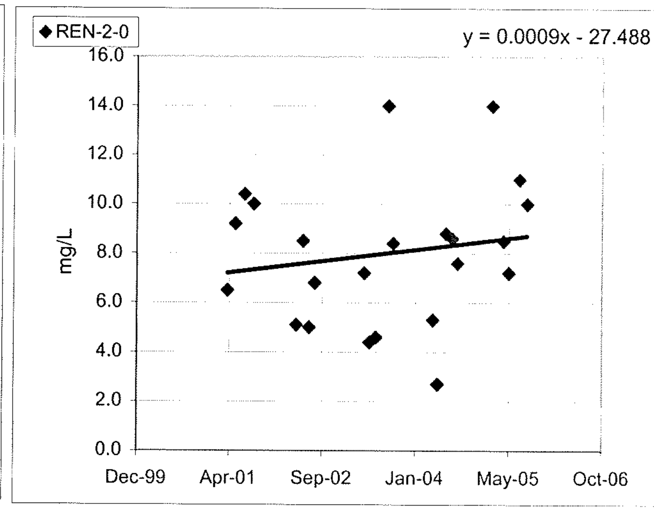
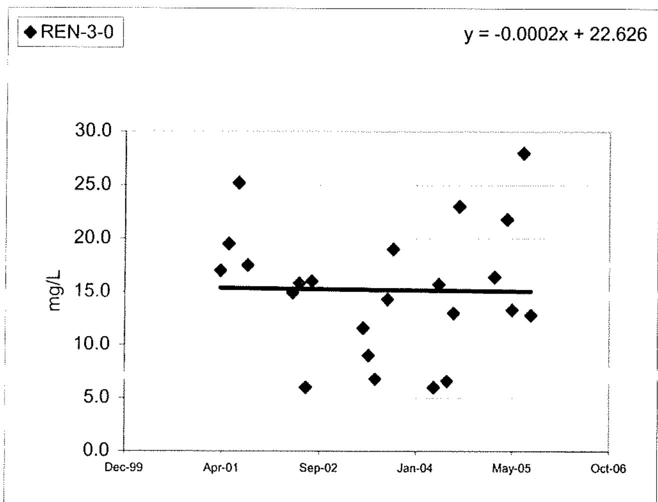
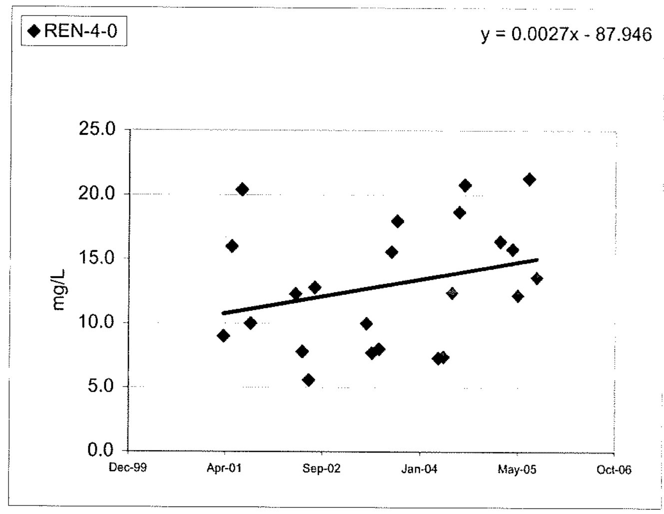
10.00
1.00
Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

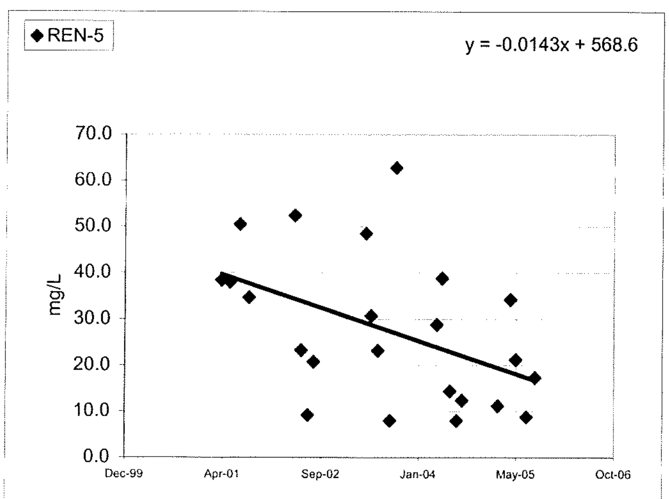
Total Suspended Solids (TSS)

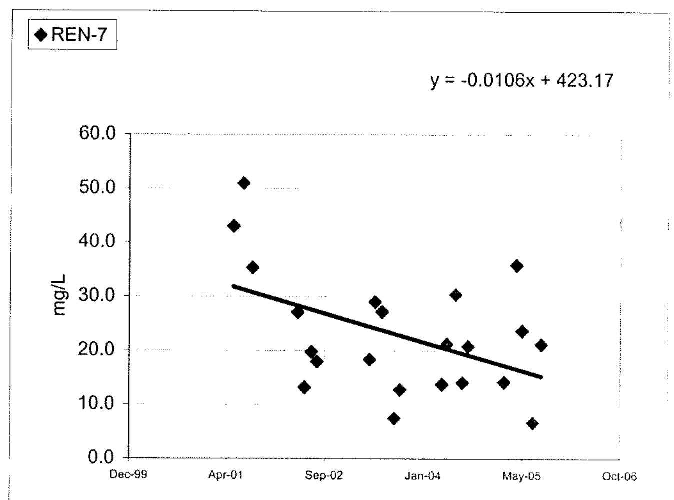




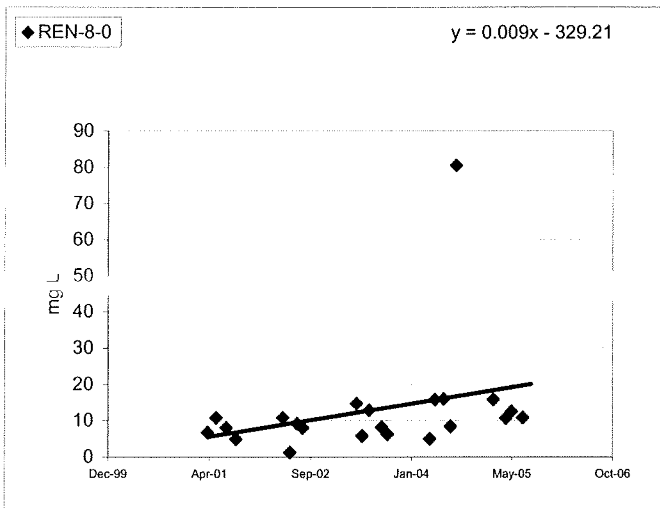


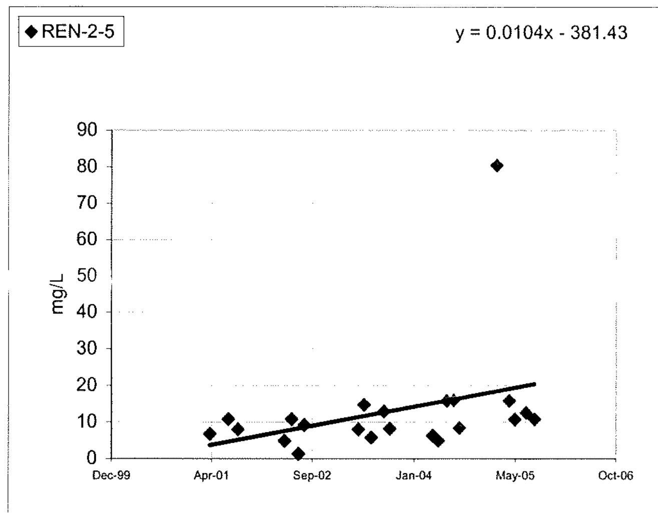


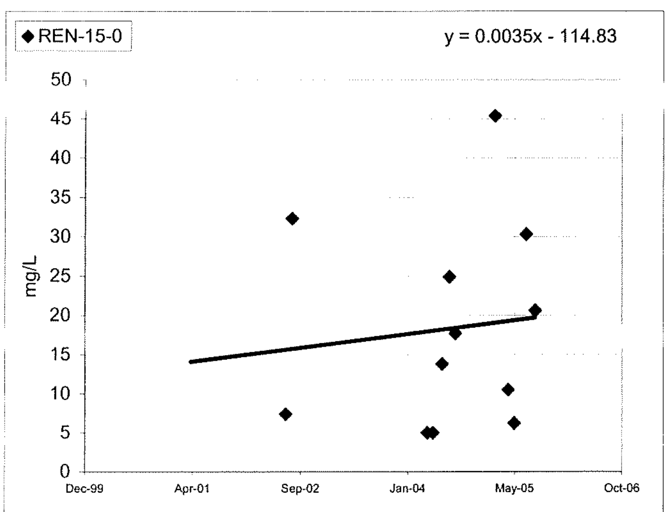




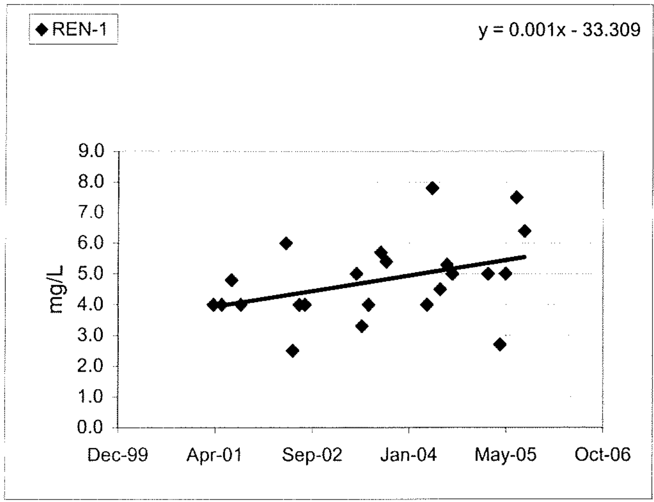
Total Suspended Solids (TSS)

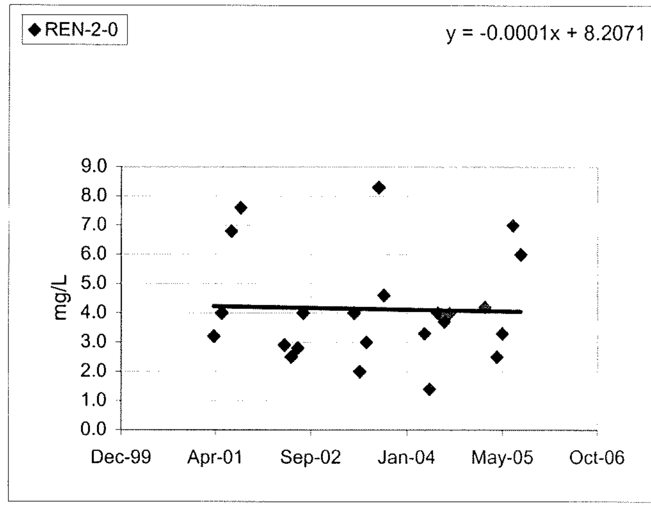


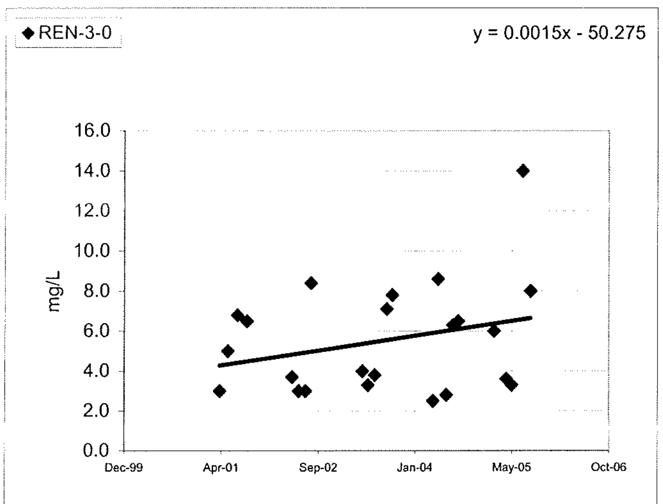


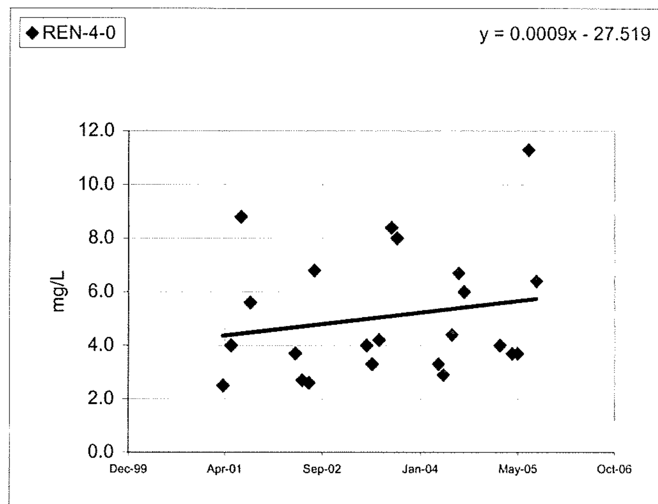


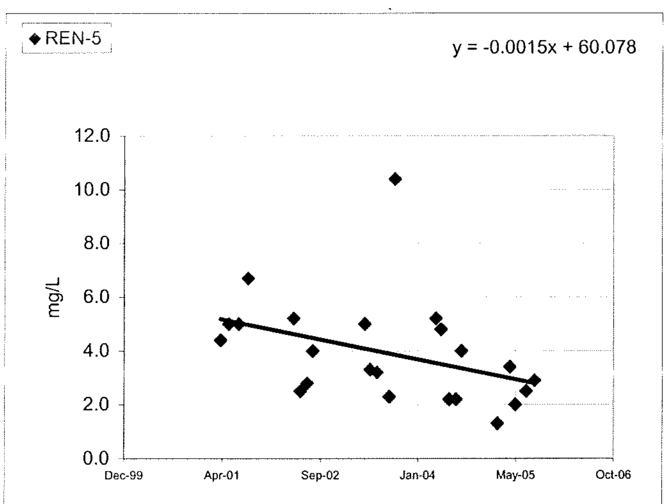
Volatile Suspended Solids (VSS)

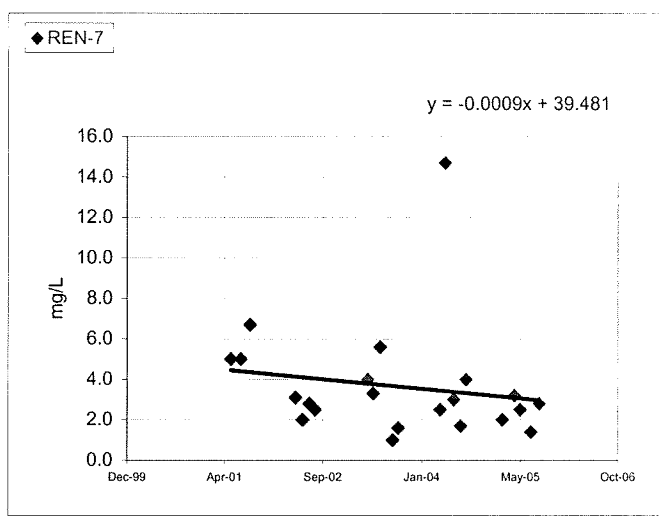




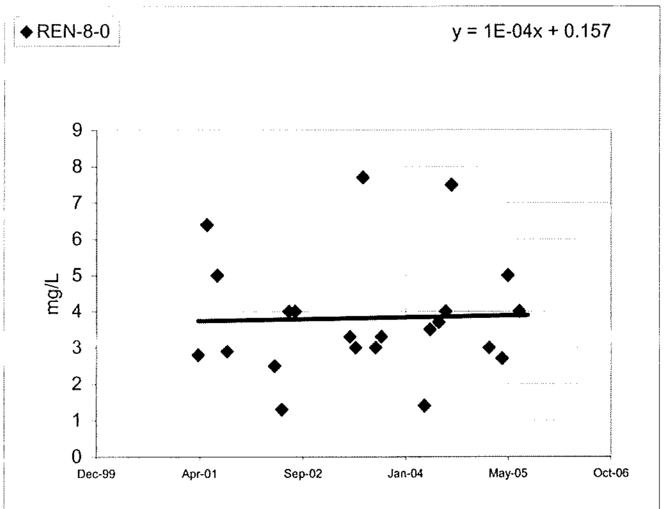


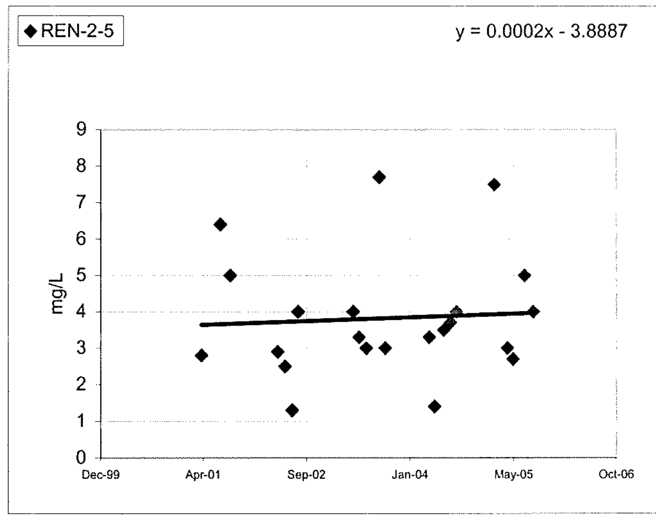


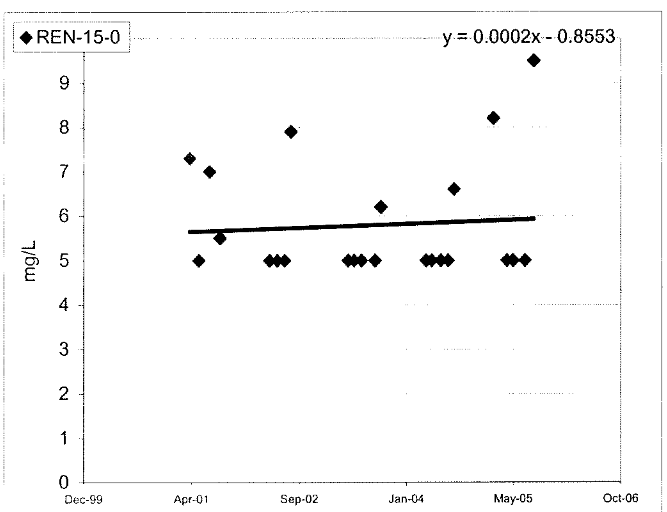


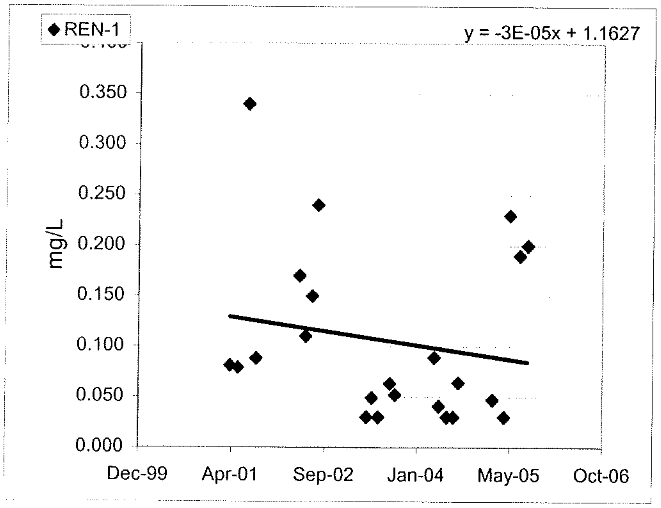


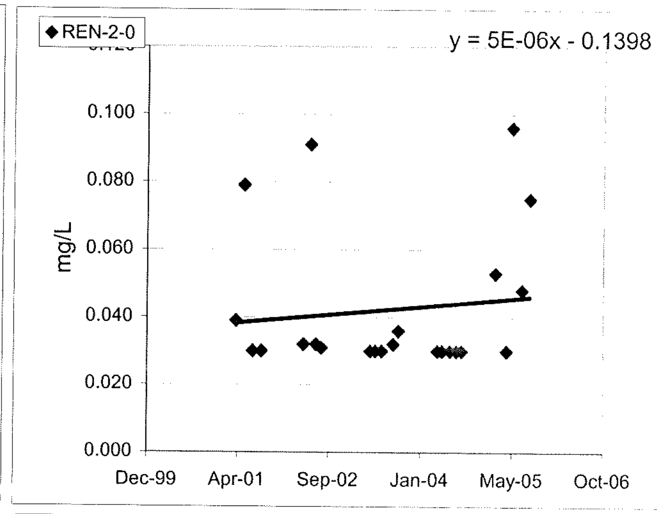
Volatile Suspended Solids (VSS)

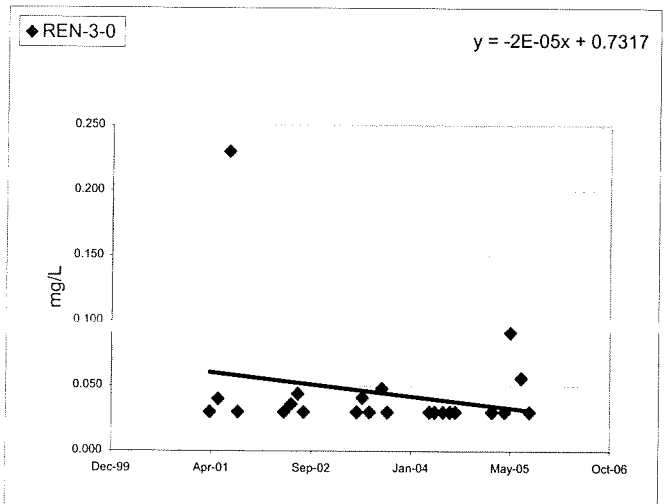


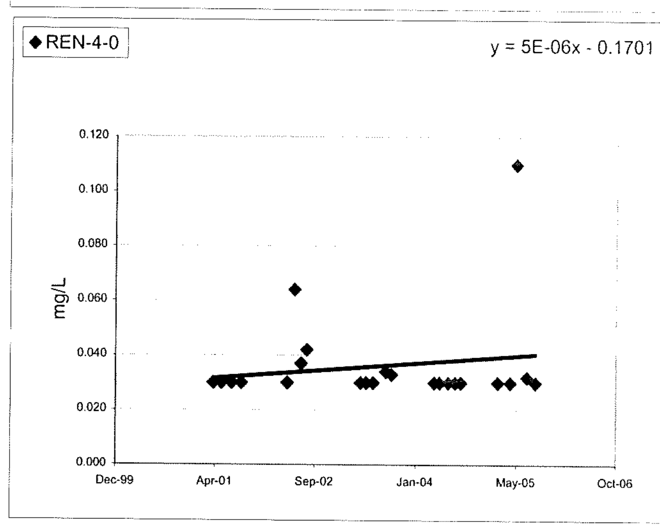


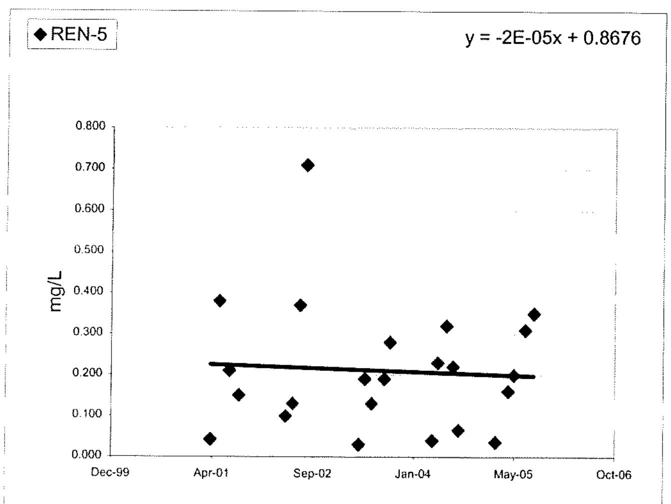


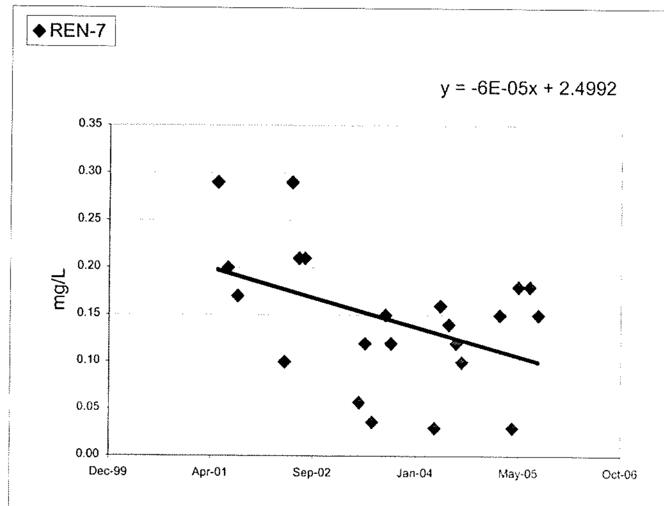

REN-1
y = -3E-05x + 1.1627
mg/L
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-2-0
y = 5E-06x - 0.1398
mg/L
0.100
0.080
0.060
0.040
0.020
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

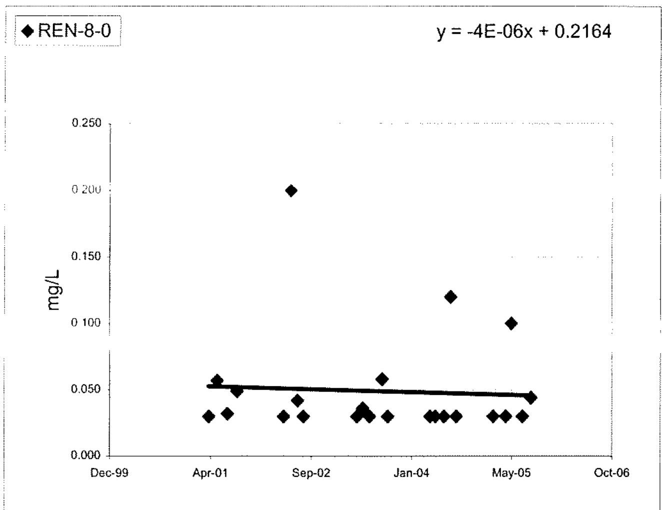

REN-3-0
y = -2E-05x + 0.7317
mg/L
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

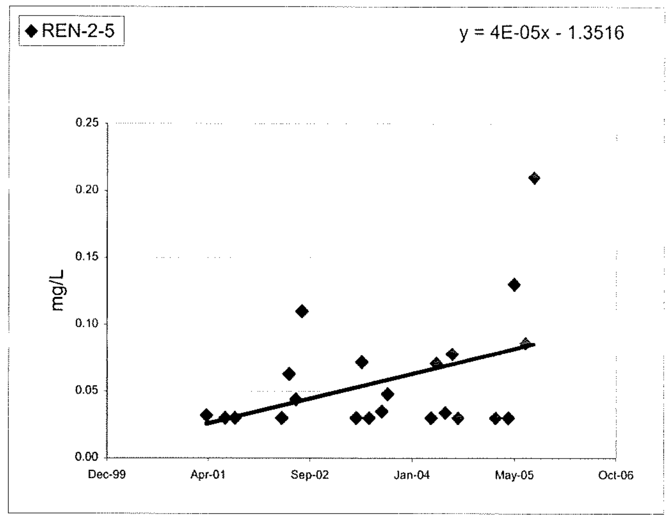

REN-4-0
y = 5E-06x - 0.1701
mg/L
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

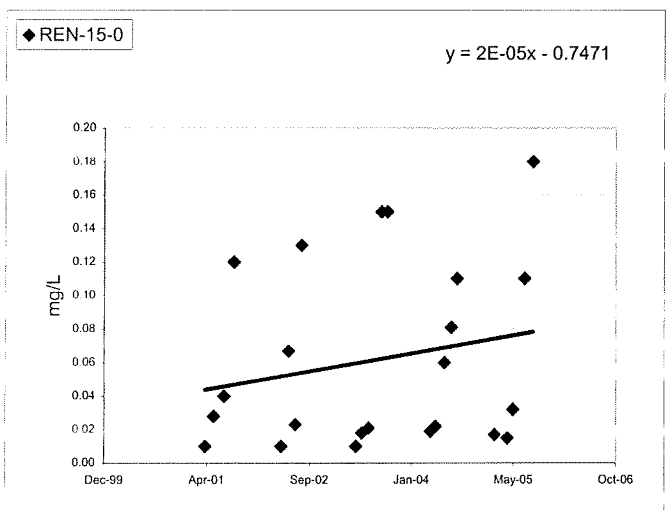

REN-5
y = -2E-05x + 0.8676
mg/L
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-7
y = -6E-05x + 2.4992
mg/L
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

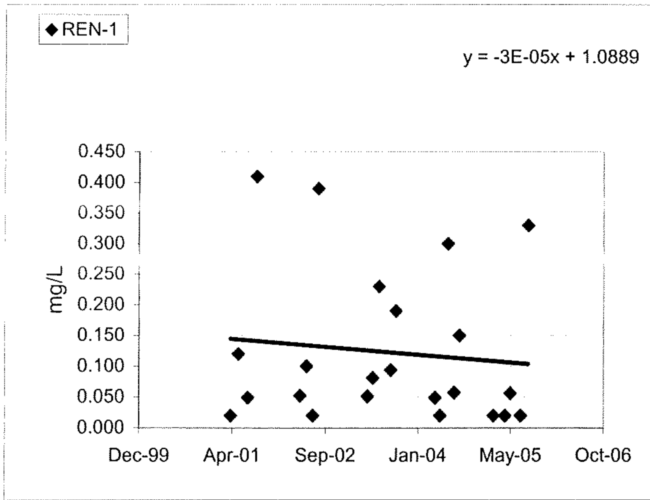
Ammonia

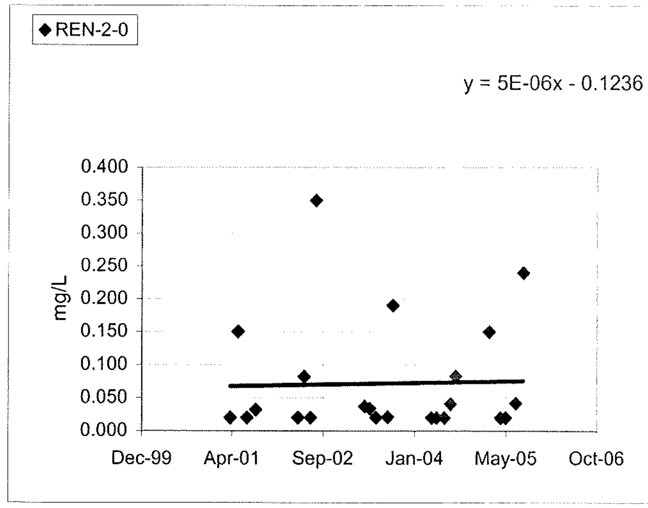

◆ REN-8-0
y = -4E-06x + 0.2164
mg/L
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

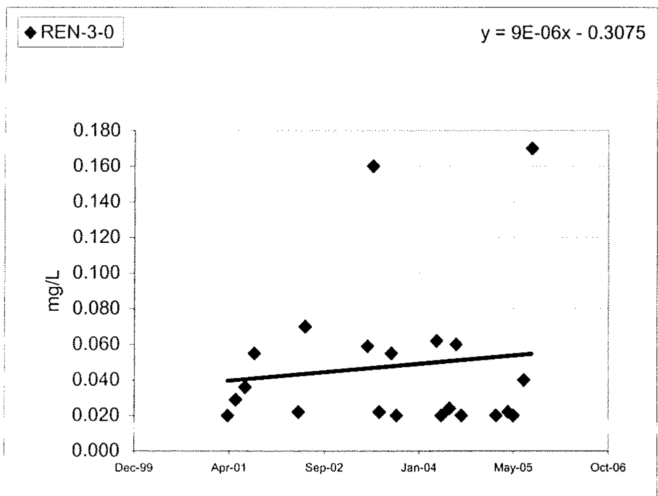

◆ REN-2-5
y = 4E-05x - 1.3516
mg/L
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

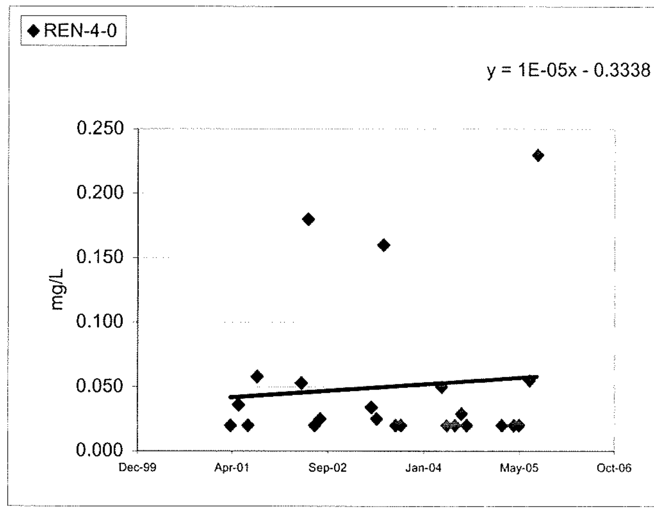

◆ REN-15-0
y = 2E-05x - 0.7471
mg/L
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

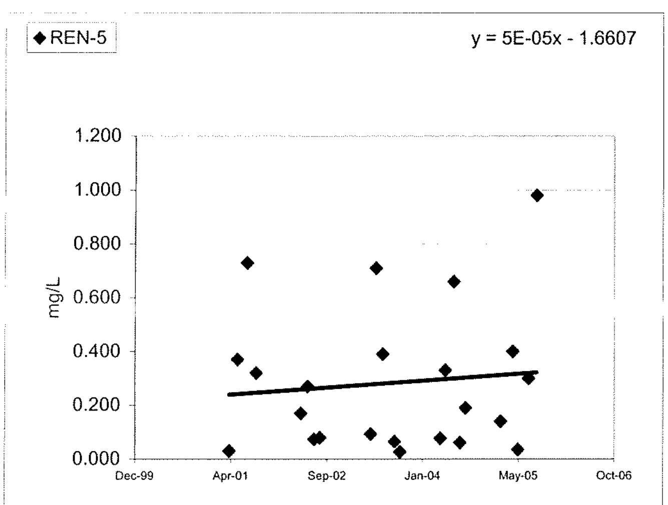
Nitrate

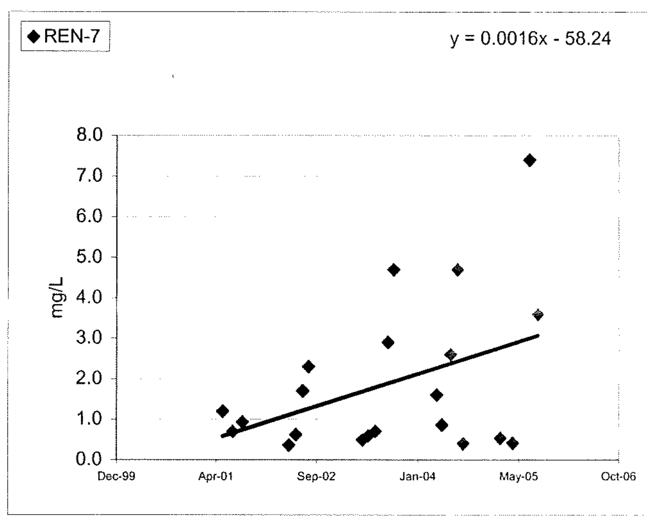

REN-1
y = -3E-05x + 1.0889
mg/L
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

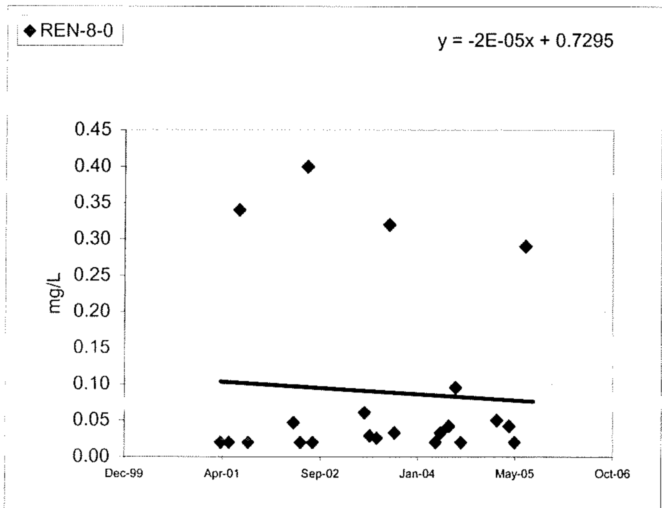

REN-2-0
y = 5E-06x - 0.1236
mg/L
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

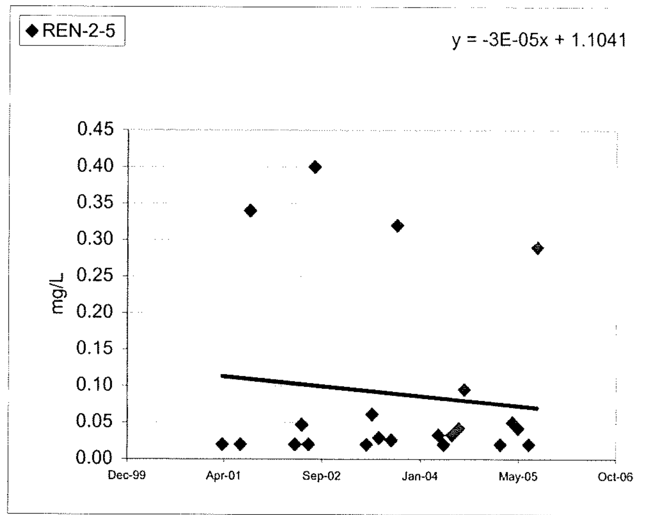

REN-3-0
y = 9E-06x - 0.3075
mg/L
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

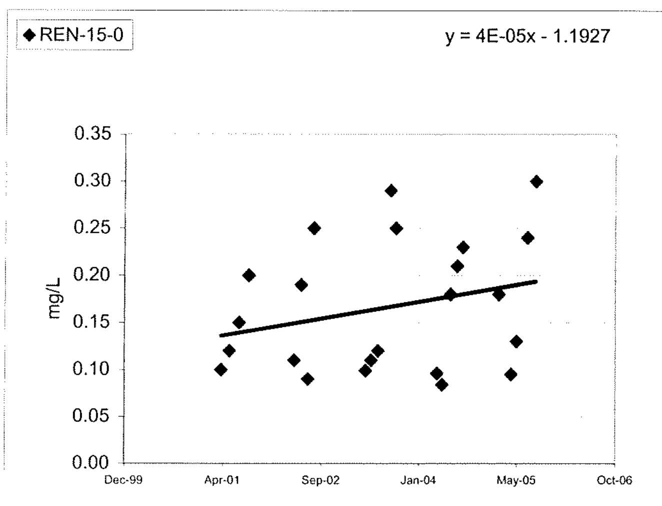

REN-4-0
y = 1E-05x - 0.3338
mg/L
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-5
y = 5E-05x - 1.6607
mg/L
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

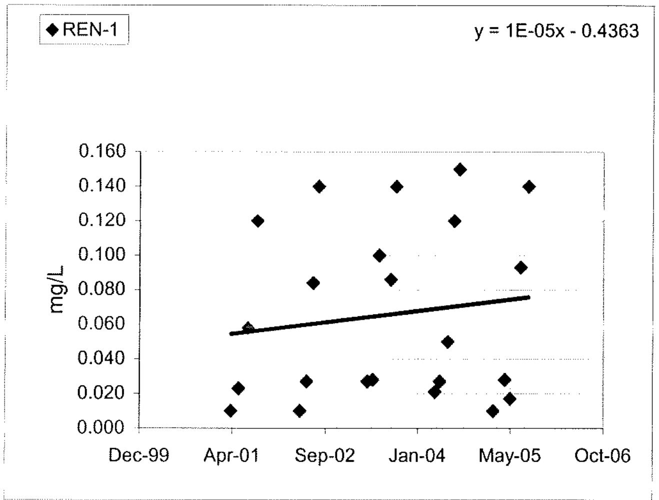

REN-7
y = 0.0016x - 58.24
mg/L
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

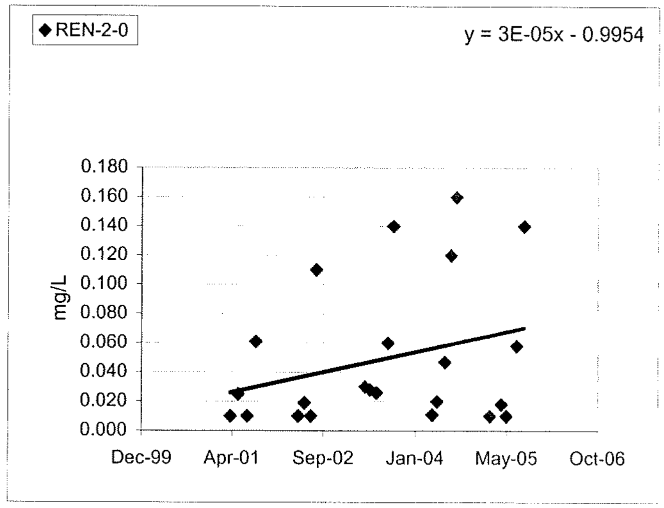

REN-8-0
y = -2E-05x + 0.7295
mg/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

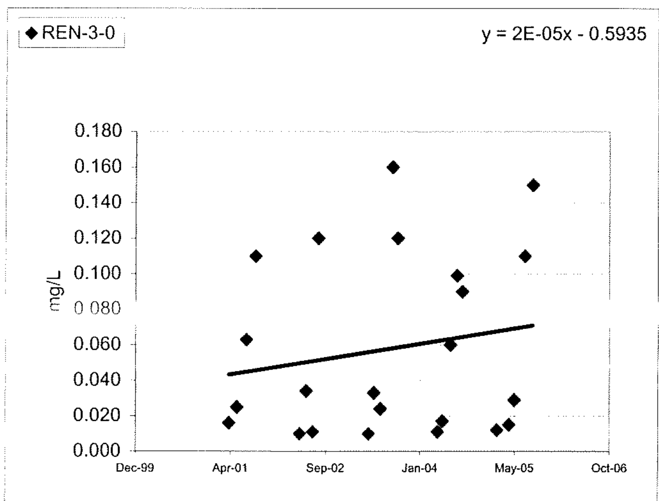

REN-2-5
y = -3E-05x + 1.1041
mg/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

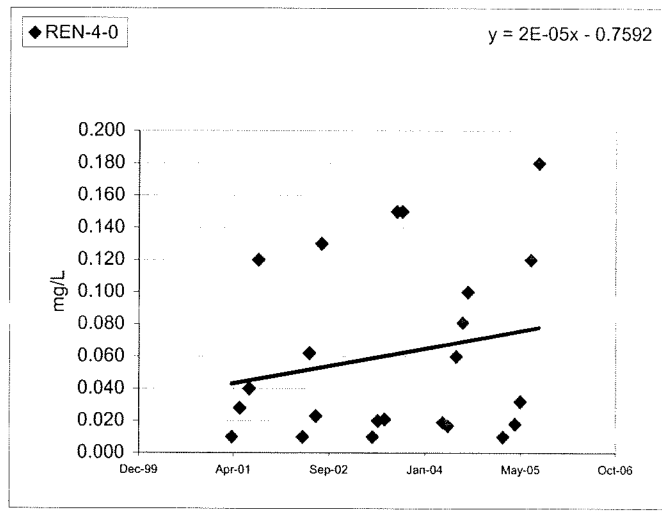

REN-15-0
y = 4E-05x - 1.1927
mg/L
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

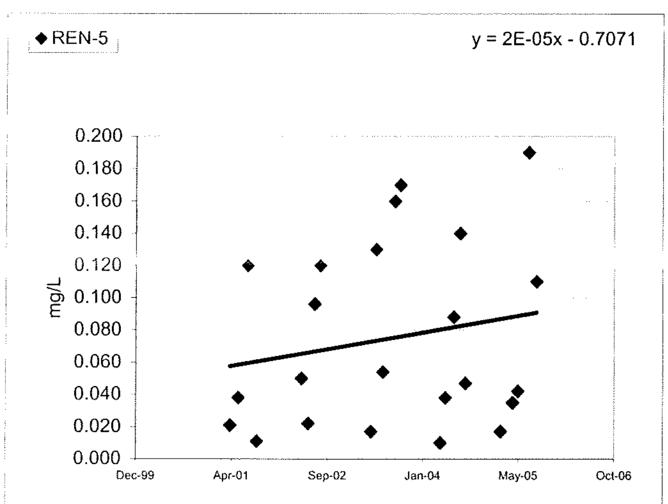
Soluble Phosphorus (o-Phosphate)

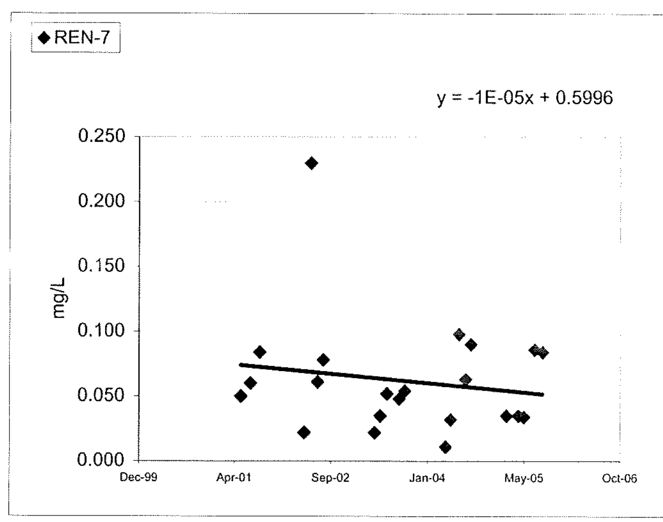




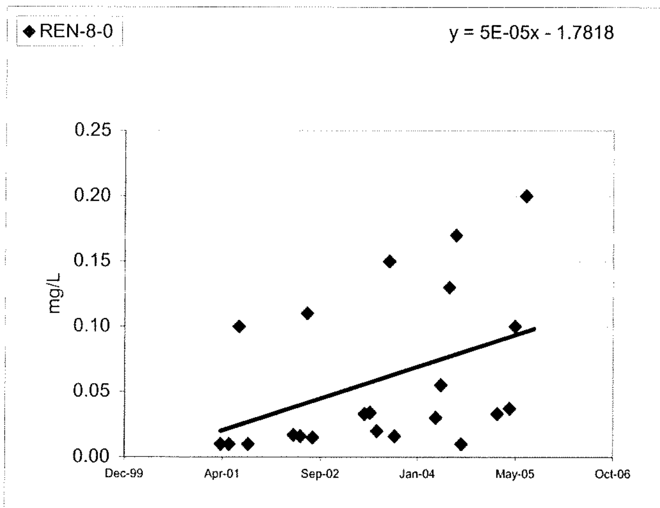


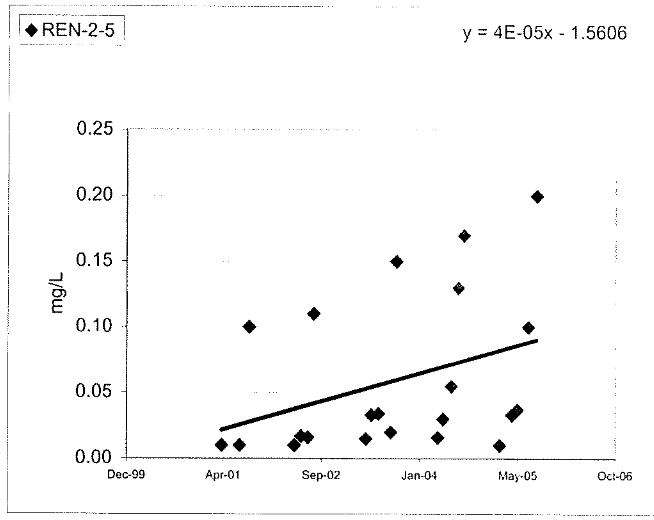


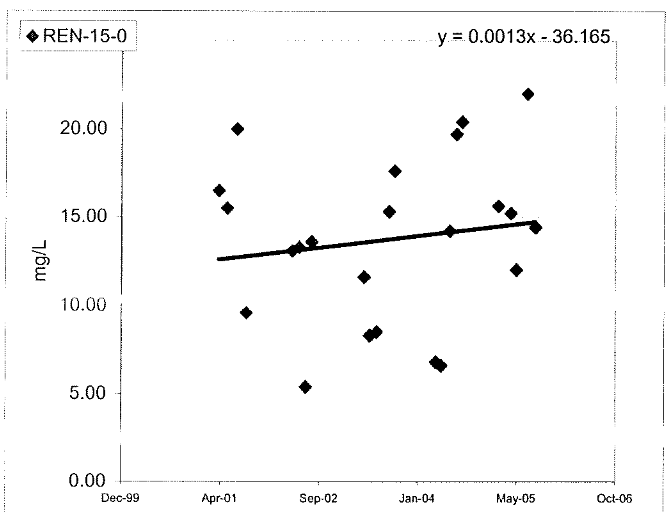


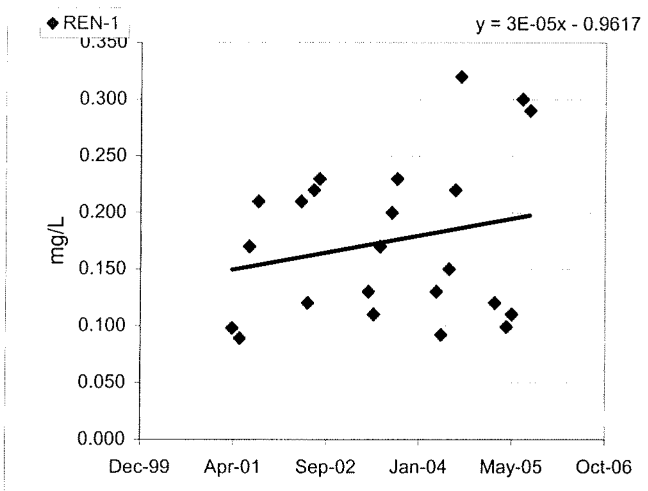


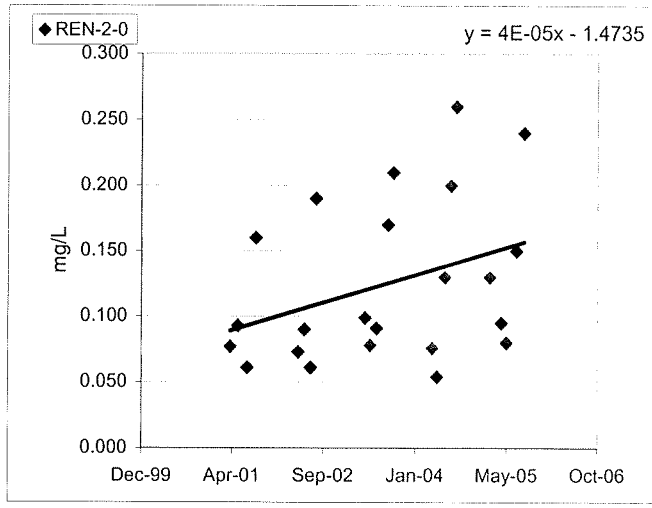
Soluble Phosphorus (o-Phosphate)

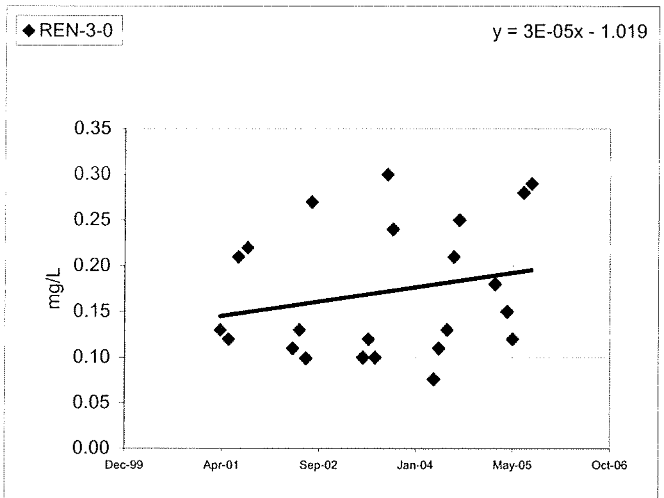


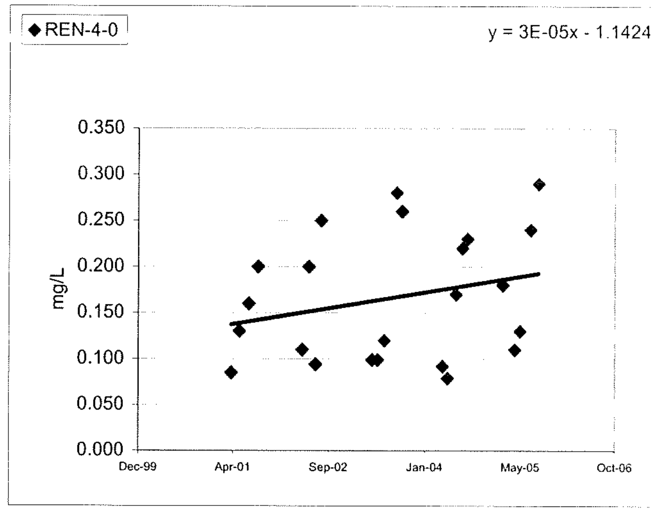


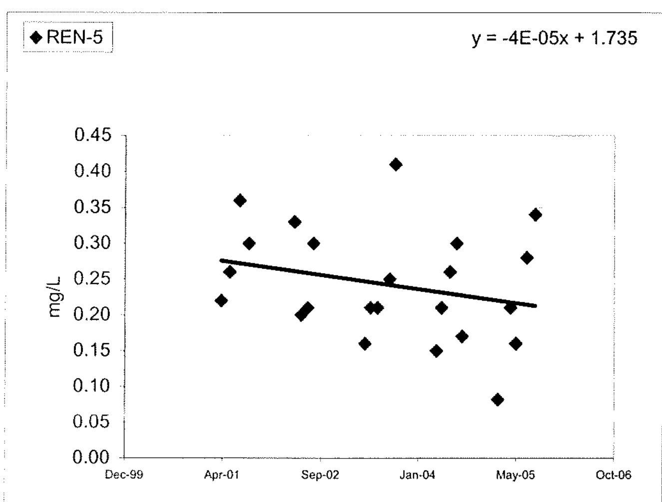


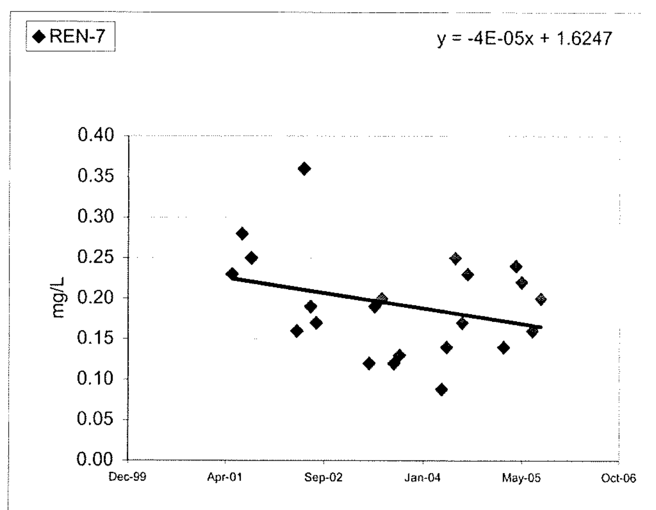

REN-1
y = 3E-05x - 0.9617
mg/L
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-2-0
y = 4E-05x - 1.4735
mg/L
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

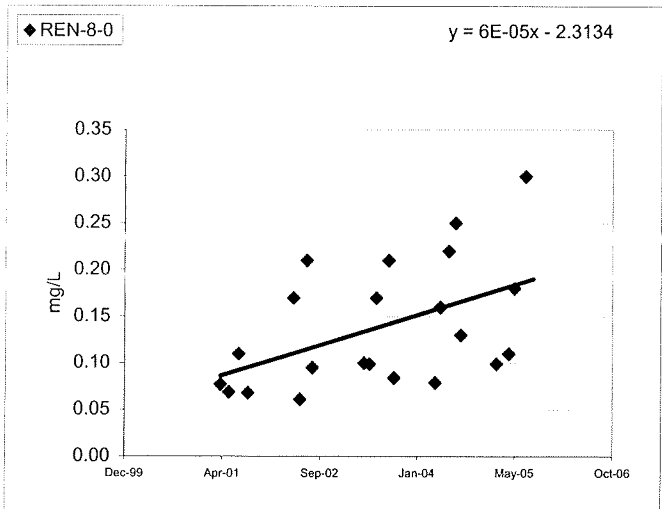

REN-3-0
y = 3E-05x - 1.019
mg/L
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

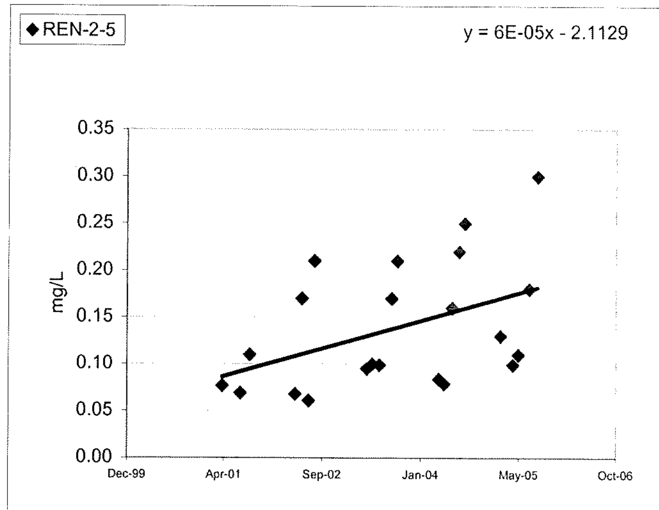

REN-4-0
y = 3E-05x - 1.1424
mg/L
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

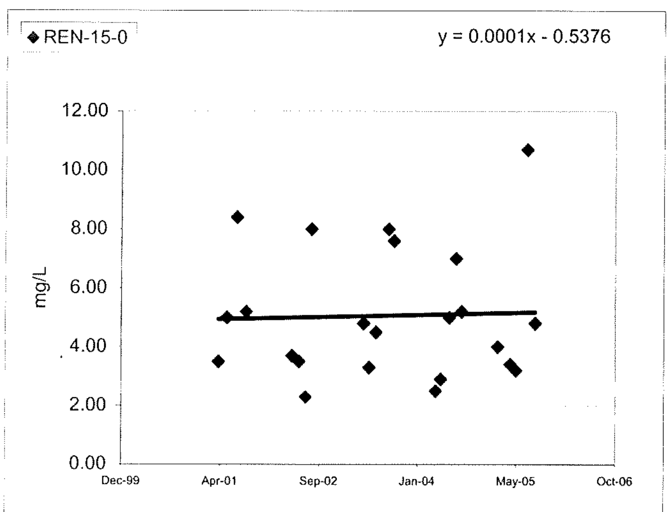

REN-5
y = -4E-05x + 1.735
mg/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


REN-7
y = -4E-05x + 1.6247
mg/L
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

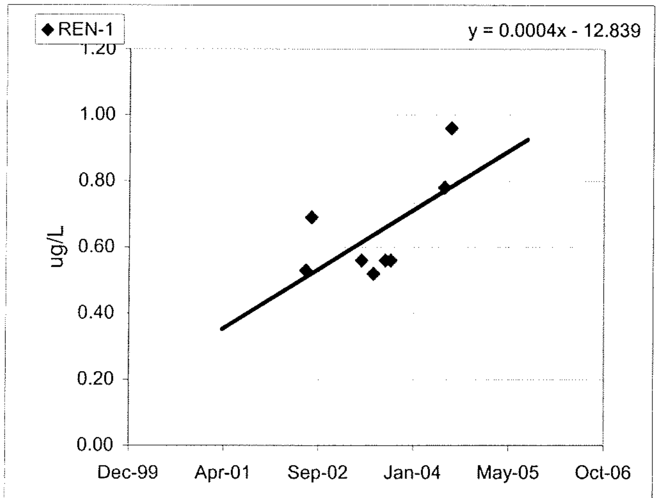
Total Phosphorus

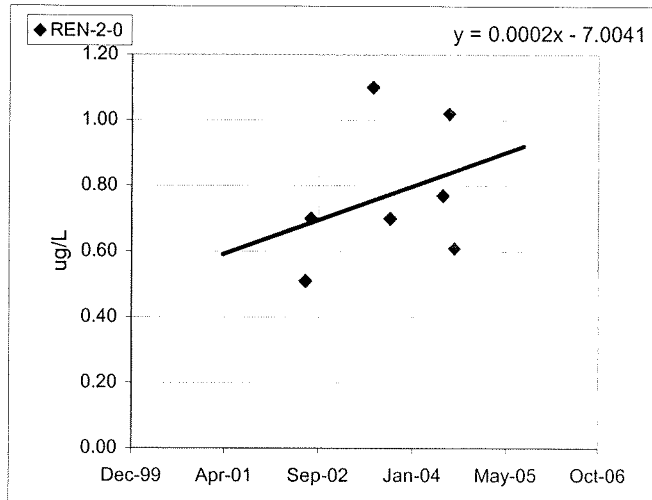


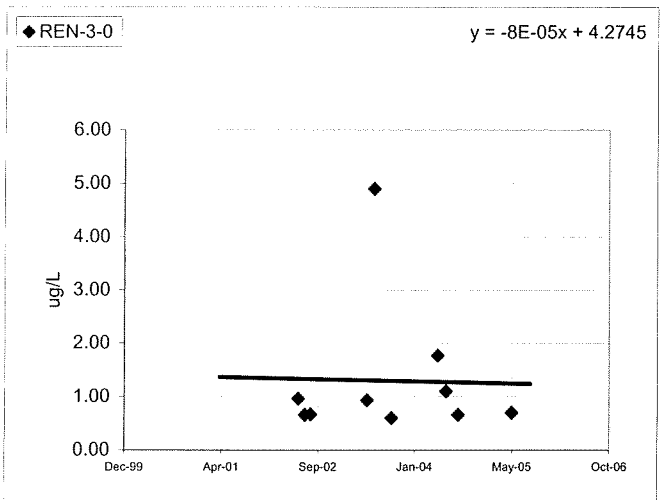


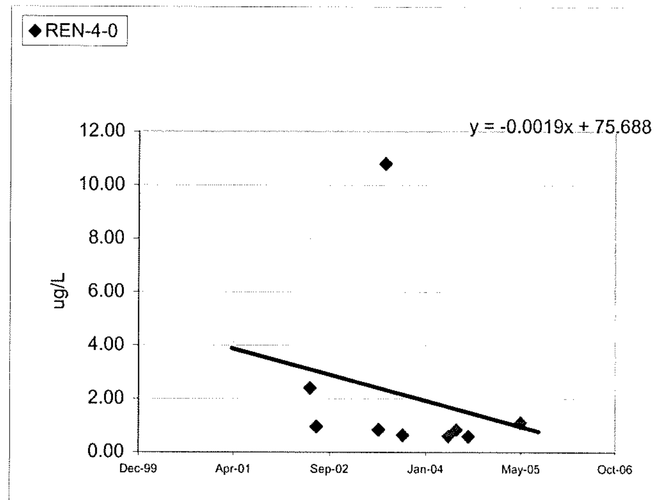


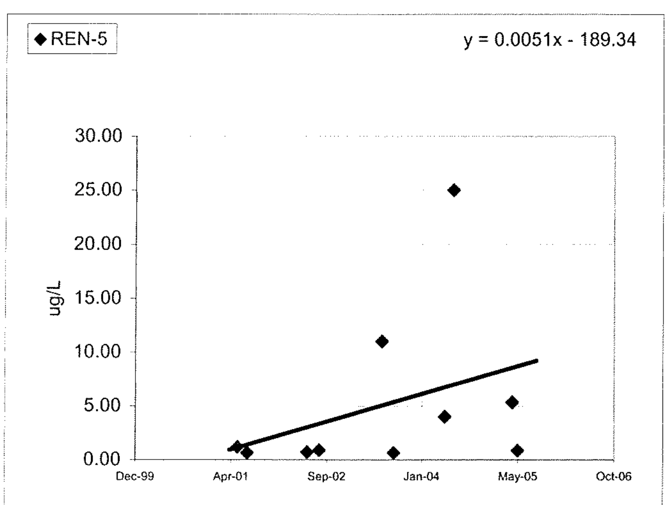
Atrazine

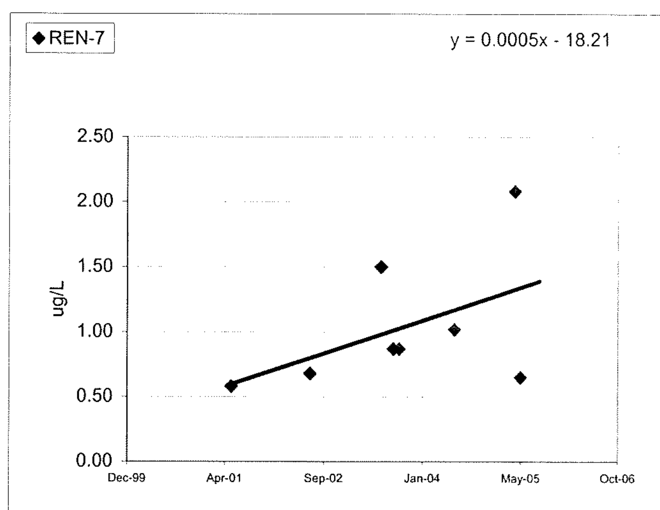

◆ REN-1
y = 0.0004x - 12.839
ug/L
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

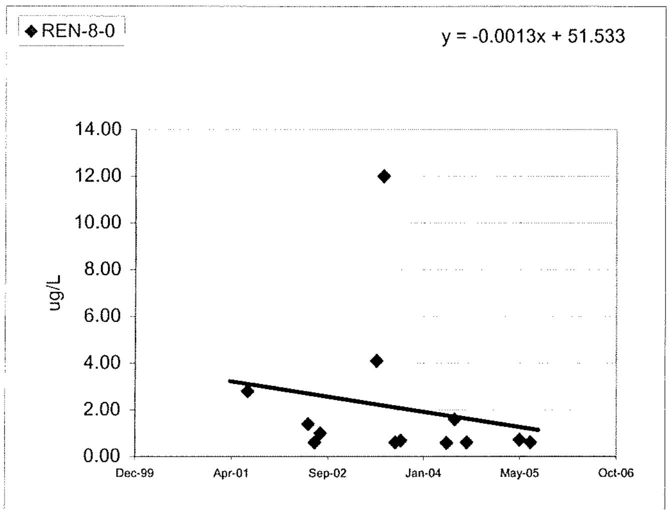

◆ REN-2-0
y = 0.0002x - 7.0041
ug/L
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


◆ REN-3-0
y = -8E-05x + 4.2745
ug/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


◆ REN-4-0
y = -0.0019x + 75.688
ug/L
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

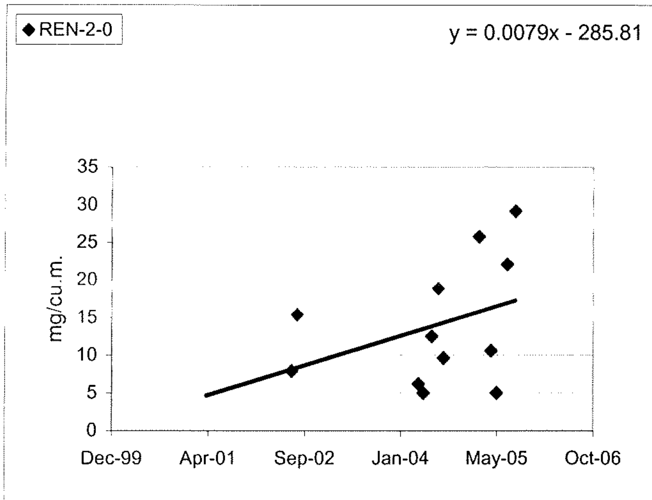

◆ REN-5
y = 0.0051x - 189.34
ug/L
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

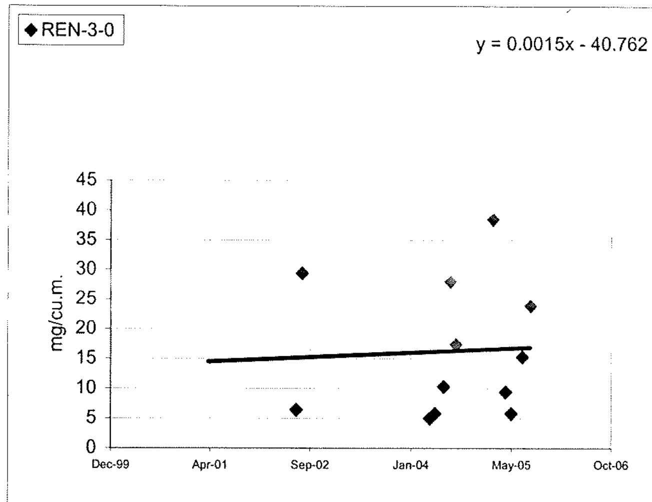

◆ REN-7
y = 0.0005x - 18.21
ug/L
2.50
2.00
1.50
1.00
0.50
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

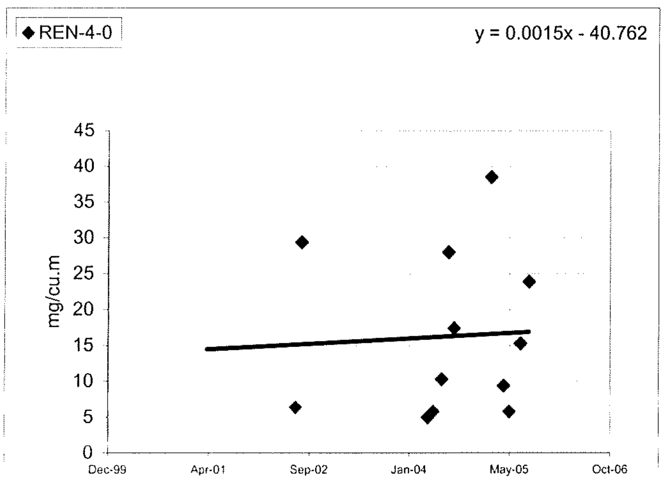


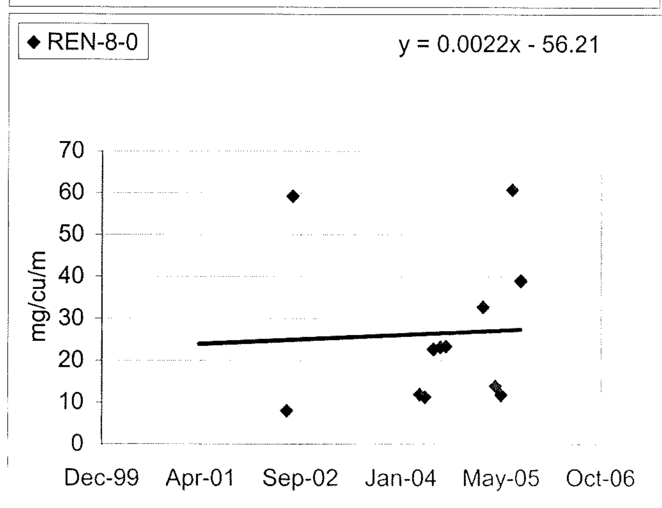
◆ REN-8-0
y = -0.0013x + 51.533
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
ug/L
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

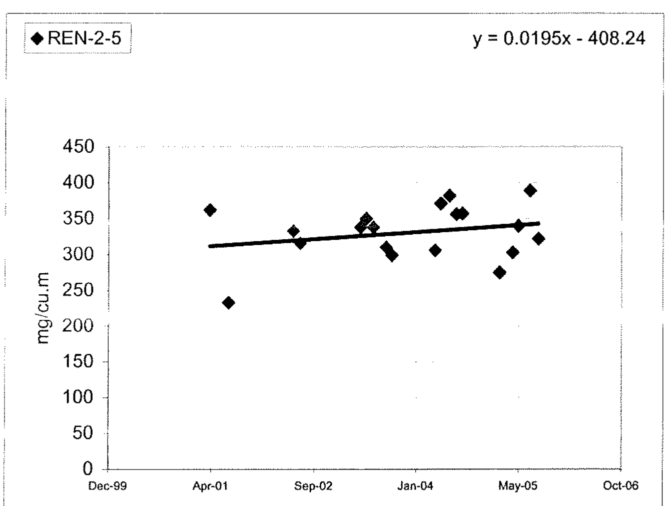
Chlorophyll

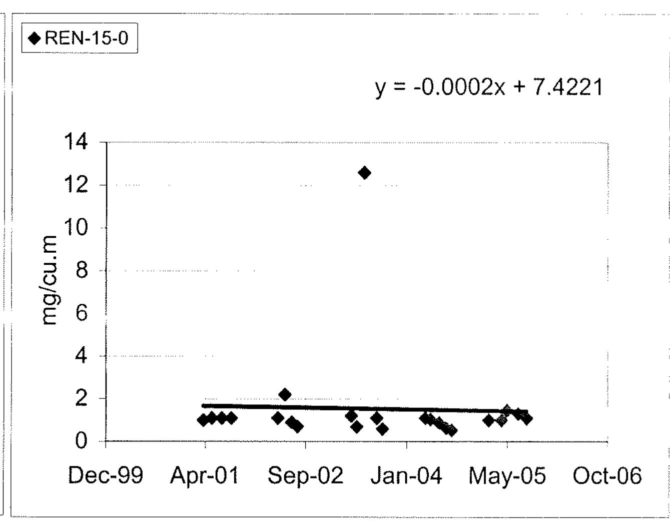




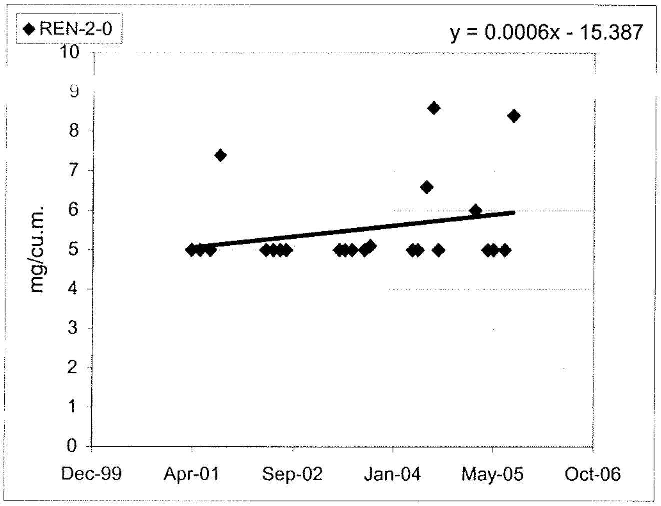




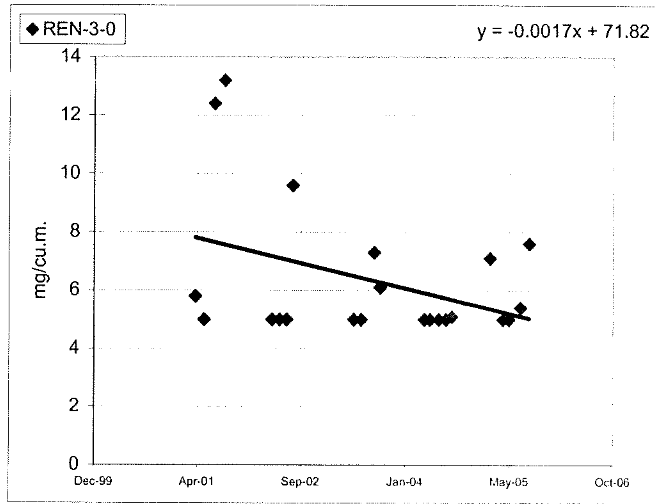




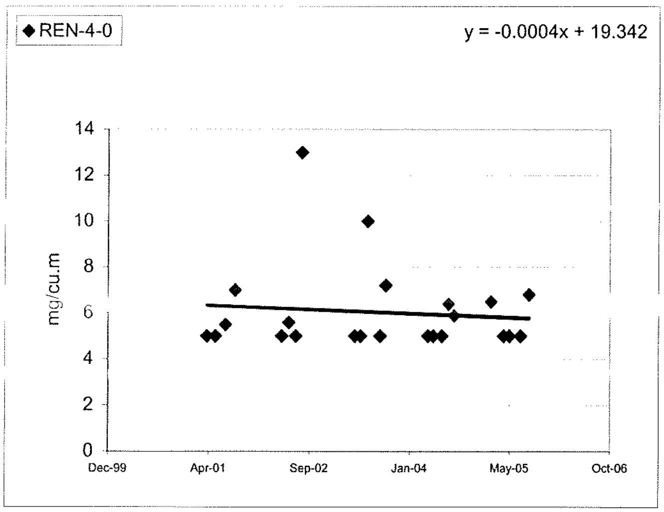
Pheophytin



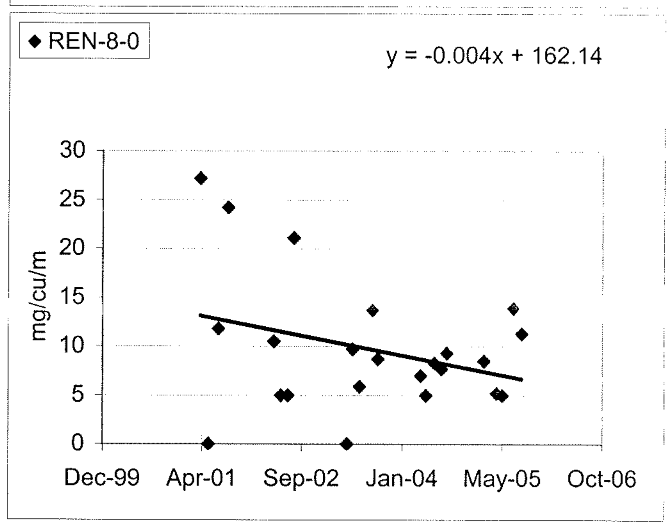
REN-2-0
y = 0.0006x - 15.387
mg/cu.m.
0
1
2
3
4
5
6
7
8
9
10
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



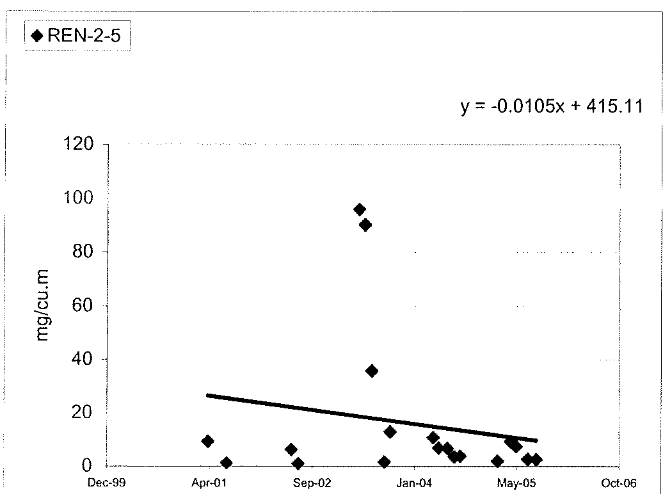
REN-3-0
y = -0.0017x + 71.82
mg/cu.m.
0
2
4
6
8
10
12
14
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



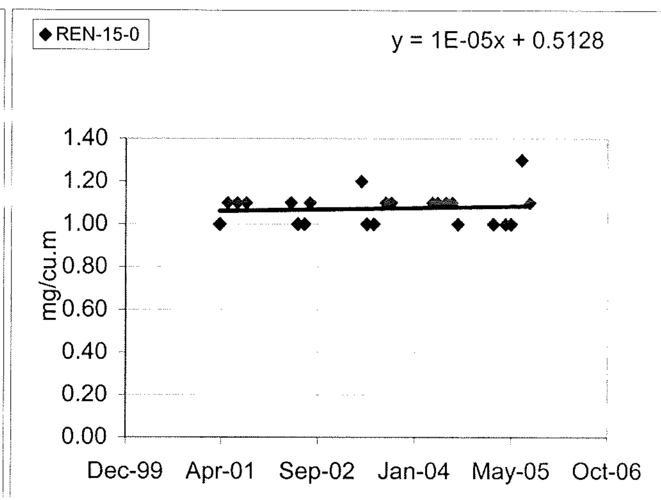
REN-4-0
y = -0.0004x + 19.342
mg/cu.m
0
2
4
6
8
10
12
14
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



REN-8-0
y = -0.004x + 162.14
mg/cu/m
0
5
10
15
20
25
30
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

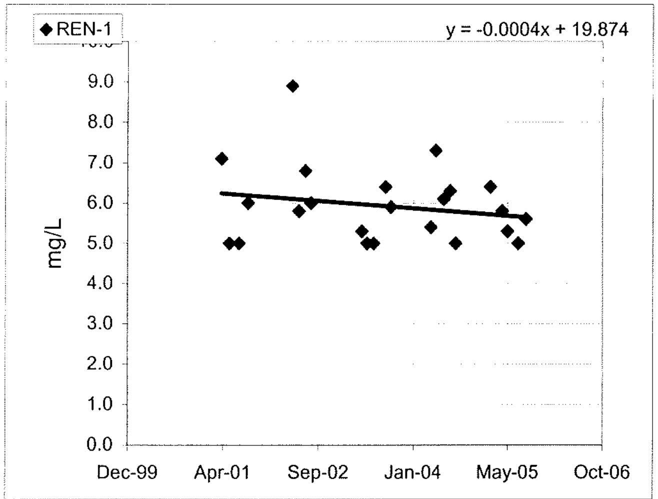


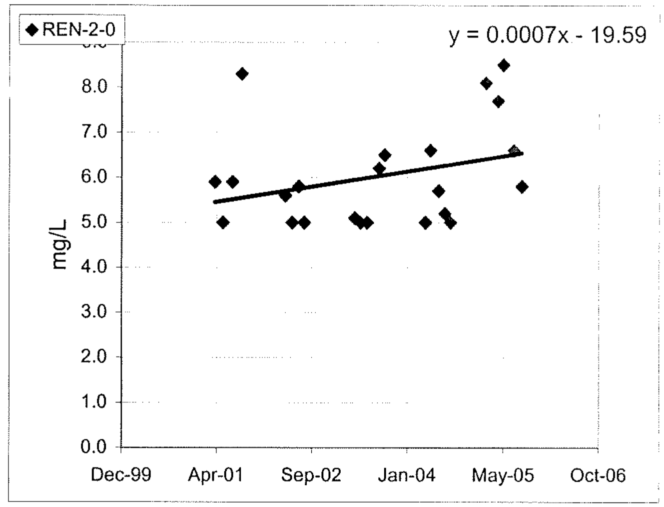
REN-2-5
y = -0.0105x + 415.11
mg/cu.m
0
20
40
60
80
100
120
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

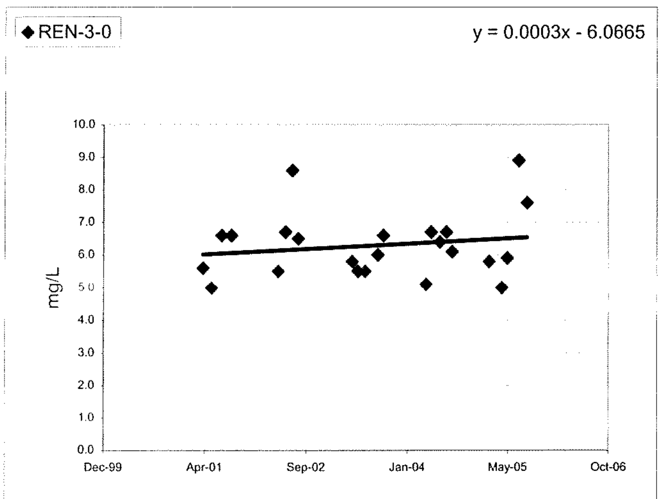


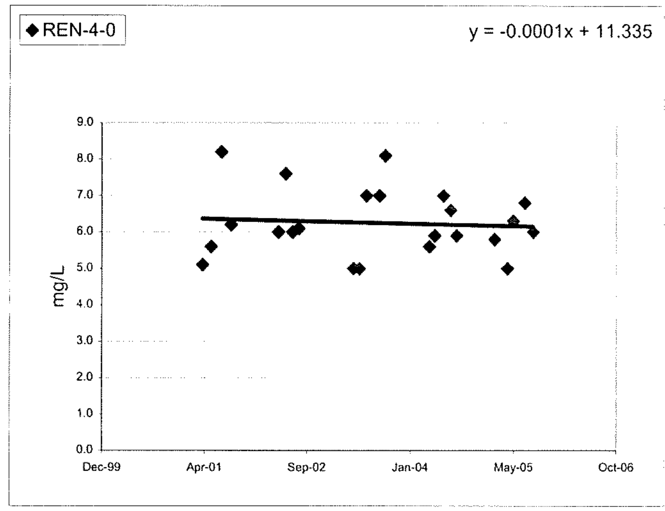
REN-15-0
y = 1E-05x + 0.5128
mg/cu.m
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

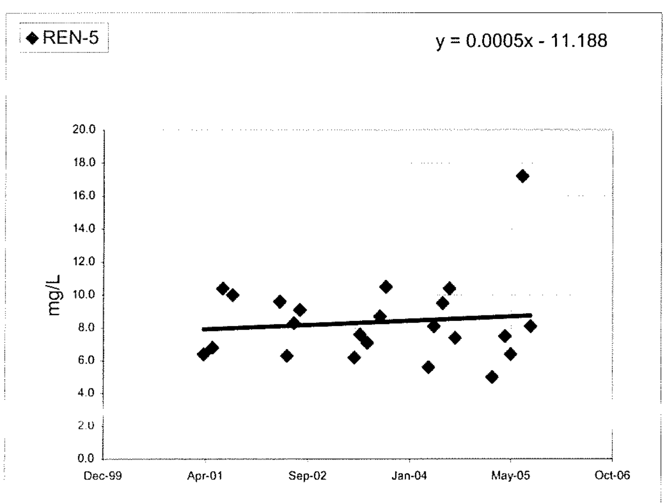
Total Organic Carbon (TOC)

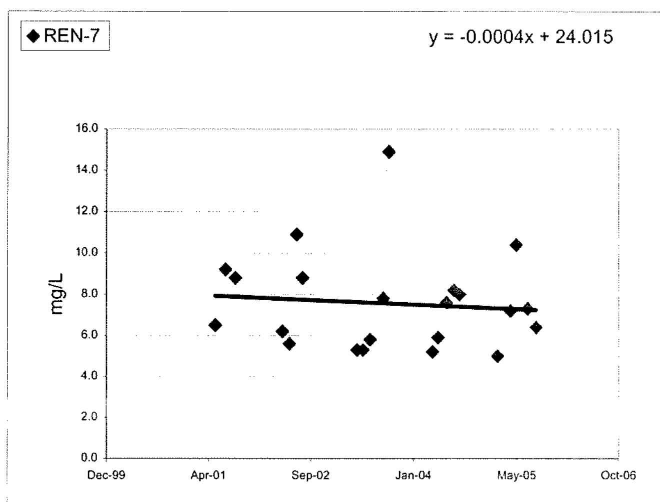


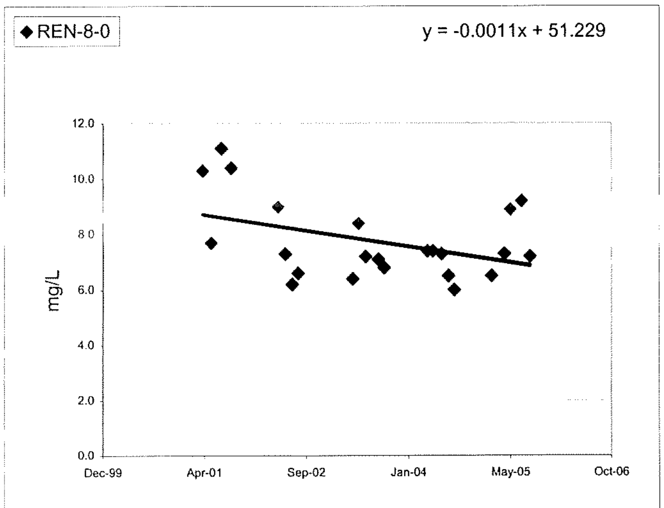


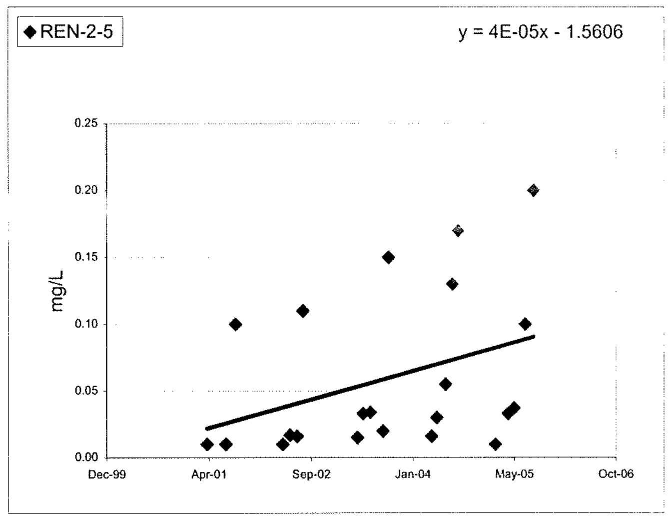


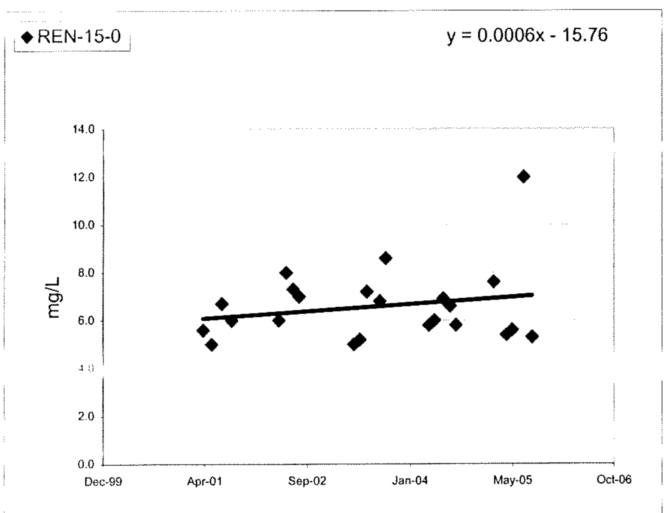







◆ REN-8-0
y = -0.0011x + 51.229
mg/L
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


◆ REN-2-5
y = 4E-05x - 1.5606
mg/L
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


◆ REN-15-0
y = 0.0006x - 15.76
mg/L
14.0
12.0
10.0
8.0
6.0
2.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06