WATER QUALITY DATABASE EVALUATION
AND TREND ANALYSIS
FOR:
CARLYLE 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 Carlyle Lake during the period 2001-2005.

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 Carlyle Lake water quality data has been collected from lake surface waters at three (3) sites and from one subsurface site. Additional data have been acquired from samples taken at sites located upriver and downriver of the body of the lake. The samples were collected by the Corps of Engineers, St. Louis District, Environmental Quality Section. Statistical analysis and the results were evaluated for seventeen (17) parameters for all sites that contained sufficient data (i.e. data from two years or more and/or a sufficient number of data points above the detection limit) on a combined and individual basis.

The data collected indicated a generally improving to stable water quality within Carlyle Lake.

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 Carlyle 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 Carlyle 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 the lake system. The statistical results obtained are compared to applicable water quality standards currently in force by regulation (State and/or Federal). In those cases where there is no regulatory limited the values observed are compared to those which are generally accepted as a good range for water quality. Illinois regulations for general use waters appear in 35 Illinois Administrative Code, Section 302, Subpart B and in Illinois Integrated Water Quality Report, 2006.

3.0 CARLYLE LAKE WATER QUALITY DATA EVALUATION

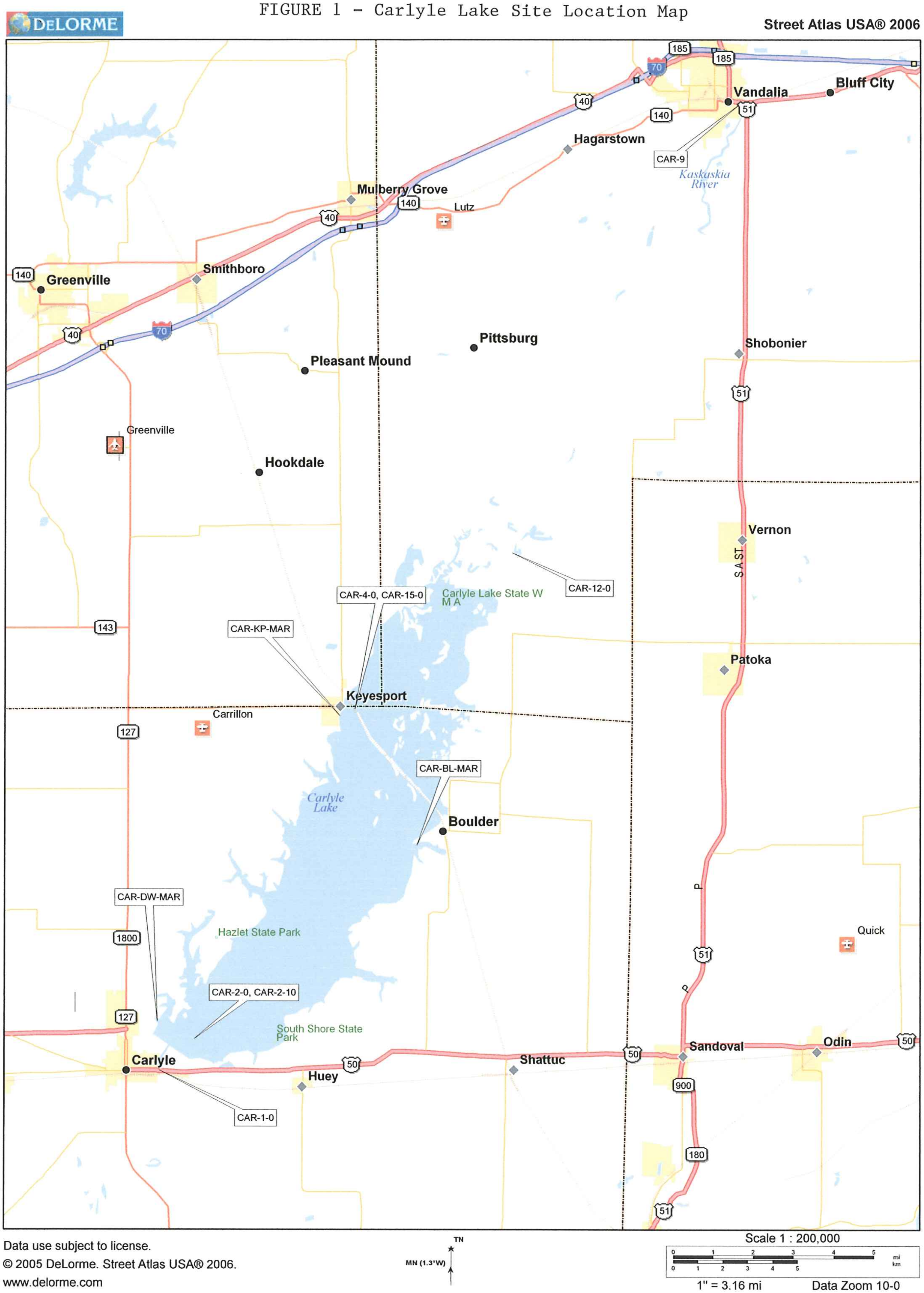
3.1 Data Sets

Data sets evaluated for Carlyle Lake originated from field sampling by the St. Louis District Corps of Engineers Environmental Quality Section at a total of seven (7) sites. Figure 1 shows the locations of these sites.

3.2 Evaluation

Evaluation of data was performed in two ways: 1) the combined values for each parameter observed at all sites; and 2) the values for each parameter observed at each site. 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. As noted, 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 in 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 - Carlyle Lake Site Location Map



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

Review of the figure will show that in general the observed values are in an approximate range of 5 to 10 mg/L. The mean, median and mode for the observed data were 6.3, 6.2 and 7.5, respectively. These data (excluding the exceptions noted below) indicate that D.O. levels in the system are acceptable and that those levels are stable.

The exceptions noted were:

- six values of less than 1 mg/L observed during summer months throughout the time span of the study at sites 2-10 and 11-0; and
- several values observed at differing sites which were well above the maximum solubility (13 mg/L) of oxygen in water which is warmer than 40° F (4.4° C).

The high values were excluded from the statistics and were not plotted.

3.3.2 pH

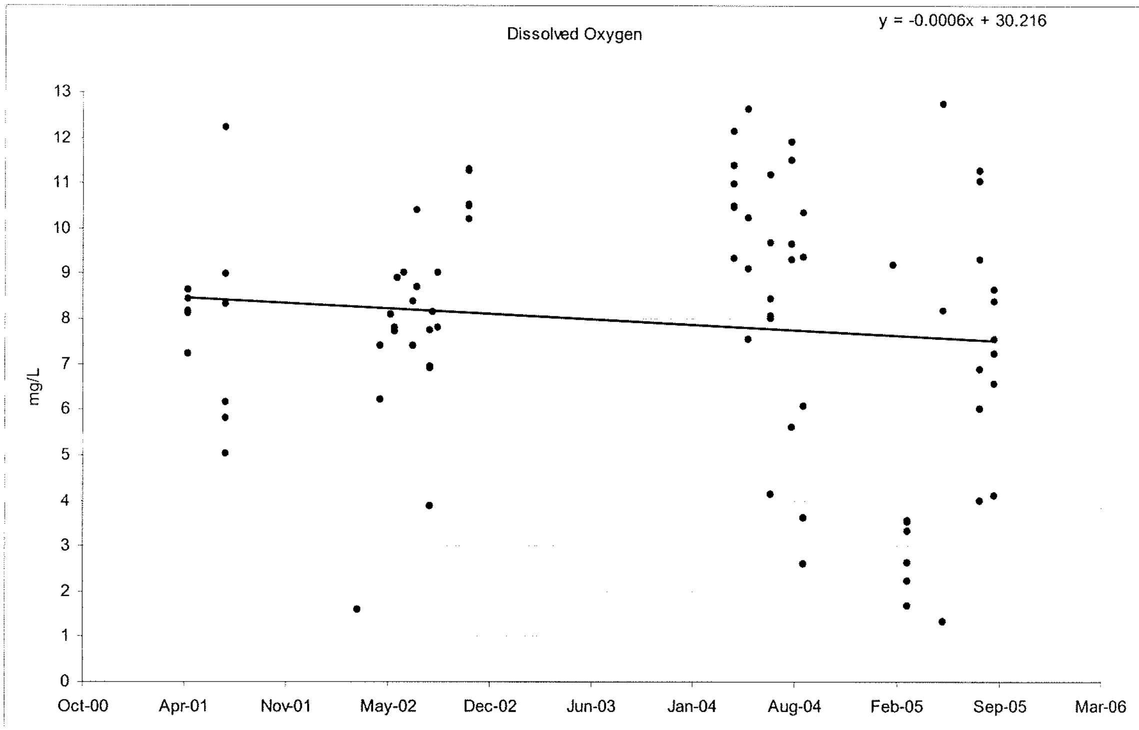
The value for pH is a logarithmic expression of the concentration of hydrogen ions. It is governed by the combined effects of dissolved gases (principally carbon dioxide) and the levels of the various salts which are present. A "neutral" system is pH 6 to 8. The pH of an acidic system is less than 6 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 unusually hot or cold temperatures, flooding, increased runoff due to rainfall, erosion from land disturbances caused by agricultural activities or land development.

Table 1 – Definitions for Descriptive Statistics

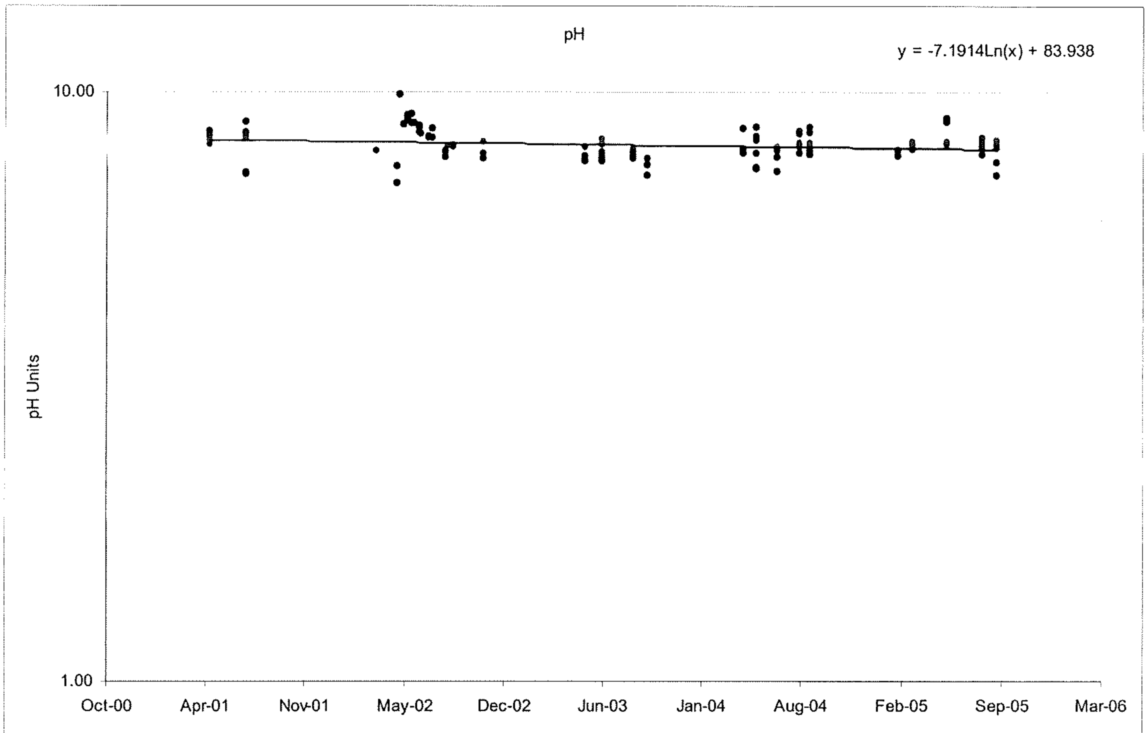
Statistic	Definition
Mean	Arithmetic average of all the data points.
Standard Error	Measure of the amount of error in the prediction of the Y(parameter of interest) data point for an individual X data point. The statistic is a function of standard deviation and the number of measurements made.
Median	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
Average	7.93
Standard Error	0.30
Median	8.26
Mode	8.39
Standard Deviation	2.77
Sample Variance	7.66
Kurtosis	-0.18
Skewness	-0.60
Range	11.42
Minimum	1.32
Maximum	12.74
Sum	682
Count	86

Figure 3



Statistic	Value
Average	8.12
Standard Error	0.04
Median	8.10
Mode	7.70
Standard Deviation	0.46
Sample Variance	0.21
Kurtosis	1.28
Skewness	0.55
Range	2.93
Minimum	6.99
Maximum	9.92
Sum	1024
Count	126

Illinois regulations specify a characteristic pH in the range 6.5 to 9 for general purpose waters. Although the observed values are in an approximate range of 6 to 10, the mean, median and mode are at or near to neutrality and are 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.

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, can indicate that a system is operating anaerobically, a condition which generally leads to generation of objectionable odors through putrefaction.

Values of ORP data are plotted in Figures 4. Review of the plot will show that during the period studied, the mean of the values observed for ORP decreased steadily from a high of approximately 250 millivolts to a low in the order of 150 millivolts or approximately 5 to 6% each seven months. The data indicate that this trend will continue.

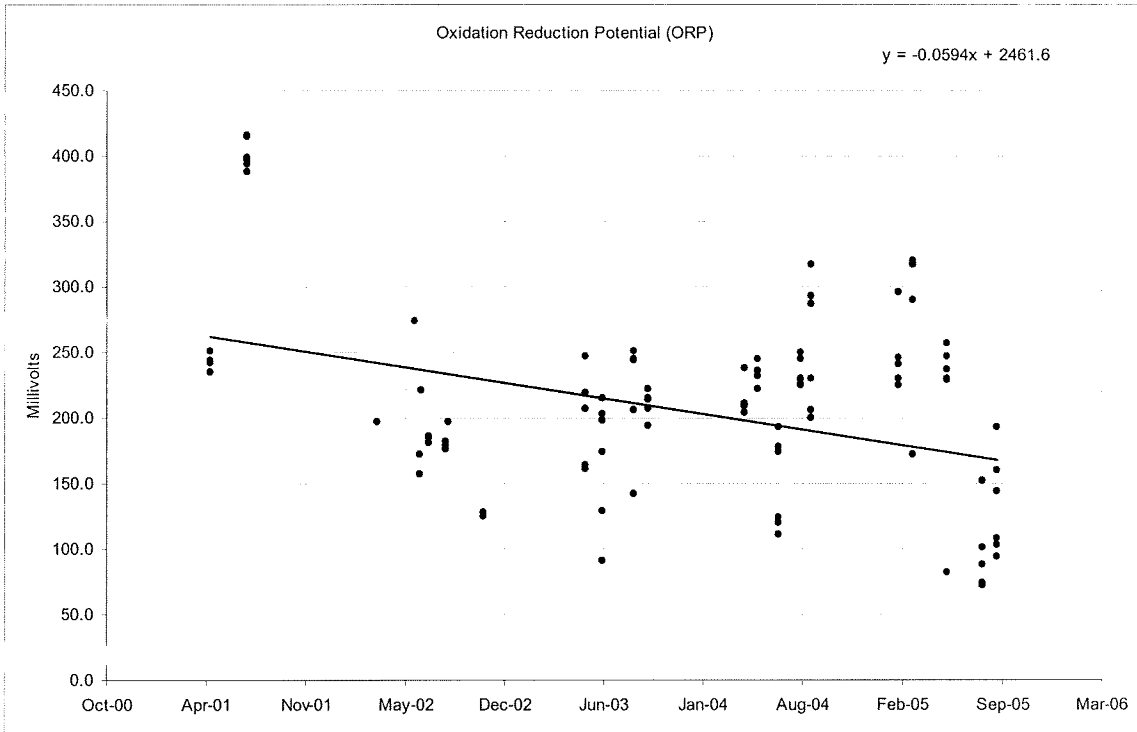
Note: Two negative values for ORP observed in samples collected in May 2004 at off-lake Sites 9 and 12. These values were included in calculation of the statistics for this property but are not plotted As noted above, negative values for ORP may indicate that there are problems in the system In this case, however, the instances are isolated and do not appear to have any significance relative to the quality of lake water.

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

3.3.4 Conductivity

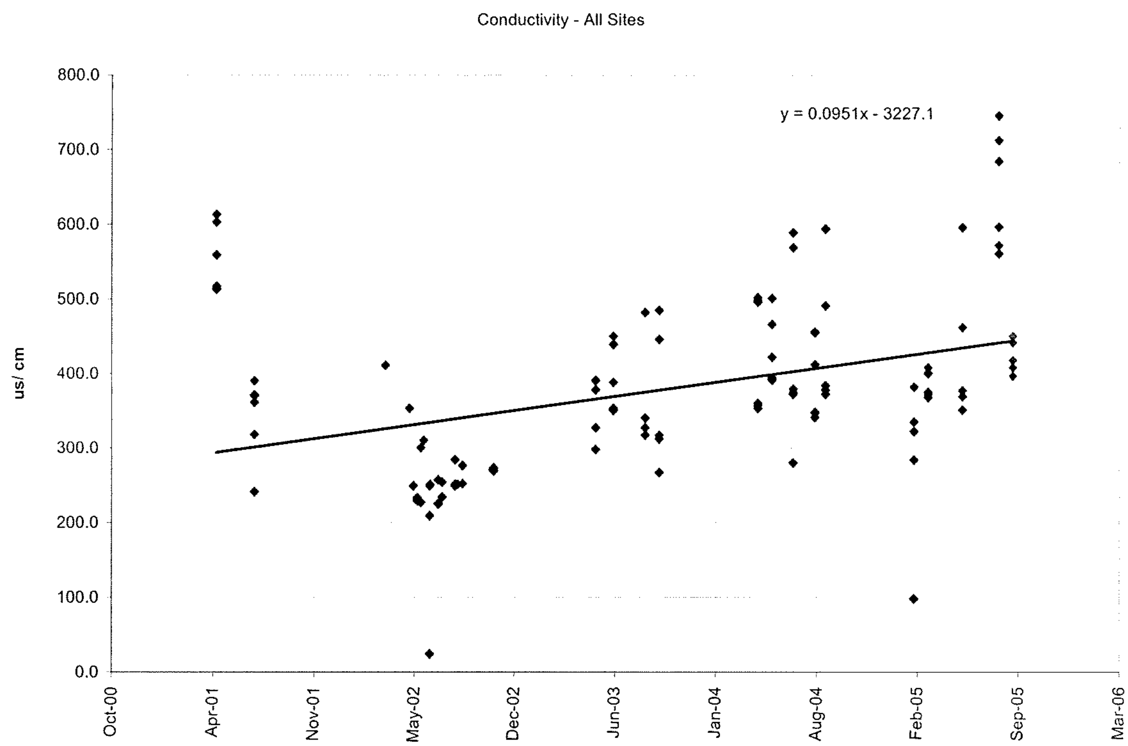
The data for conductivity appears in Figure 5. The descriptive statistics for those data appear in the table below the plotted values.

Figure 4



Statistic	Value
Average	205.75
Standard Error	8.63
Median	212.50
Mode	242.00
Standard Deviation	89.71
Sample Variance	8048.42
Kurtosis	5.08
Skewness	-0.98
Range	591.00
Minimum	-175.00
Maximum	416.00
Sum	22221
Count	108

Figure 5



Statistic	Value
Average	377.98
Standard Error	10.85
Median	371.50
Mode	372.00
Standard Deviation	120.77
Sample Variance	14585.84
Kurtosis	0.74
Skewness	0.49
Range	722.00
Minimum	24.00
Maximum	746.00
Sum	46869
Count	124

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^{o} 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.

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 maximum observed was 746 uS/cm. The mean, mode and median of the values, however, are in close agreement at approximately 370 uS/cm. There is a slight upward trend in those values but the data suggest that future values for this property will be of magnitudes similar to those 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 appears in Figure 6.. The descriptive statistics for those data appear in the table below the plotted values.

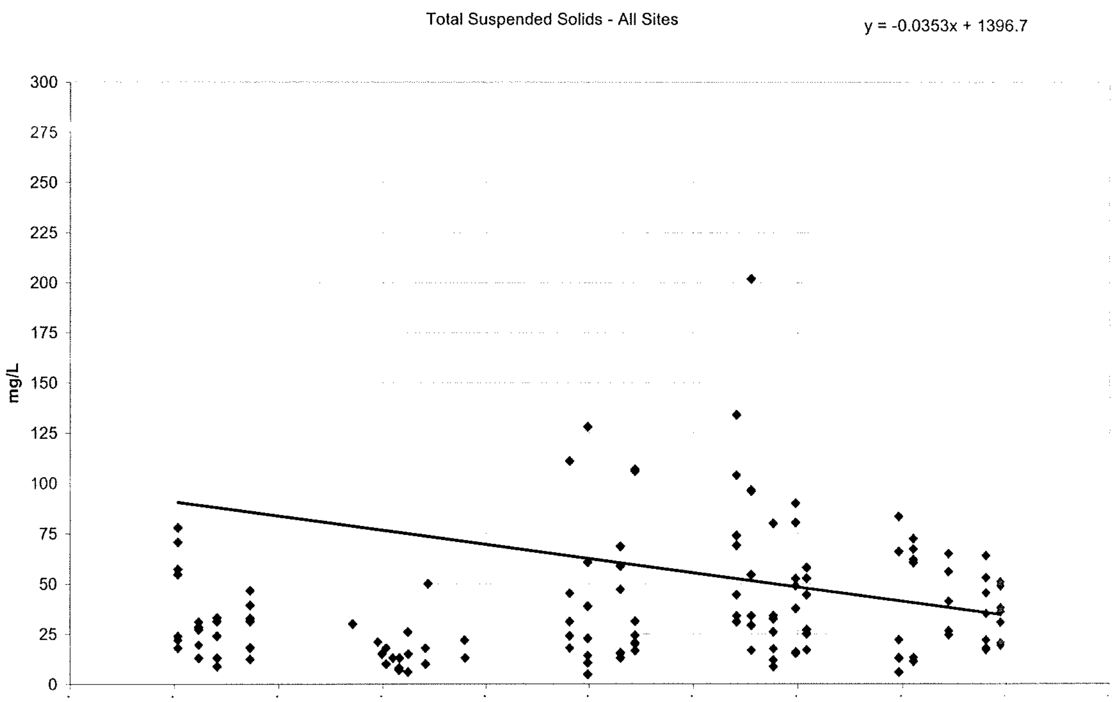
Suspended solids affect the clarity and appearance of water. In general, these solids are soil and/or plant particulates introduced to the system by local or watershed erosion or biomaterials produced by aquatic flora and fauna. Individual measurements taken at separate sites in the system are quite often highly variable because of these localized effects. Five values in the range 400 to 1000 were observed during the during the study and were not plotted to avoid scaling problems in the chart. Except for those high values, the data acquired are in reasonable agreement. The data indicate that this property is stable and that it will remain in the range shown in the plot for the foreseeable future.

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

3.3.6 Volatile Suspended Solids

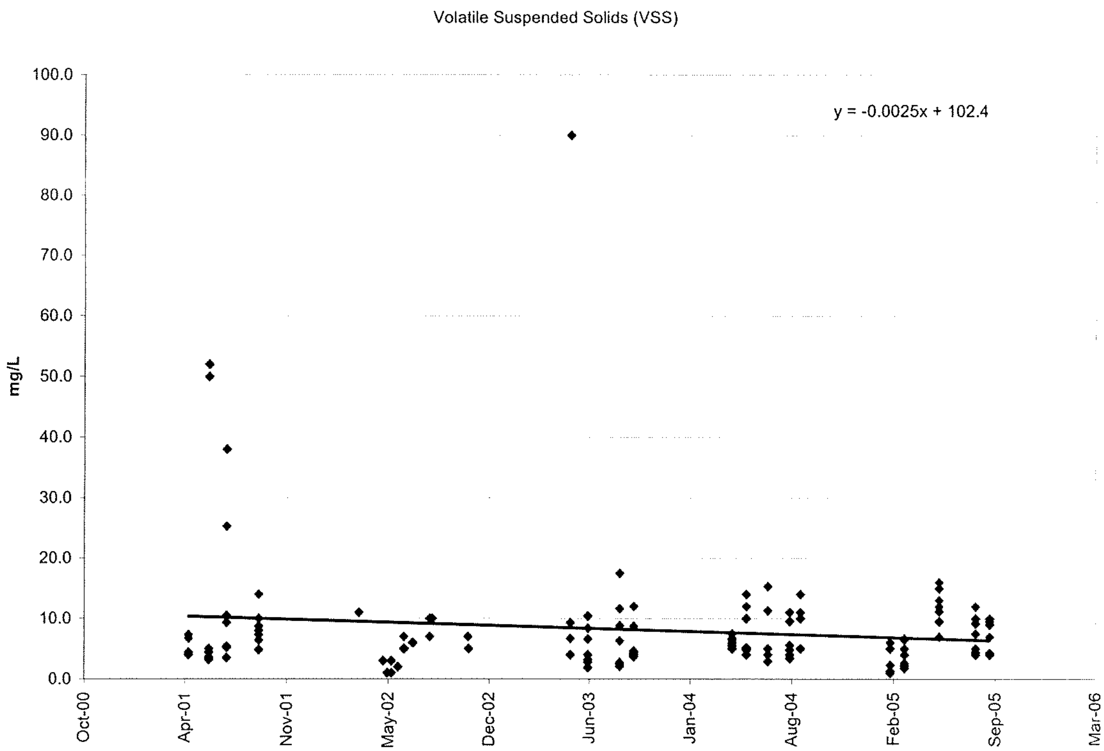
The data for volatile suspended solids appears in Figure 7.. The descriptive statistics for those data appear in the table below the plotted values.

Figure 6



Statistic	Value
Average	59.92
Standard Error	10.41
Median	31.00
Mode	18.00
Standard Deviation	123.61
Sample Variance	15278.91
Kurtosis	36.18
Skewness	5.70
Range	1025.20
Minimum	4.80
Maximum	1030.00
Sum	8449
Count	141

Figure 7



Statistic	Value
Average	26.96
Standard Error	3.30
Median	21.30
Mode	5.00
Standard Deviation	21.12
Sample Variance	445.89
Kurtosis	-0.09
Skewness	0.91
Range	72.30
Minimum	5.00
Maximum	77.30
Sum	1105.30
Count	41

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

3.3.7 Total Phosphorus

The data for total phosphorus appears in Figure 8. The descriptive statistics for those data appear 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) adds 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 trendline is flat indicating that the characteristic is stable and that future data will parallel the values shown in the figure.

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 7. Further, the maximum values observed were in the order of 20 to 30 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.

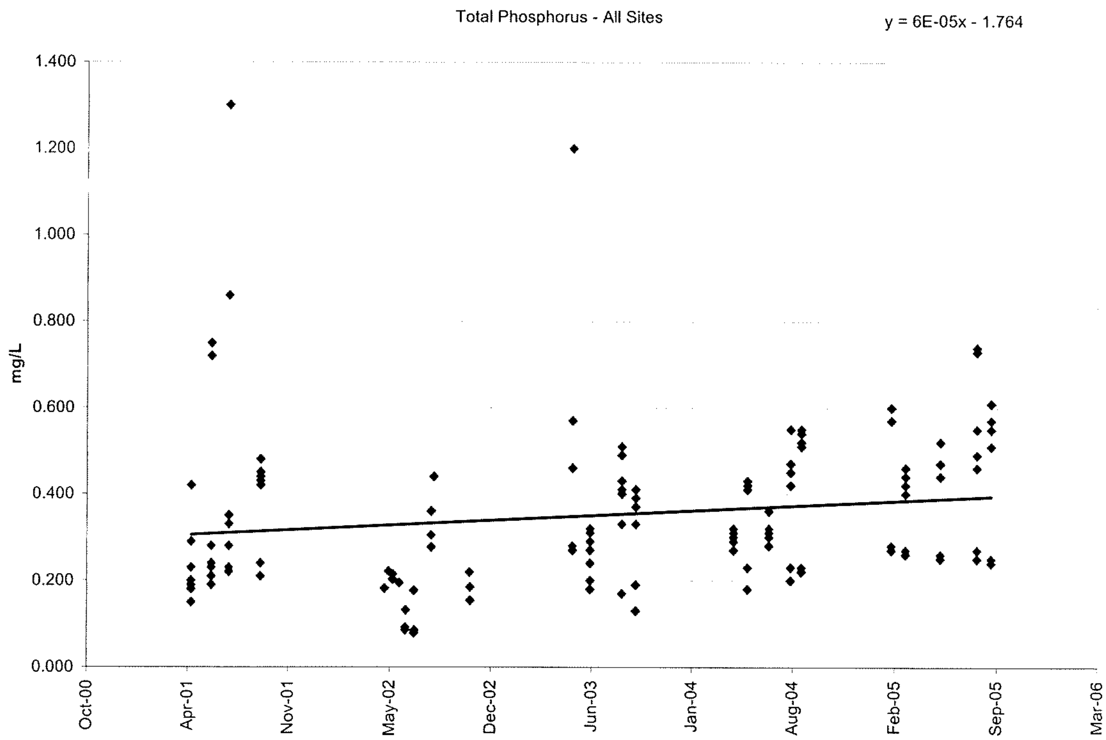
3.3.8 Soluble Phosphorus (ortho Phosphate)

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 total phosphorus (Figure 8) which is in soluble form. The remarks relative to the action, environmental threat potential and origin of total phosphorus entities apply to soluble forms as well. The data indicate that the profile of the nutrient in lake waters is stable.

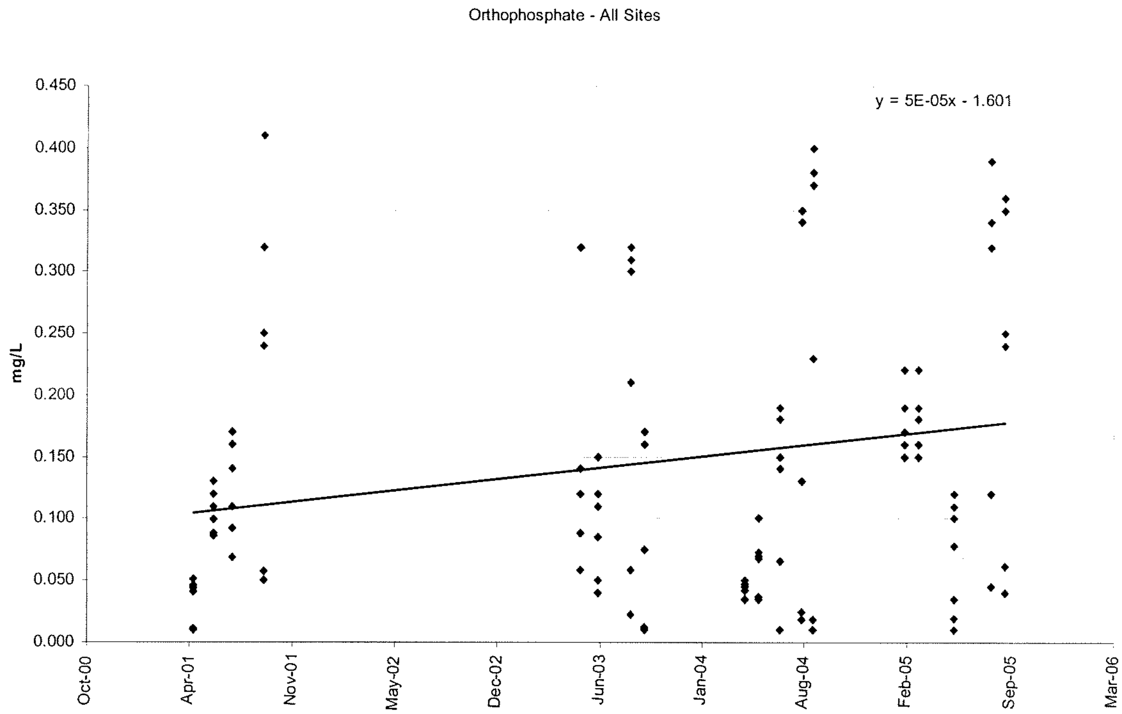
There is no water quality standard for this characteristic published by Illinois.

Figure 8



Statistic	Value
Average	0.35
Standard Error	0.02
Median	0.31
Mode	0.23
Standard Deviation	0.18
Sample Variance	0.034
Kurtosis	7.08
Skewness	2.01
Range	1.22
Minimum	0.08
Maximum	1.30
Sum	49.92
Count	141

Figure 9



Statistic	Value
Average	0.15
Standard Error	0.01
Median	0.12
Mode	0.11
Standard Deviation	0.11
Sample Variance	0.012
Kurtosis	-0.42
Skewness	0.80
Range	0.40
Minimum	0.01
Maximum	0.41
Sum	18.04
Count	123

3.3.9 Nitrate

The data for nitrate appears in Figure 10. The descriptive statistics for those data appear 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.

There is no general use standard of water quality for nitrate in Illinois. The limit for finished water, however, is 10 mg/L. Although a few of the values observed during the subject study exceed that level, the mean, median and mode of the observed data are well below it. The data show that the concentrations of this nutrient in the lake are stable and acceptable.

3.3.10 Ammonia

The data for ammonia appears in Figure 11. The descriptive statistics for those data appear 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 levels of ammonia observed in lake samples are acceptable and stable.

The current level of ammoniacal components in Carlyle 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 the statutory level is far lower (0.10 mg/L). Ammonia ionizes completely at a pH above 4.7, however, and pH levels in Carlyle Lake waters ensure that all of the compound present is in ionic form.

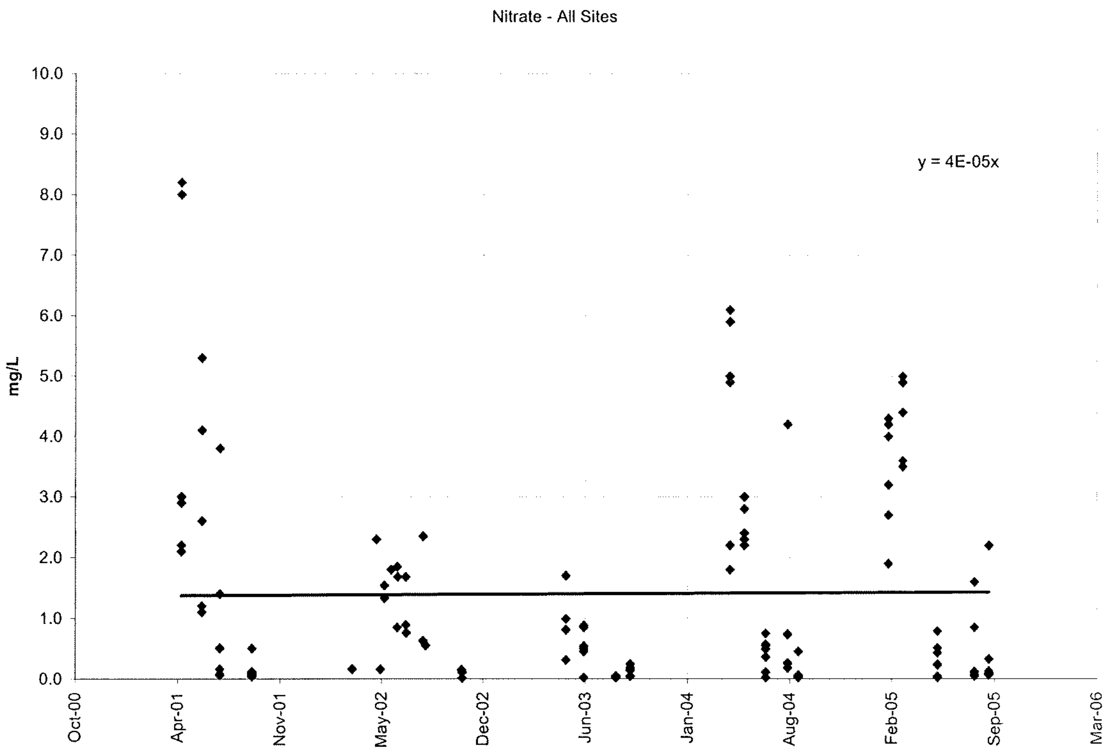
3.3.11 Manganese

Manganese was evaluated in samples collected from two sites. The data are plotted in Figure 12. Statistics calculated from the data appear in the table below the chart.

Manganese was observed in all samples. The median and mode of observed data were approximately 0.04 mg/L and only one exceeded 0.25 mg/L. The level of the metal in lake waters is stable.

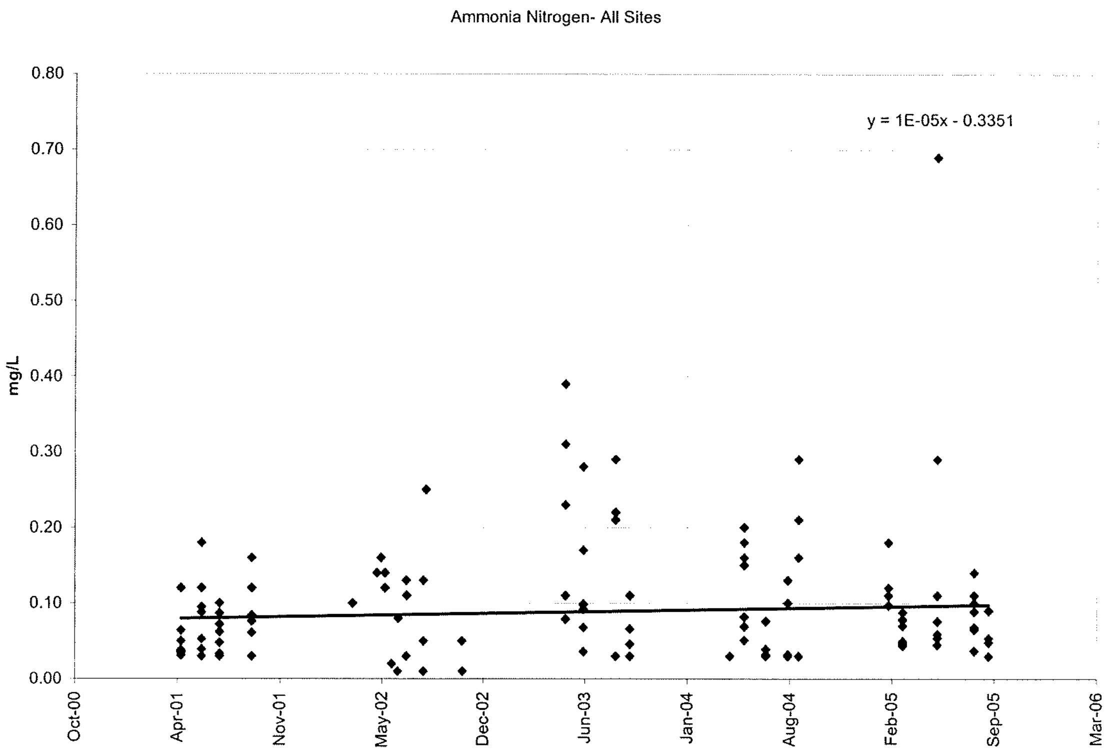
The regulatory limit for general use waters in Illinois for manganese is 1 mg/L. The secondary maximum contaminant level (SMCL) for manganese in drinking water is 0.05 mg/L. SMCL values are set on aesthetic grounds and imply no health hazard.

Figure 10



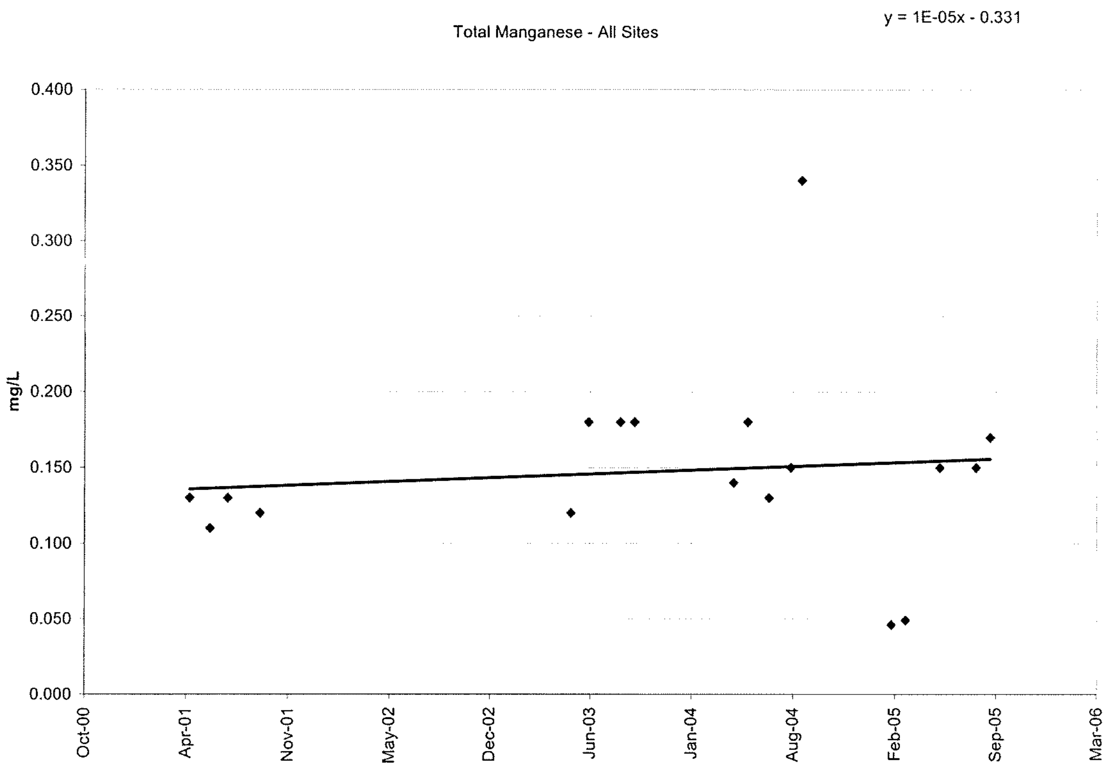
Statistic	Value
Average	1.40
Standard Error	0.15
Median	0.56
Mode	0.02
Standard Deviation	1.73
Sample Variance	3.002
Kurtosis	2.37
Skewness	1.59
Range	8.19
Minimum	0.01
Maximum	8.20
Sum	199.46
Count	142

Figure 11



Statistic	Value
Average	0.09
Standard Error	0.01
Median	0.07
Mode	0.03
Standard Deviation	0.09
Sample Variance	0.008
Kurtosis	16.57
Skewness	3.22
Range	0.68
Minimum	0.01
Maximum	0.69
Sum	12.72
Count	142

Figure 12



Statistic	Value
Average	0.15
Standard Error	0.01
Median	0.15
Mode	0.18
Standard Deviation	0.06
Sample Variance	0.004
Kurtosis	5.26
Skewness	1.42
Range	0.29
Minimum	0.05
Maximum	0.34
Sum	2.66
Count	18

3.3.12 Iron

Iron was evaluated in samples collected from two sites. The data are plotted in Figure 13 and statistics calculated from them appear in the table below the chart.

Iron was detected in all samples but one and all values observed were 2.0 mg/L or less. The data indicate the iron concentrations in lake waters are stable.

There is no regulatory limit for general use waters in Illinois for iron. The secondary maximum contaminant level (SMCL) for iron in drinking water is 0.3 mg/L. SMCL values are set on aesthetic grounds and imply no health hazard.

3.3.13 Alachlor

The data for Alachlor at all sites appears in Figure 14.

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 1.3 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.

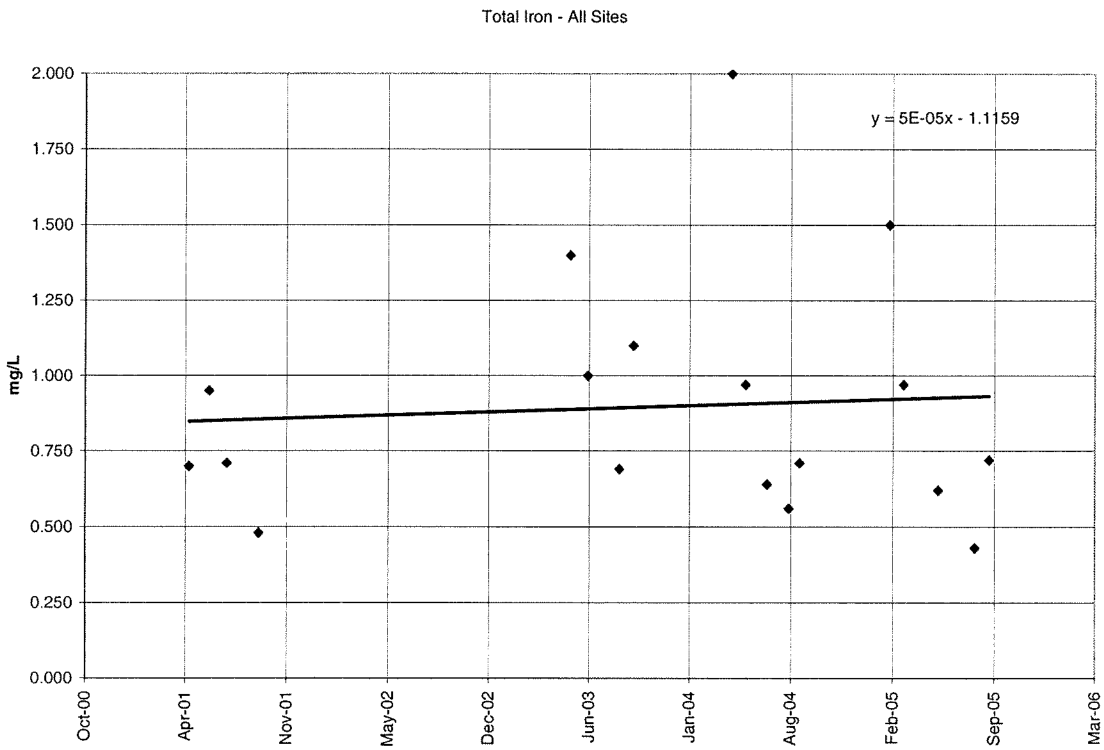
3.3.14 Atrazine

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

A total of 107 samples were analyzed for the herbicide, Atrazine. Among these, none of the compound was detected in 61. None of these data points are included in the plot. Among the remainder of the samples, however, 46 contained reportable levels of the compound and these are plotted. Approximately half of those values were less than the reporting (1.0 to 1.4 ug/L) but greater than the detection limit (0.4 to 0.6 ug/L). The levels of Atrazine in the remaining half were above the reporting limit (sometimes by significant amounts) but it does not appear that the presence of the compound has a significant effect on water quality in Carlyle Lake.

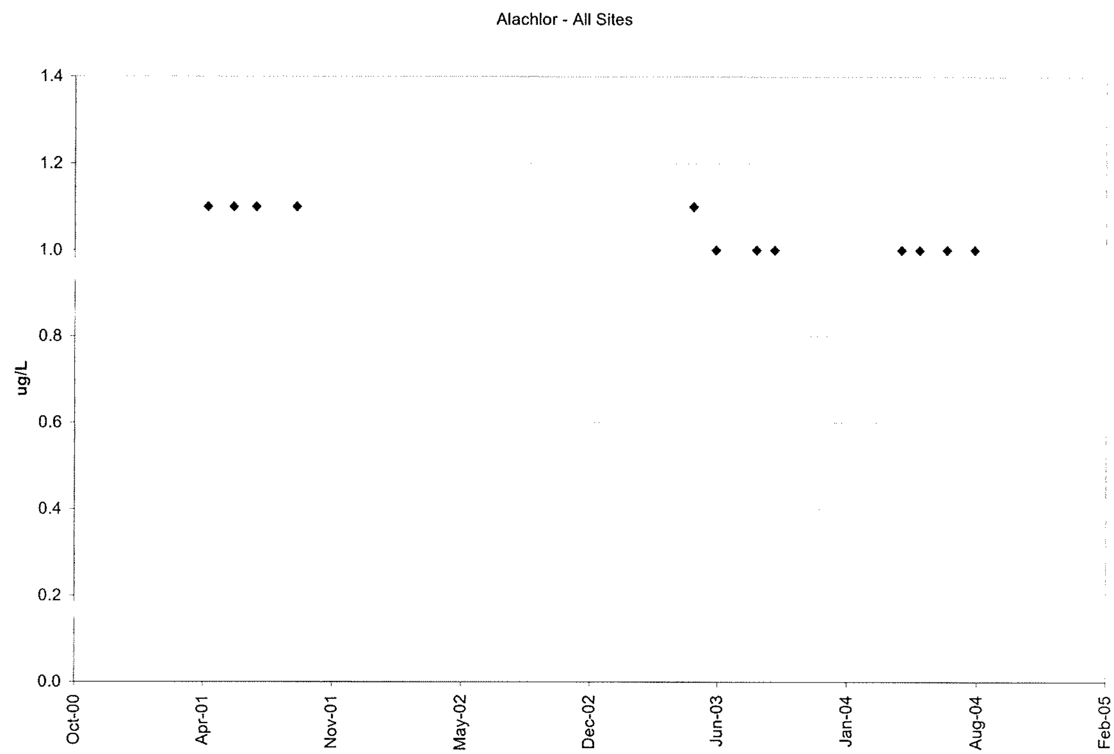
Because this compound is suspected to be carcinogenic a low regulatory limit of 3 ug/L has been set by the USEPA for drinking waters. No standard has been set by Illinois for general use waters.

Figure 13



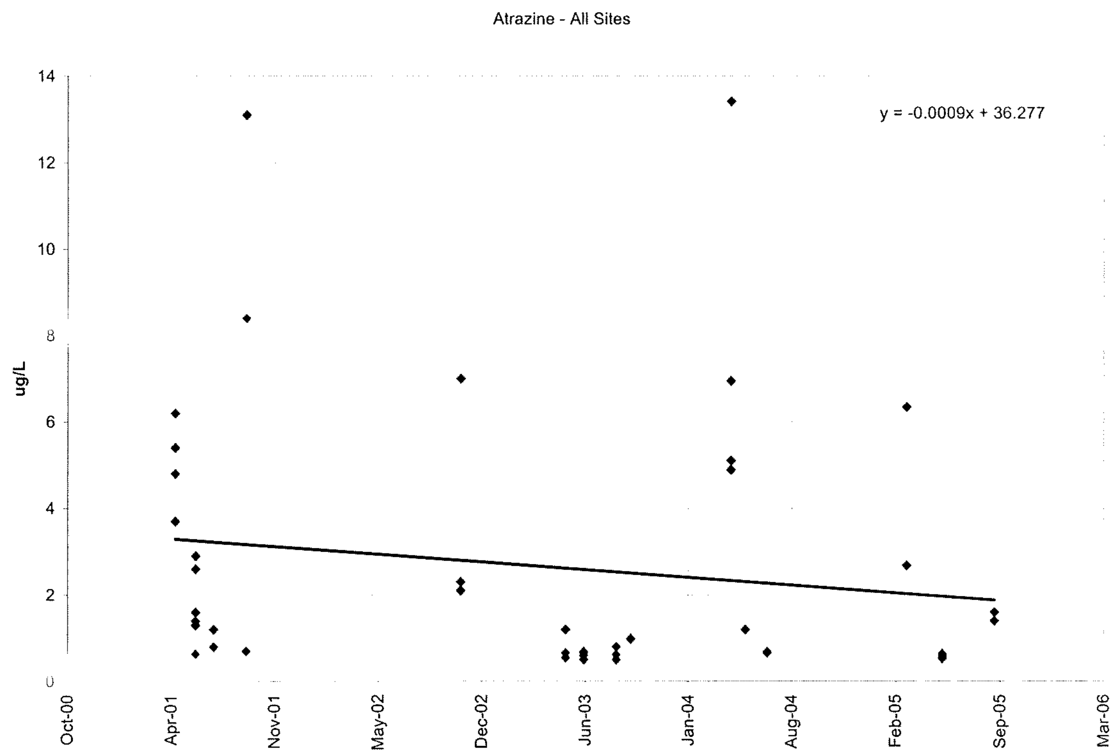
Statistic	Value
Average	0.90
Standard Error	0.09
Median	0.72
Mode	0.71
Standard Deviation	0.40
Sample Variance	0.161
Kurtosis	2.19
Skewness	1.45
Range	1.57
Minimum	0.43
Maximum	2.00
Sum	16.15
Count	18

Figure 14



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

Figure 15



Statistic	Value
Average	2.67
Standard Error	0.46
Median	1.20
Mode	1.20
Standard Deviation	3.14
Sample Variance	9.83
Kurtosis	4.08
Skewness	2.02
Range	12.92
Minimum	0.50
Maximum	13.42
Sum	122.96
Count	46

3.3.15 Chlorophyll

The data for chlorophyll at all sites appears in Figure 16. 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 in the plant bodies from atmospheric carbon dioxide.

There is no regulatory limit for chlorophyll. The mean and median values for this property were within a few points and there was a decreasing trendline in the data. Evaluation of data indicates that primary productivity of life forms utilizing chlorophyll is stable in lake waters.

3.3.16 Pheophytin

The data for pheophytin at all sites appears in Figure 17. 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. Pheophytin was not detected in a significant number of samples. Those occasions are shown on the at 5 mg/cubic meter, the reporting limit for the material. The data strongly indicate that the life cycles in lake wasters utilizing photosynthesis are stable and healthy.

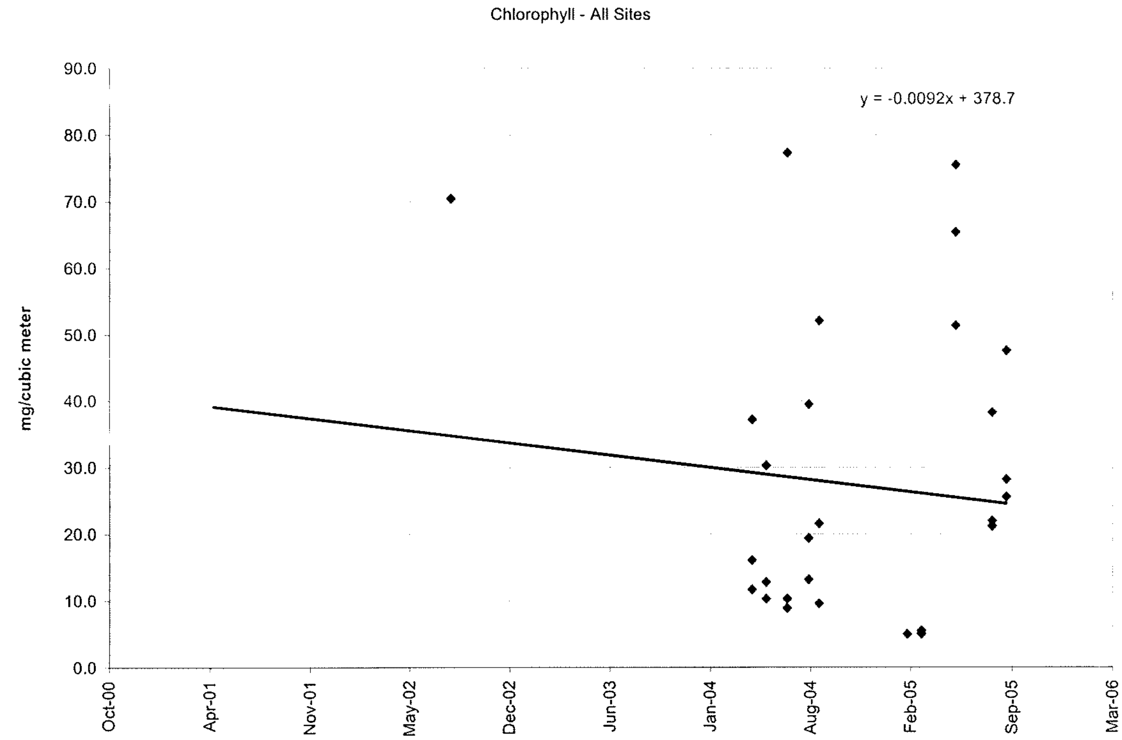
3.3.17 Total Organic Carbon

The data for total organic carbon at all sites appears in Figure 18. 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.

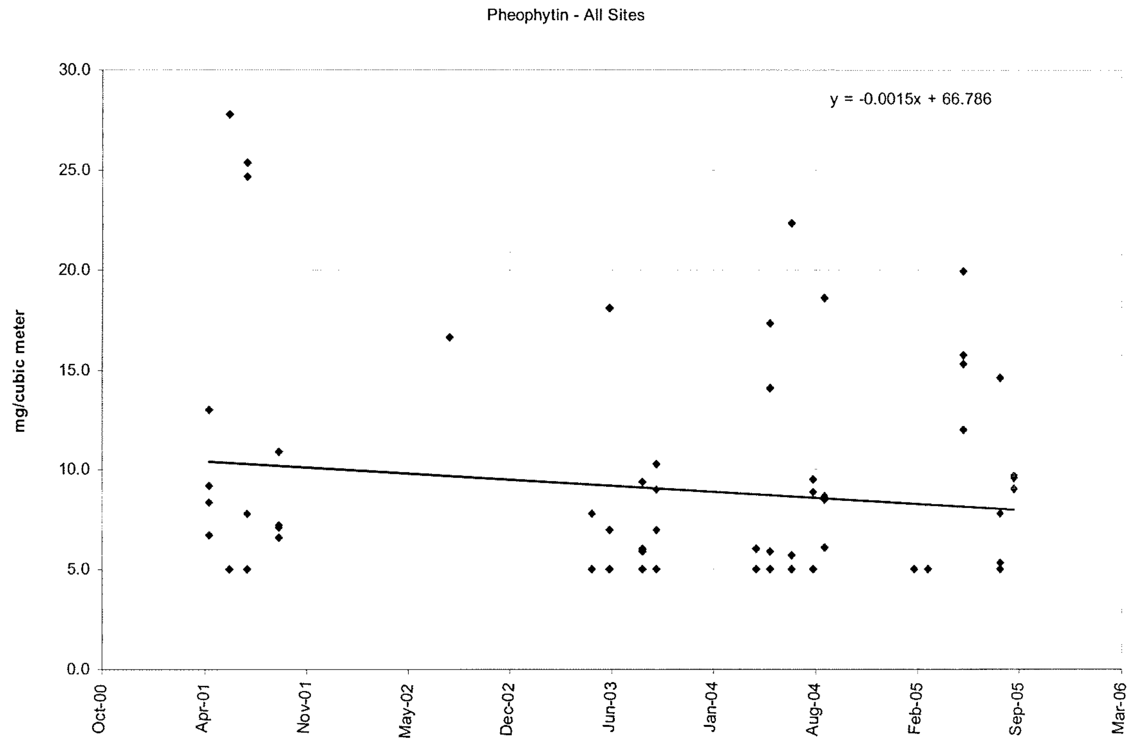
The values observed at all sites during the current study were an average of 6.6 and a median of 5.1 mg/L. These data strongly suggest that all aspects of dealing with organic materials in Carlyle Lake are stable and healthy. There is no regulatory limit set for this property

Figure 16



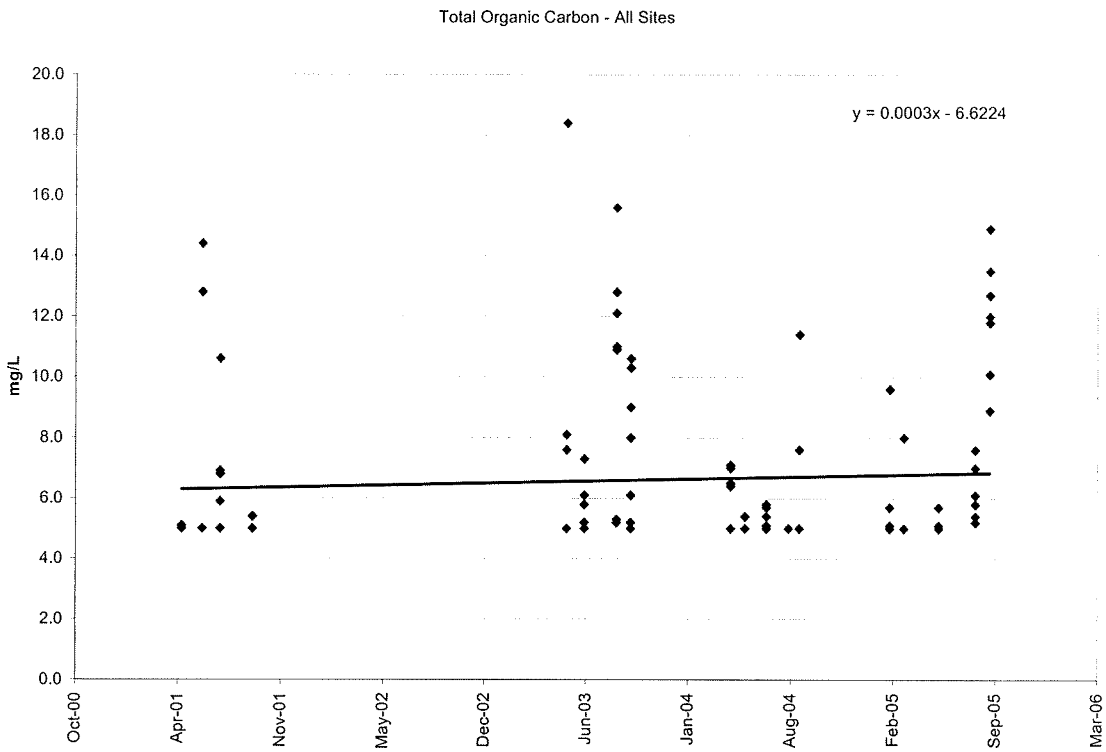
Statistic	Value
Average	26.96
Standard Error	3.30
Median	21.30
Mode	5.00
Standard Deviation	21.12
Sample Variance	445.89
Kurtosis	-0.09
Skewness	0.91
Range	72.30
Minimum	5.00
Maximum	77.30
Sum	1105.30
Count	41

Figure 17



Statistic	Value
Average	8.98
Standard Error	0.65
Median	6.85
Mode	5.00
Standard Deviation	5.53
Sample Variance	30.60
Kurtosis	2.46
Skewness	1.74
Range	22.80
Minimum	5.00
Maximum	27.80
Sum	646.50
Count	72

Figure 18



Statistic	Value
Average	6.62
Standard Error	0.25
Median	5.10
Mode	5.00
Standard Deviation	2.77
Sample Variance	7.673
Kurtosis	3.63
Skewness	2.01
Range	13.40
Minimum	5.00
Maximum	18.40
Sum	814.00
Count	123

3.4 Individual Sites

3.4.1 Overview

Surface waters from three sites on the lake proper and subsurface water from one of those sites were evaluated during performance of the subject study. The locations of these sites are shown in Figure 1, above. As noted: CAR-2-0 and -2-10 are located on the lower portions of the lake near the dam while CAR-4-0 and -15-0 are located in the upper portion of the lake near Keyesport. The remaining sites are off lake. CAR-1-0 is located in the river just below the dam. CAR-9 is located in the upper reach of the watershed near Vandalia while CAR12-0 is located just above the upper end of the lake body.

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 1. Two statistics (average and median) calculated from those data appear in Table 2.

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 to that trend are noted in the paragraphs below. Those exceptions are often associated with the values found in the watershed run-off in Sites 9 and 12-0.

3.4.2 Chemical/Physical Properties

3.4.2.1 Dissolved Oxygen

The profile of dissolved oxygen was similar at all sites except for the readings obtained at depth at site 2-10. Mean and median levels and trend lines were essentially flat

3.4.2.2 pH

The profile of pH was also reasonably constant at all sites although two abnormally acidic values were observed at Site 1-0. In all cases, trend lines were flat.

3.4.2.3 Oxidation-Reduction Potential (ORP)

When data from all sites were considered (see Figure 4) there was a substantial, time related reduction in ORP of approximately 5 to 8% for each 17months of the study period. As shown in the table below, there was an apparent sharp reduction in the values observed after the first year of the study. The slope of trend lines for the individual sites was similar and, excepting the reduction noted above, the mean and median of observed values at each of the sites were in general agreement.

	2001	2002	2003	2004	2005
mean	322	179	199	190	193
median	320	181	207	217	225

Table 2 – Site Specific Statistics

		CAR-1-0	CAR-2-0	CAR-4-0	CAR-9	CAR-12-0	CAR-15-0	CAR-2-10
Dissolved Oxygen	mean	8.5	8.0	9.1	8.1	7.1	---	5.3
	median	8.9	8.1	8.5	8.6	8.0	---	5.6
pH	mean	8.2	8.3	8.2	7.9	7.8	---	8.1
	median	8.2	8.2	8.2	8.0	7.8	---	8.0
ORP	mean	211	223	194	192	190	---	227
	median	209	230	205	206	210	---	239
Conductivity	mean	331	331	341	483	480	---	385
	median	347	346	320	484	455	---	372
TSS	mean	19.5	16.5	49.6	176	108	52.3	29.5
	median	18.0	16.9	49.0	69.6	50.9	41.2	43.3
VSS	mean	4.7	5.0	8.5	17.2	11.0	8.5	5.0
	median	4.4	4.0	8.7	9.4	7.2	7.3	6.6
Total Phosphorus	mean	0.29	0.30	0.37	0.42	0.35	0.42	0.36
	median	0.27	0.28	0.38	0.28	0.26	0.27	0.42
Soluble Phosphorus	mean	0.20	0.18	0.16	0.06	0.07	0.15	0.21
	median	0.16	0.16	0.14	0.04	0.06	0.06	0.16
Nitrate	mean	0.91	0.87	1.38	2.43	2.28	1.41	0.96
	median	0.55	0.34	0.62	1.55	0.92	0.99	0.45
Ammonia	mean	0.12	0.08	0.08	0.06	0.08	0.06	0.14
	median	0.10	0.06	0.05	0.04	0.06	0.07	0.06
Manganese	mean	0.15	---	---	---	---	---	---
	median	0.15	---	---	---	---	---	---
Iron	mean	0.90	---	---	---	---	---	---
	median	0.72	---	---	---	---	---	---
Alachlor (1)	---	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---
Atrazine	mean	1.2	1.3	2.7	4.6	4.6	1.8	---
	median	0.90	0.83	1.6	3.2	3.1	1.4	---
Chlorophyll	mean	---	21.4	30.5	---	29.0	25.9	---
	median	---	10.3	30.3	---	17.6	17.6	---
Pheophytin	mean	8.9	6.1	10.1	---	10.3	---	---
	median	---	5.0	8.7	---	7.1	---	---
TOC	mean	6.6	5.7	6.4	7.5	7.1	6.5	5.7
	median	5.1	5.0	5.1	5.0	5.7	5.7	5.0

(1) Undetected in all samples

3.4.2.4 Conductivity

Trend lines rose slightly for all sites. Readings in the upstream off-lake sites (CAR-9 and CAR12-0) were generally higher than the values observed in sites on-lake or in the lake outfall. Those higher readings upstream of the lake body may be related to increased agricultural or land development activities in the areas drained.

3.4.3 Total and Volatile Suspended Solids

As shown in the table below, suspended solids values of both kinds were reasonable and in general agreement for sites located in the same general areas. As distances from CAR-9 and CAR-12 increased there was a decline in both TSS and VSS. These data suggest that there was considerable erosion in the areas near the off lake sites (particularly CAR 9) and that portions of that load became sediment as the material passed through the body of the lake.

	CAR-1-0	CAR-2-0	CAR-4-0	CAR-9	CAR-12	CAR-15	CAR-2-10
TSS Mean	19	17	50	176	108	52	29
Median	18	17	49	70	51	41	43
VSS Mean	4.7	5.0	8.5	17.2	11.0	8.5	5.0
Median	4.4	4.0	8.7	9.4	7.2	7.3	6.6

The decreasing trendline in plots of data from Sites 9 and 12 are undoubtedly due to several high values observed in samples from those site taken early in then study.

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 five or more. These high levels were observed in all samples from all sites. These levels are most likely due to agricultural practices in the area.

3.4.4.2 Nitrate

Levels of this compound in lake pose no threat to overall water quality. Although average and median levels were higher the off-lake sites, the compound generally was present at all sites at approximately the same levels. It is noteworthy that after April a decline begins in the both the mean and median values and that decline becomes pronounced in August and September. The changes are probably associated with seasonal agricultural practices.

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Mean	3.4	3.7	4.1	1.25	1.23	0.62	0.32	0.13	0.09
Median	3.6	4.0	3.0	0.99	0.85	0.54	0.06	0.09	0.11

3.4.4.3 Ammonia

Levels of this compound in lake pose no threat to overall water quality. There was general agreement in the levels found in all sites in all years of the study. A cyclic trend was noted in the observed concentrations with a high levels in February and May followed by steadily declining levels in the intervening months. The most probable cause for those changes is seasonal agricultural practices.

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Mean	0.12	0.070	0.042	0.169	0.073	0.076	0.095	0.070	0.023
Median	0.11	0.074	0.031	0.140	0.053	0.062	0.030	0.064	0.010

3.4.4.4 Iron and Manganese

Levels of these two metals were evaluated at only one site (CAR-1-0). The observed concentrations of each metal were approximately equivalent at all sites, for all years and all months studied.

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 Carlyle Lake sites.

As already noted, 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. None of the material was detected in February, March or October. Detectible concentrations first appeared in May, increased by a factor of nearly six in June and then began a steady decline through September. The highest levels were observed in samples from Sites SVL-9 and 12-0.

3.4.5.2 Chlorophyll/Pheophytin

Chlorophyll and Pheophytin concentrations were evaluated irregularly during the study and the absence of data sometimes hampered trendline evaluations. In those cases trendline values have been omitted from the plots.

Chlorophyll concentrations were low in February and March, rose to a peak in May and thereafter declined steadily. Pheophytin was less than detection limits in a substantial proportion of the samples. By convention, non-detects are recorded on the charts at the reporting limit of 5 mg/cubic meter.

3.4.5.3 Total Organic Carbon (TOC)

Excepting occasional high levels of TOC observed in all samples, most contained less than the minimum detectible level. That situation is reflected in the plots of these data by the heavy concentration of points at the 5 mg/L level. These was no significant difference in this property observed in any particular month or year of the study

4.0 CONCLUSIONS AND RECOMMENDATIONS

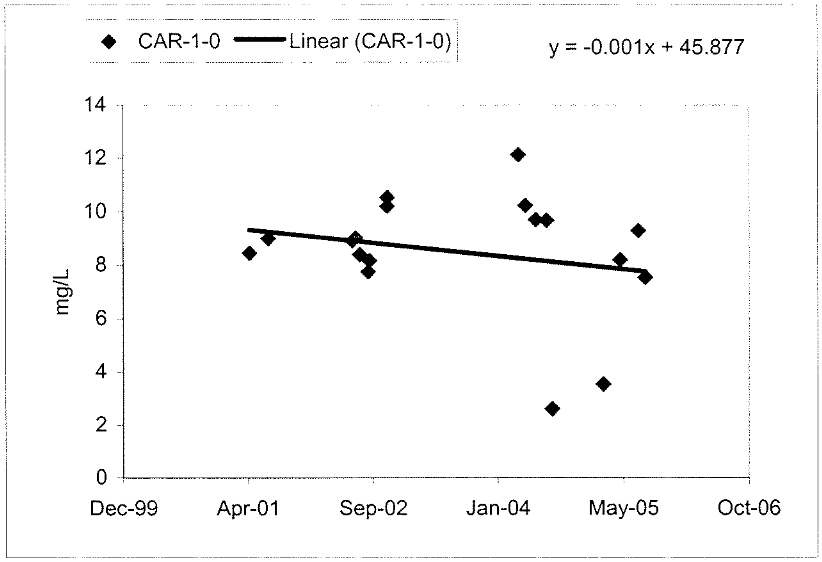
The result of the evaluations in this document are compared in the table below to those described in the referenced previous report

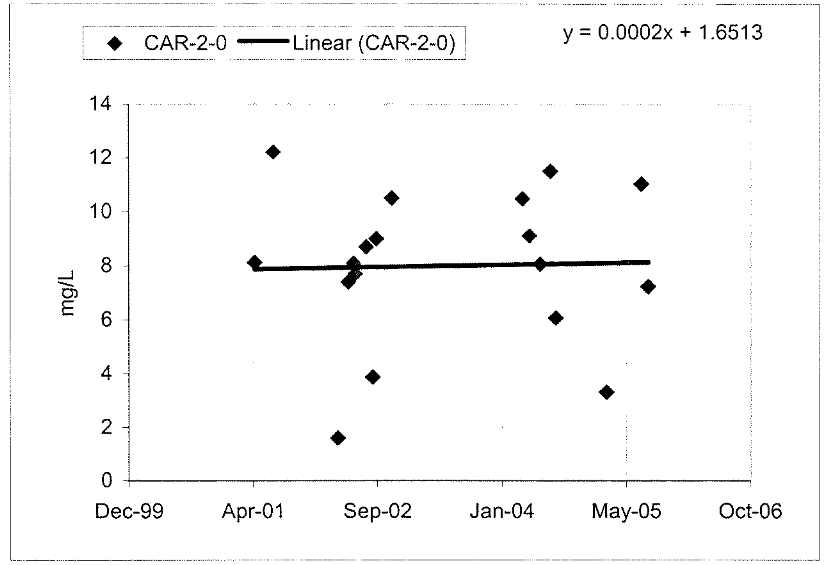
PARAMETER	TREND
Dissolved Oxygen	Stable
pH	Stable
Oxidation Reduction Potential	Improving
Conductivity	Stable
Total Suspended Solids	Stable
Volatile Suspended Solids	Stable
Total Phosphorus	Stable but high
Soluble Phosphorous (ortho-Phosphate)	Stable
Nitrate	Cyclic
Ammonia	Cyclic
Manganese	Stable
Iron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

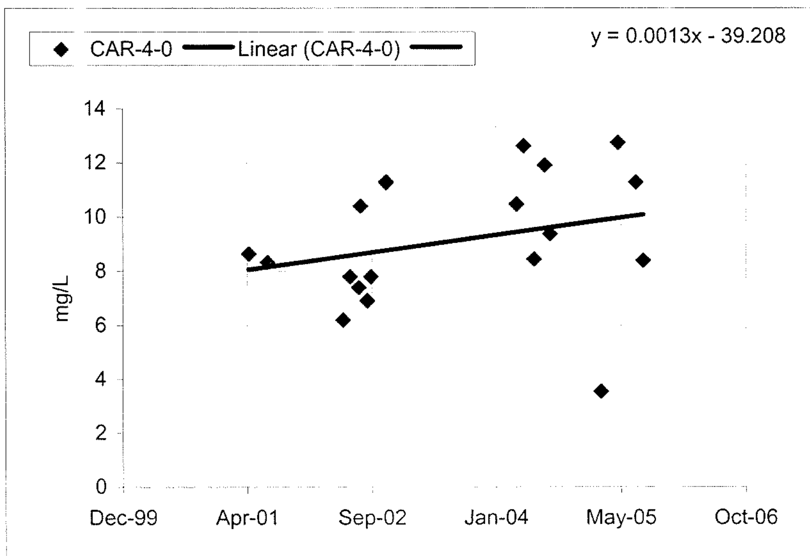
The trends noted suggest that the condition of Carlyle Lake has improved and is stable. Efforts to achieve better control of the phosphate levels in the system should be considered.

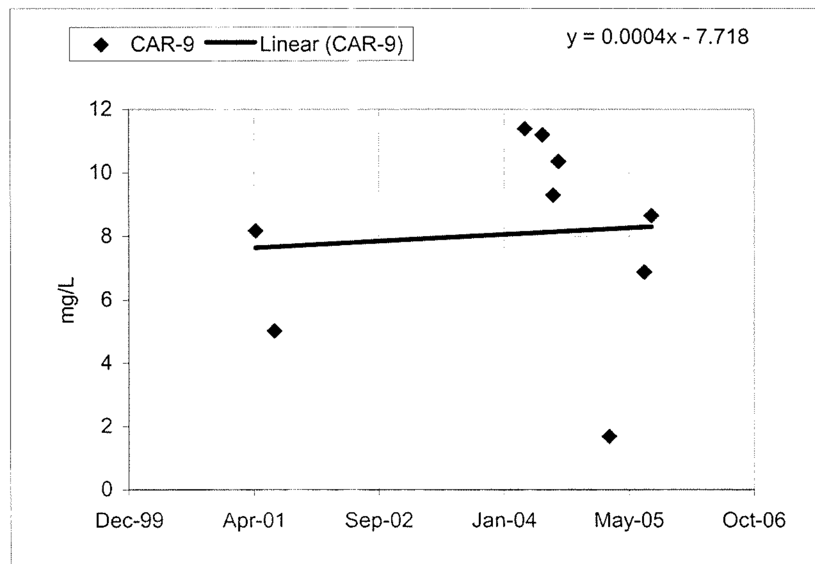
Appendix 1 – Plots of Data Collected from Individual Sample Sites

Dissolved Oxygen

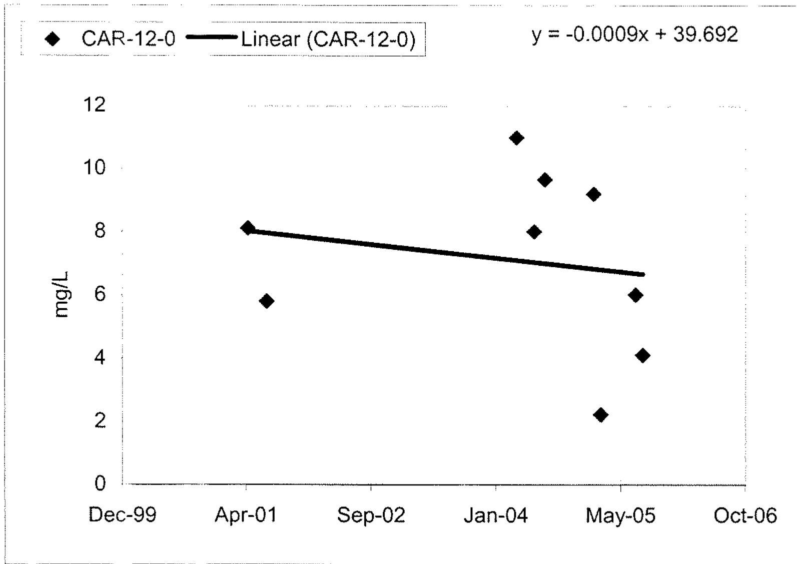


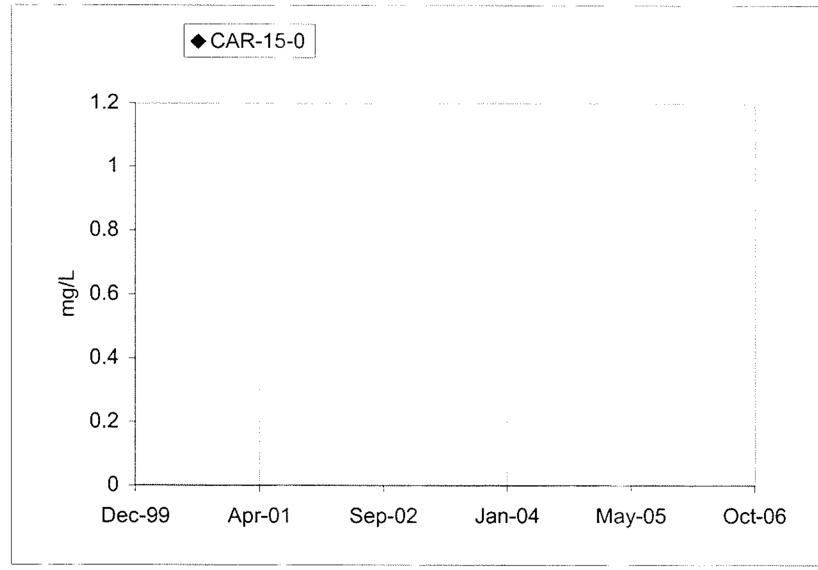


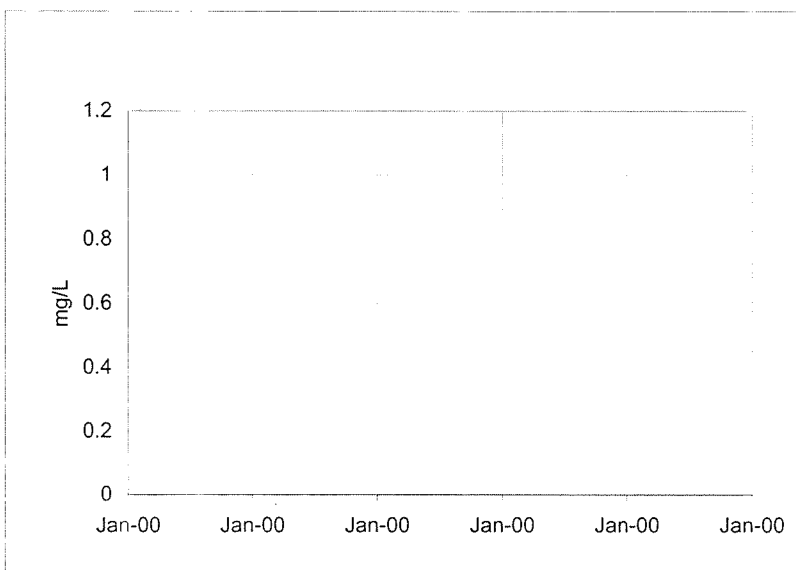


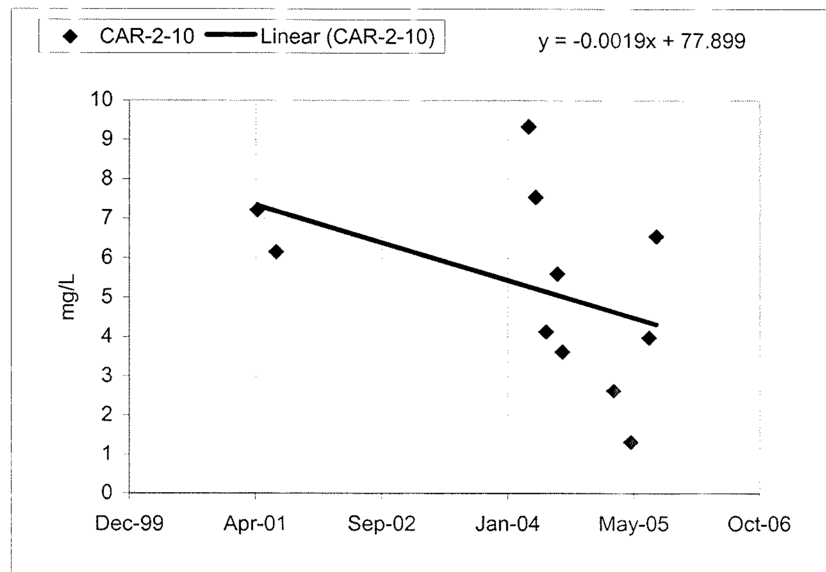


Dissolved Oxygen

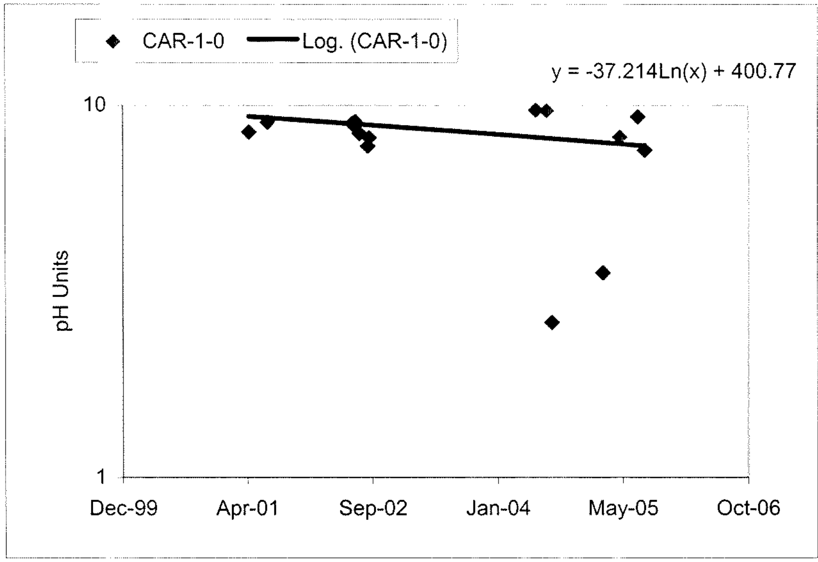




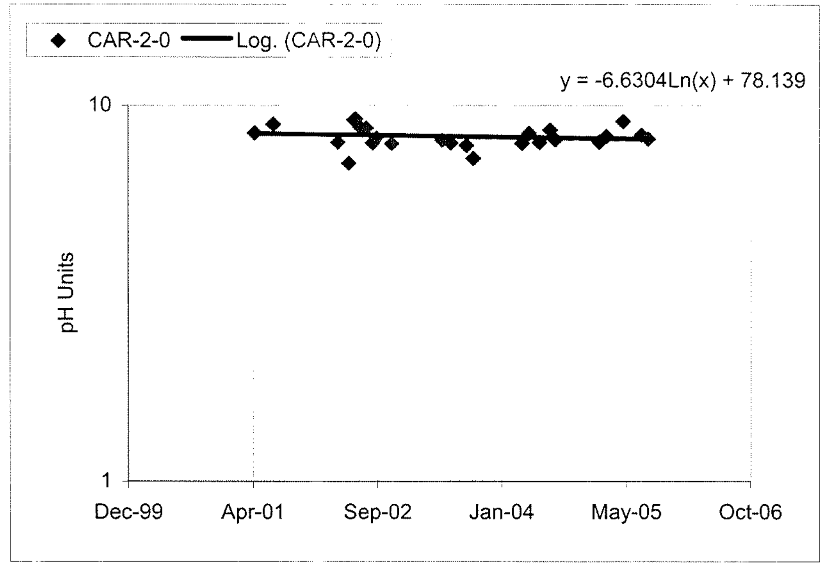




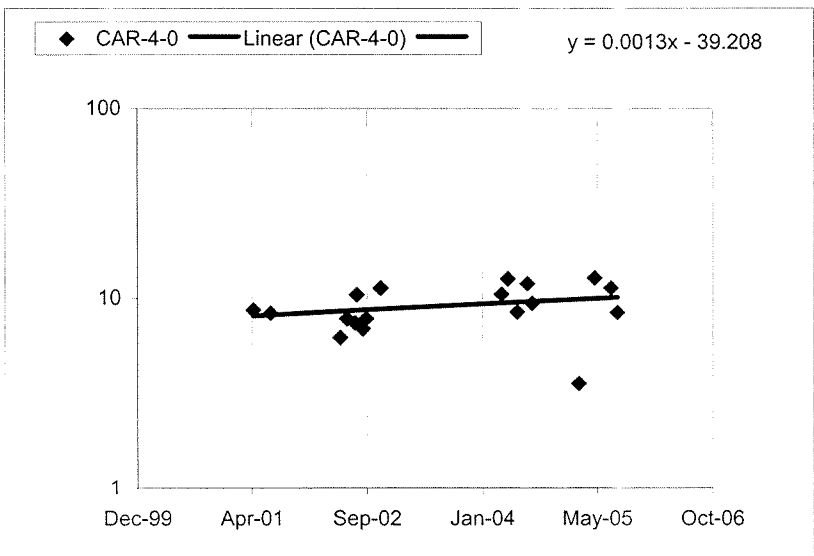
pH



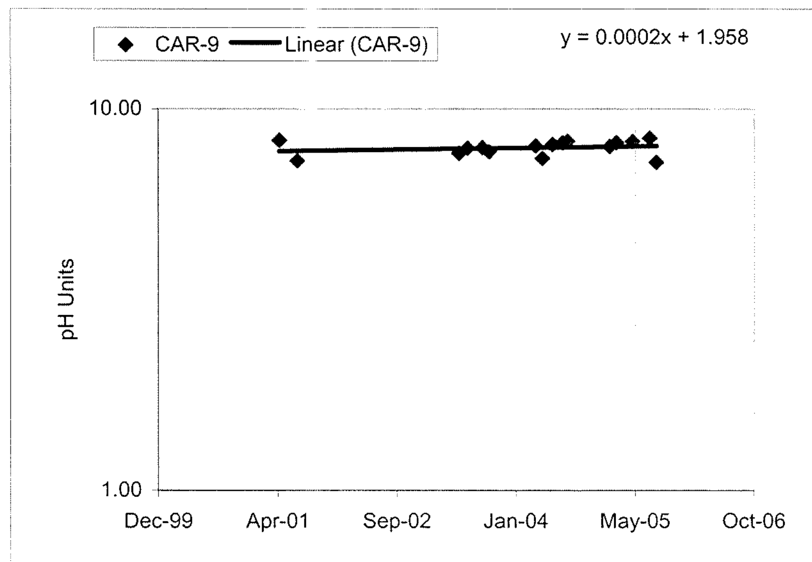
CAR-1-0
Log. (CAR-1-0)
y = -37.214Ln(x) + 400.77
pH Units
10
1
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



CAR-2-0
Log. (CAR-2-0)
y = -6.6304Ln(x) + 78.139
pH Units
10
1
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

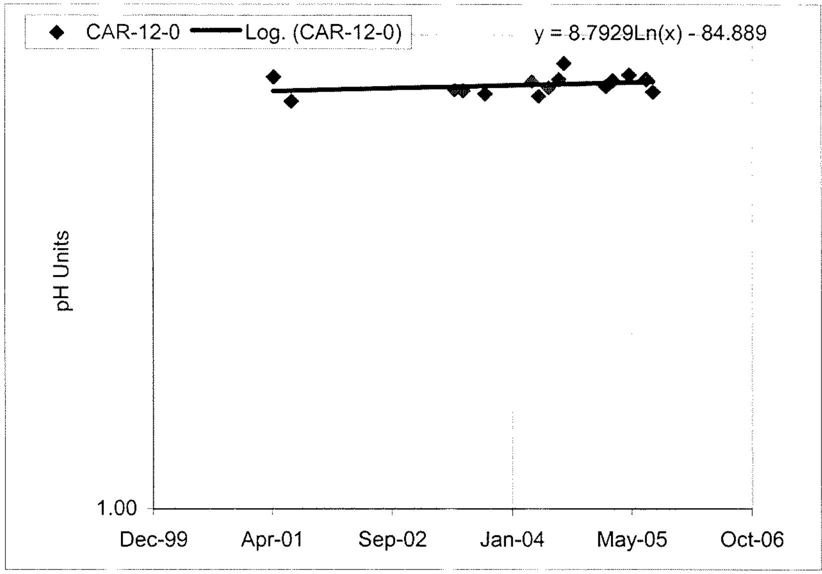


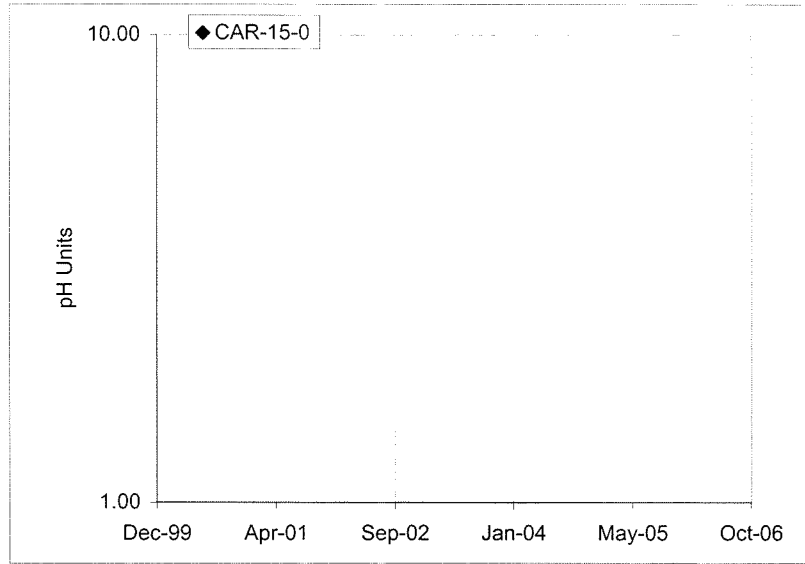
CAR-4-0
Linear (CAR-4-0)
y = 0.0013x - 39.208
100
10
1
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

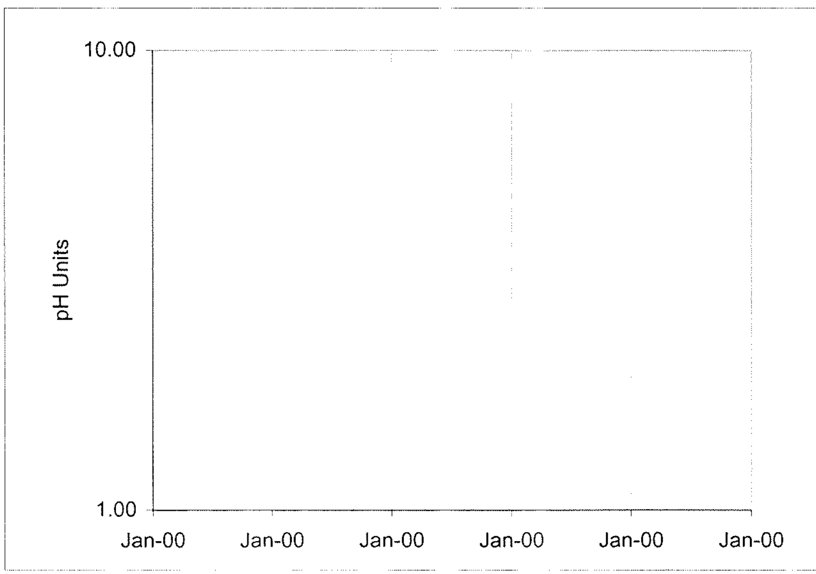


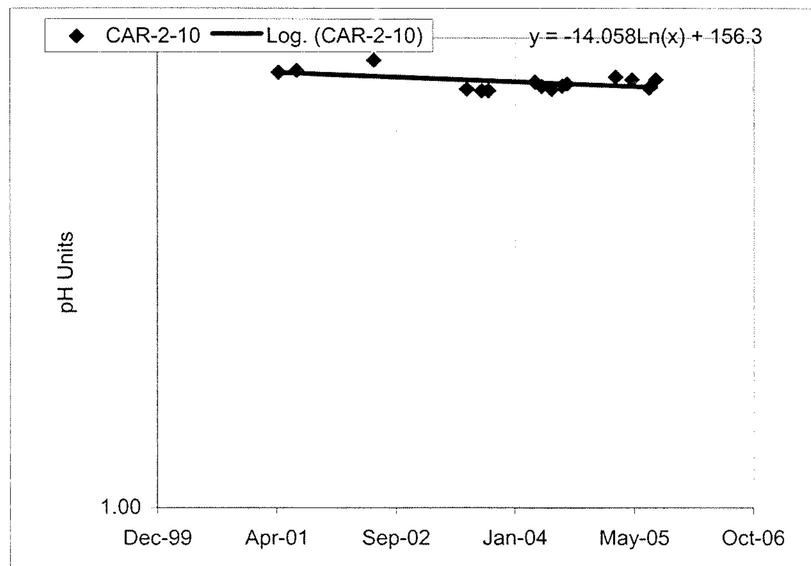
CAR-9
Linear (CAR-9)
y = 0.0002x + 1.958
pH Units
10.00
1.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

pH

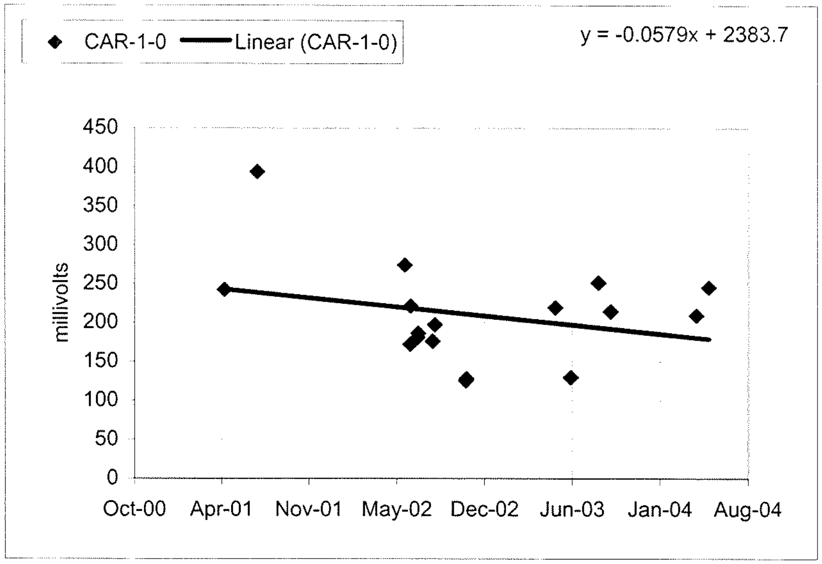

CAR-12-0
Log. (CAR-12-0)
y = 8.7929Ln(x) - 84.889
pH Units
1.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

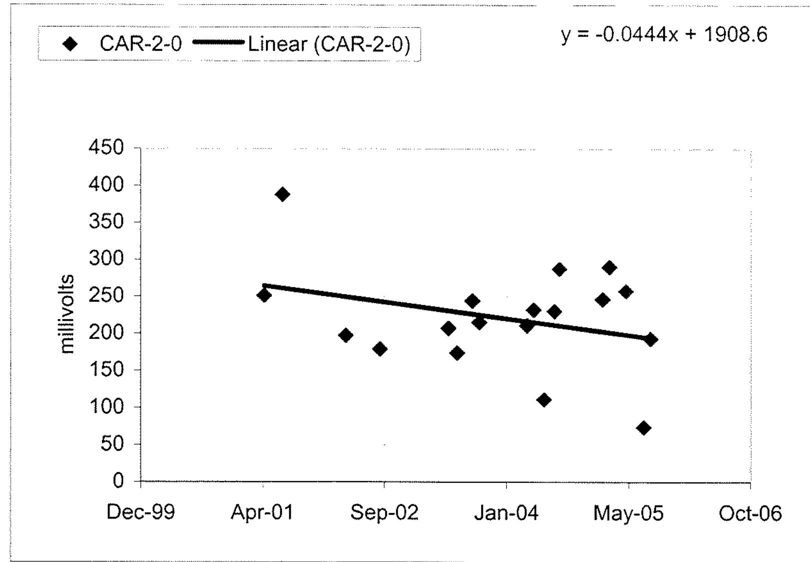

CAR-15-0
10.00
1.00
pH Units
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

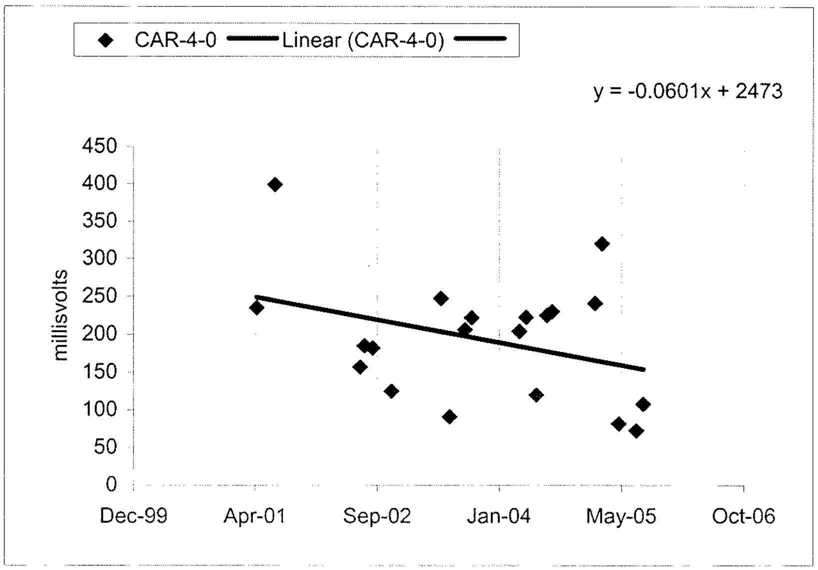

10.00
1.00
pH Units
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00

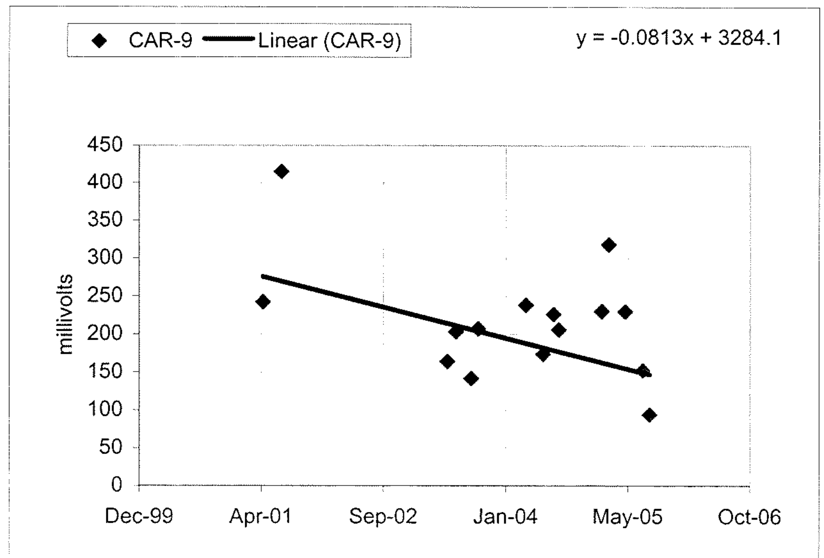

CAR-2-10
Log. (CAR-2-10)
y = -14.058Ln(x) + 156.3
pH Units
1.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

Oxiddation Reduction Potential (ORP)

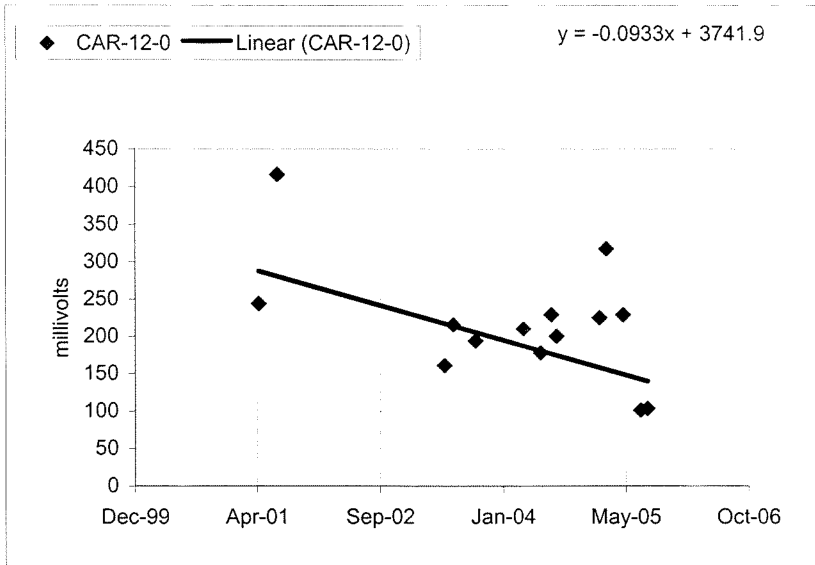


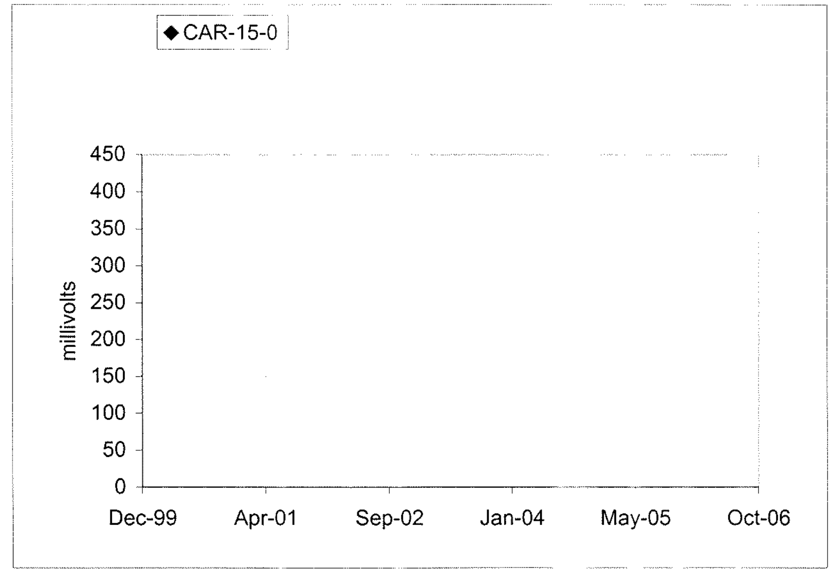


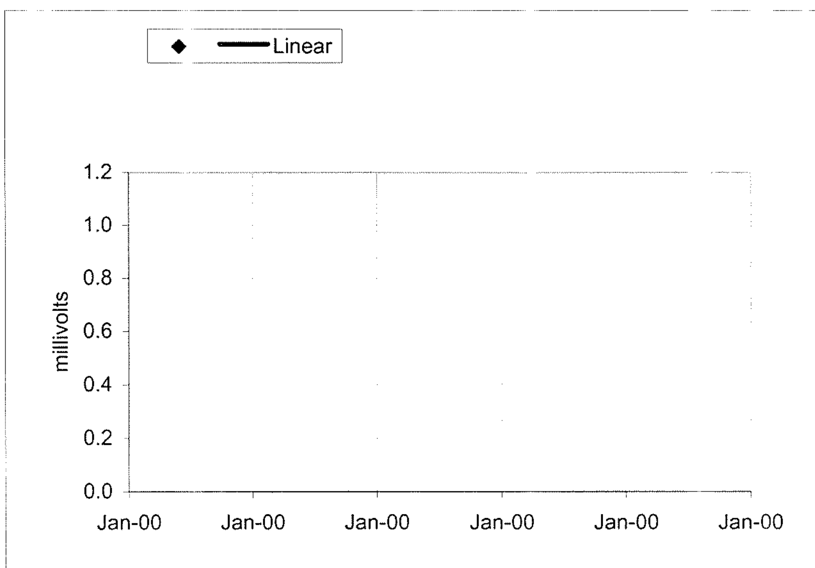


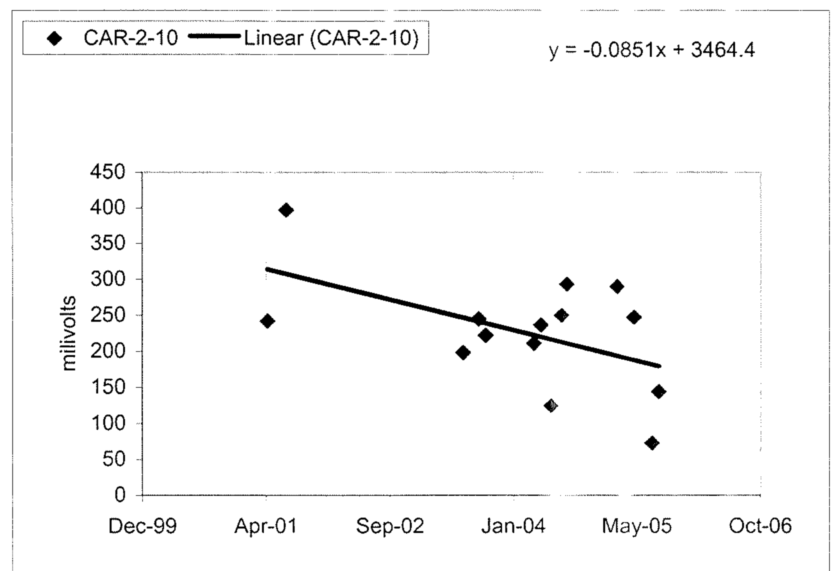


Oxiddation Reduction Potential (ORP)

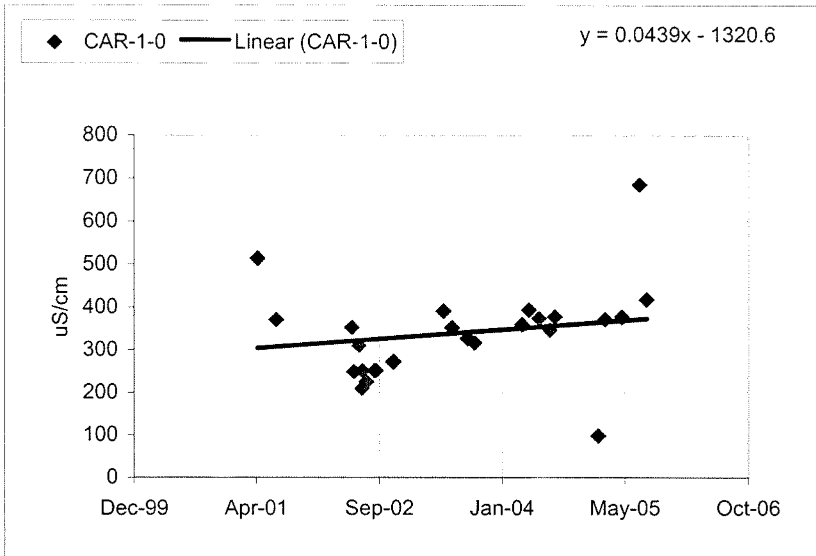


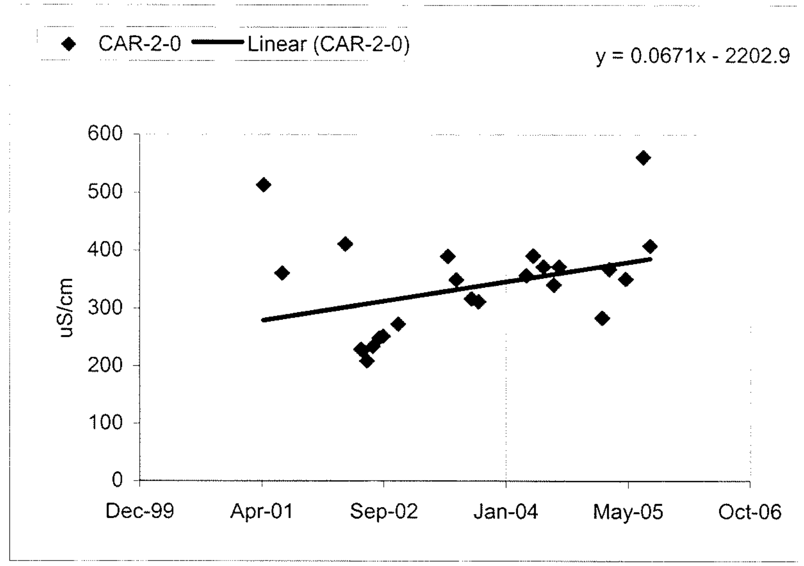


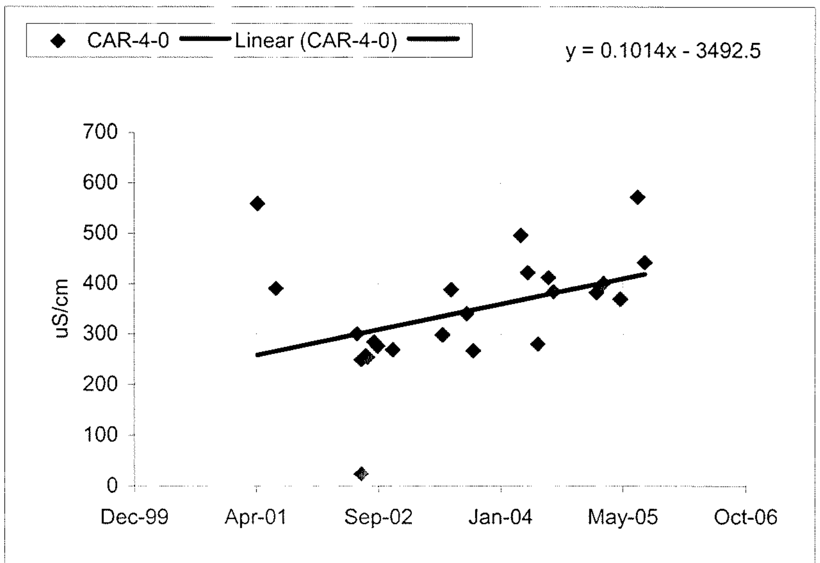


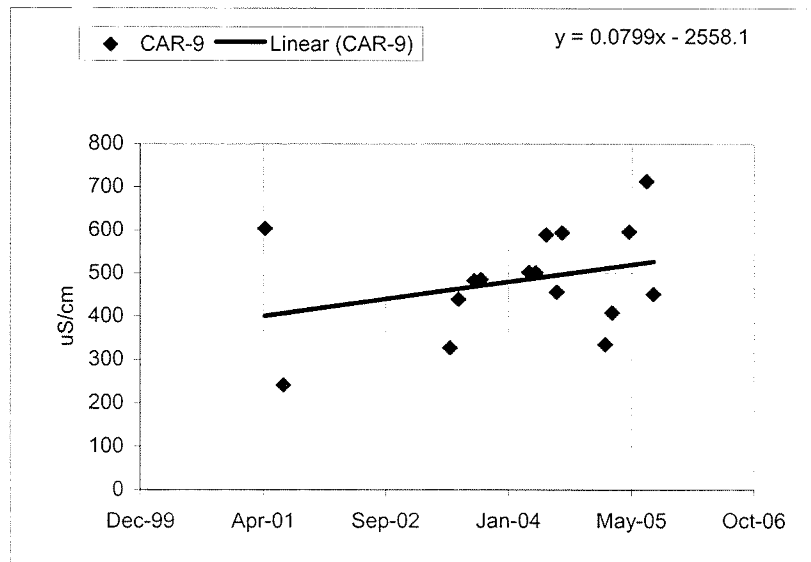


Conductivity

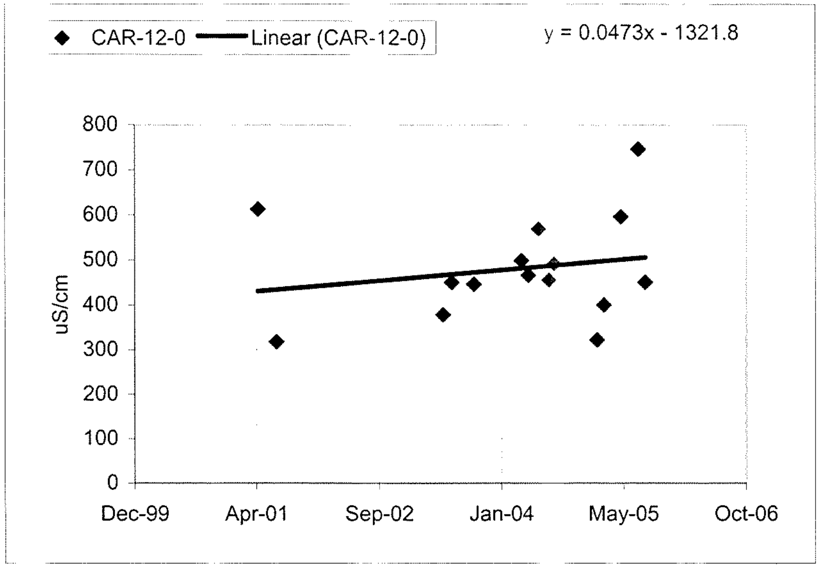


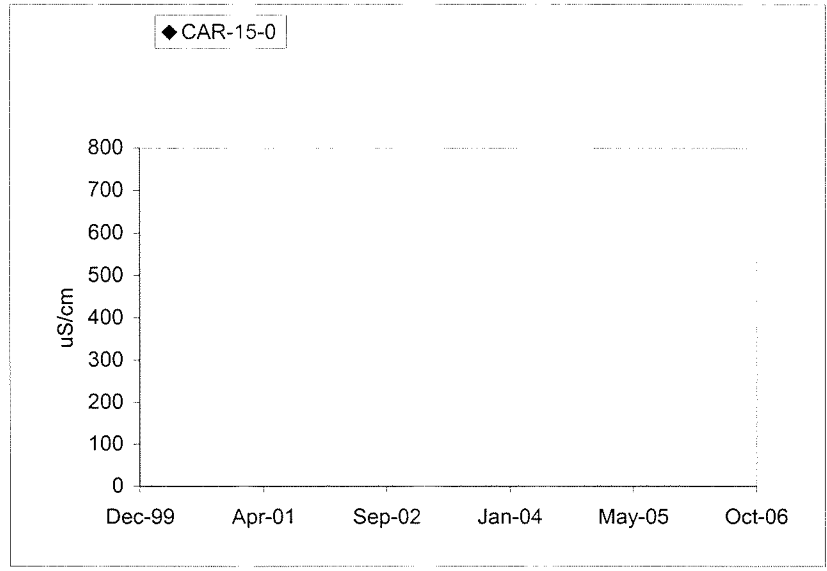


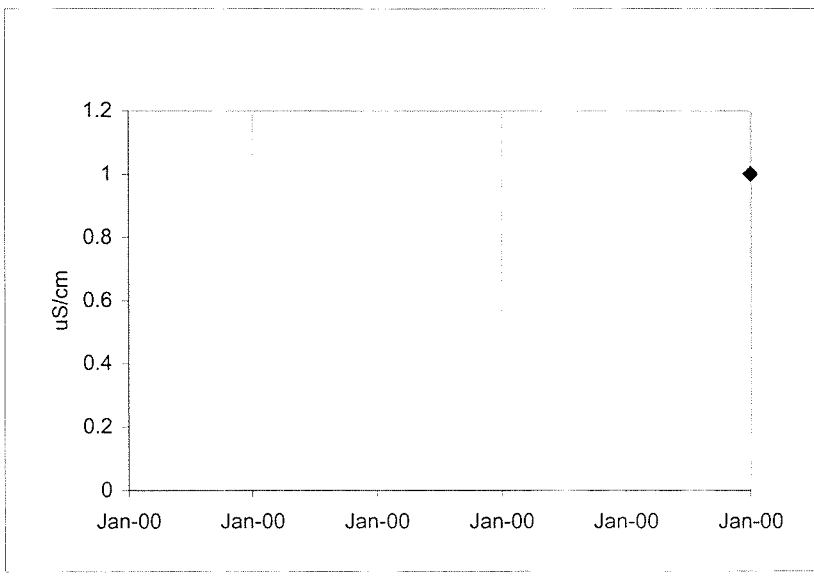


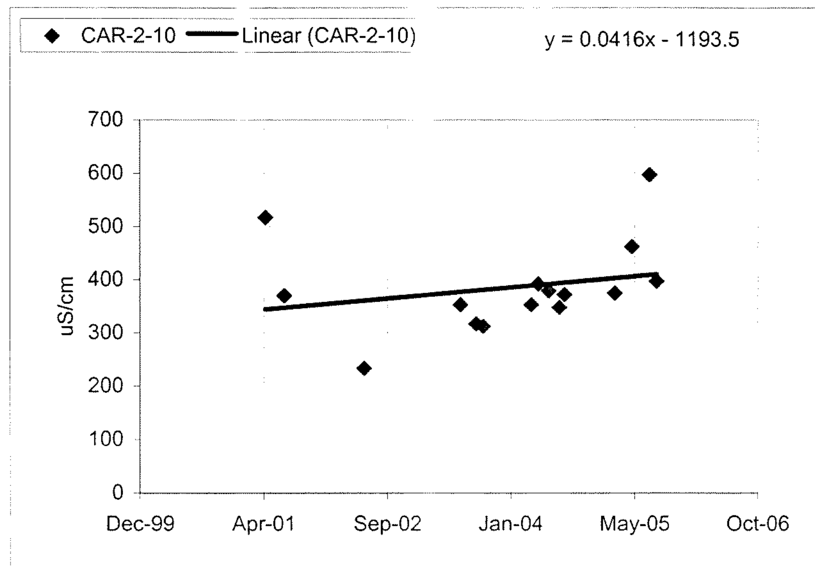


Conductivity

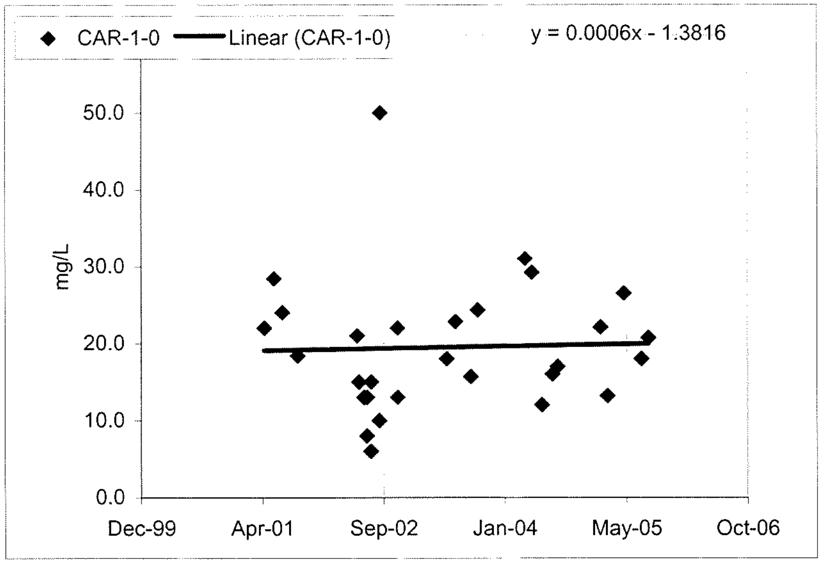


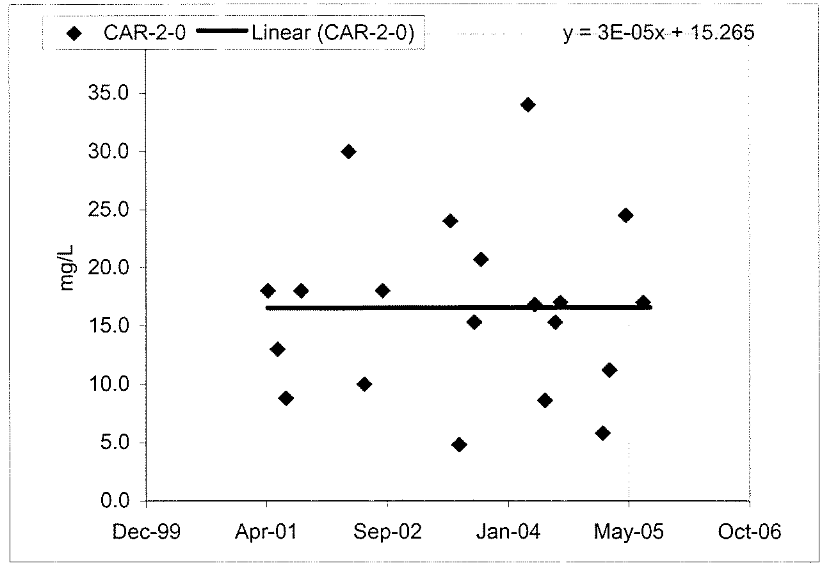


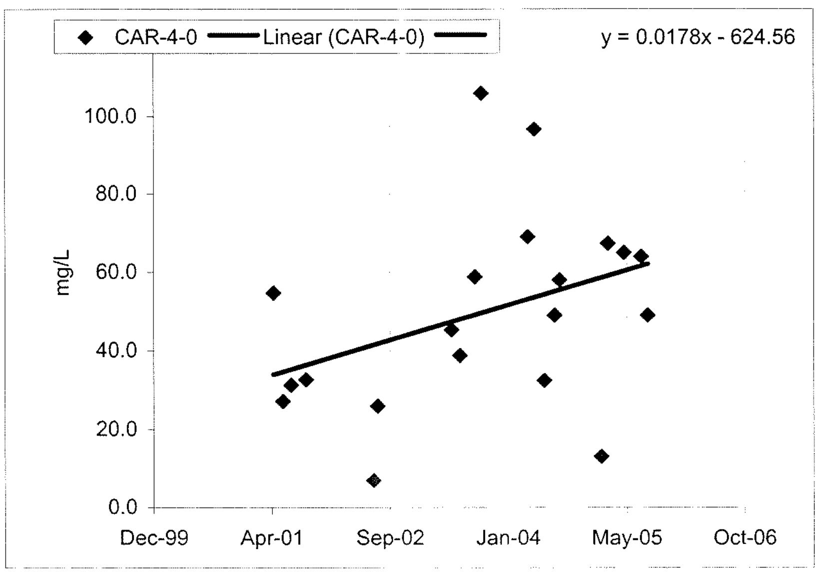


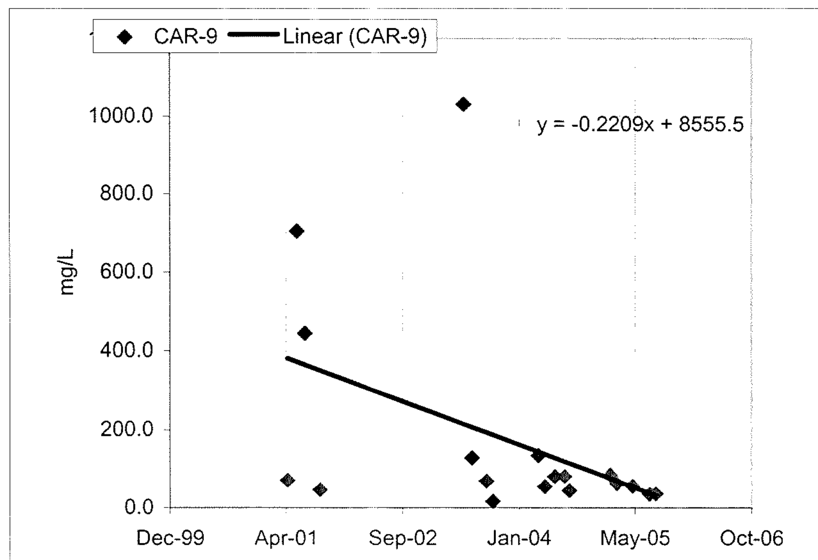


Total Suspended Solids (TSS)

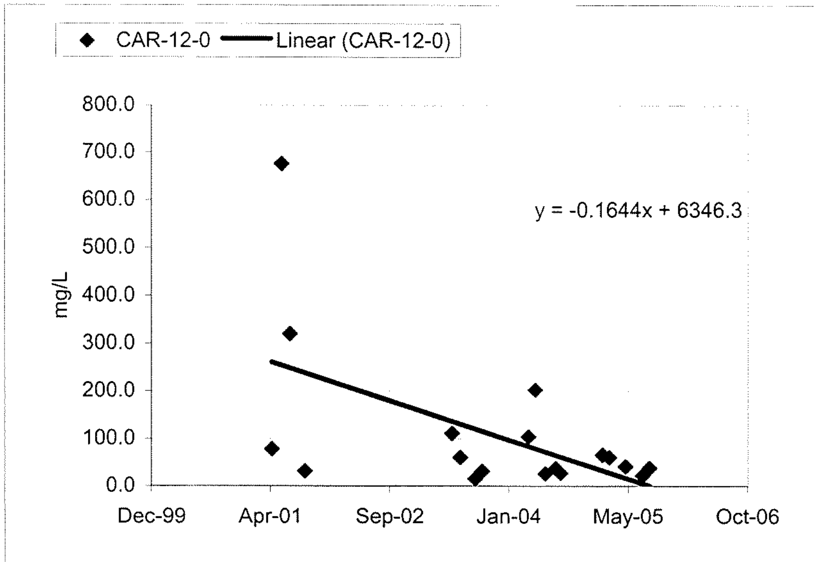


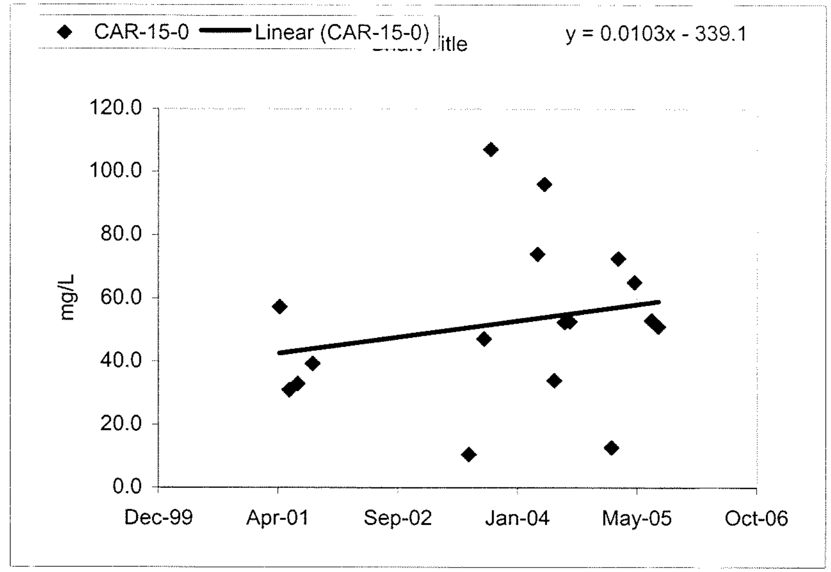


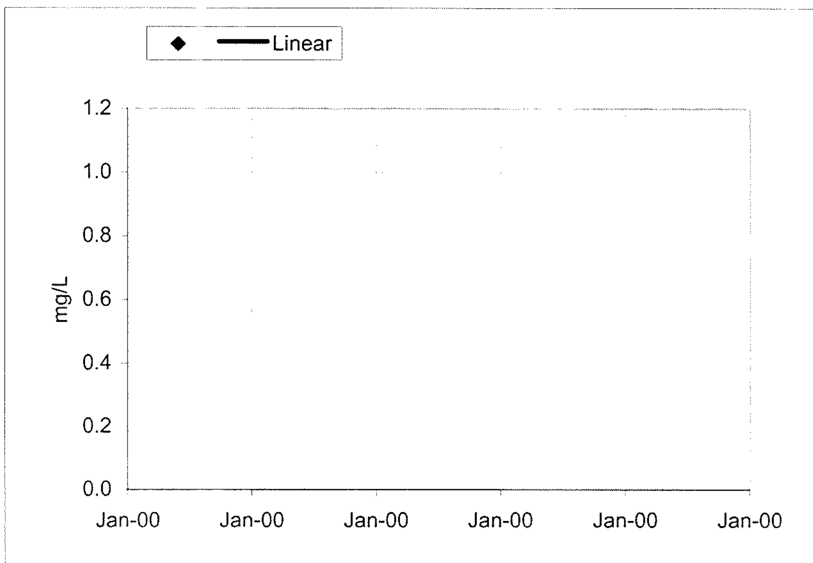


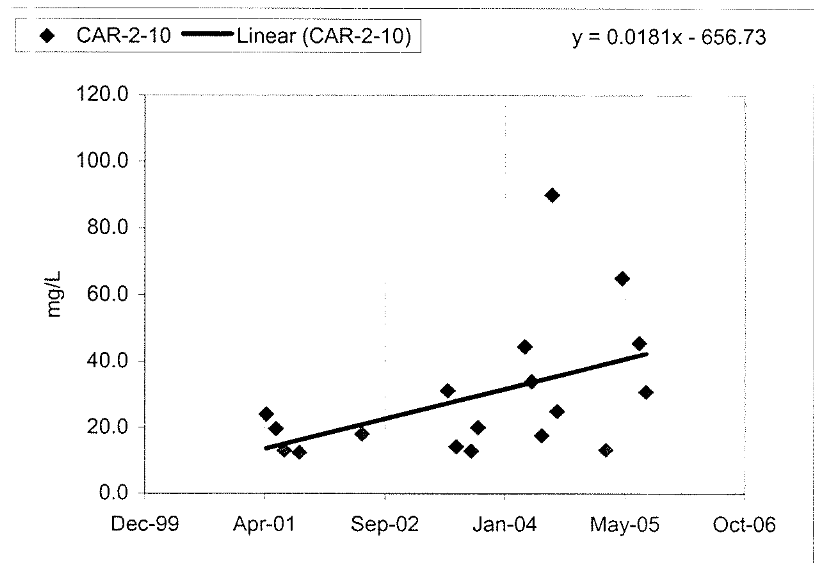


Total Suspended Solids (TSS)

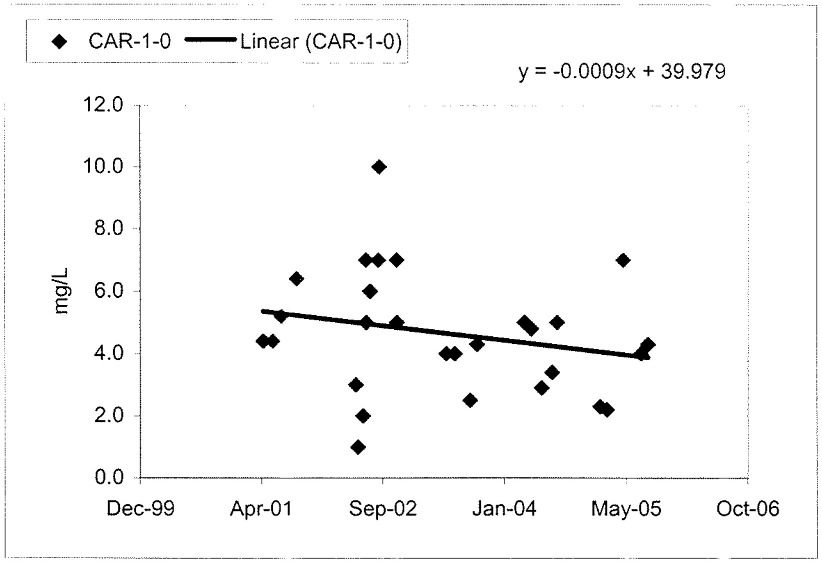


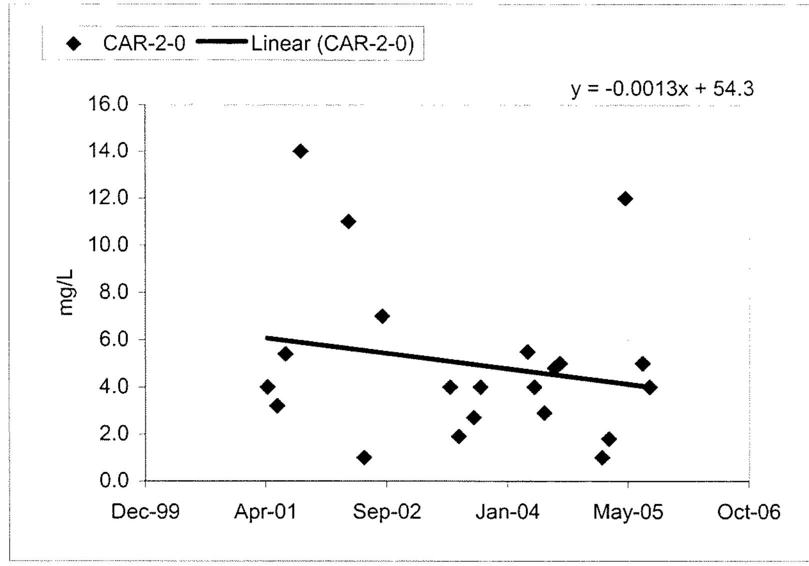


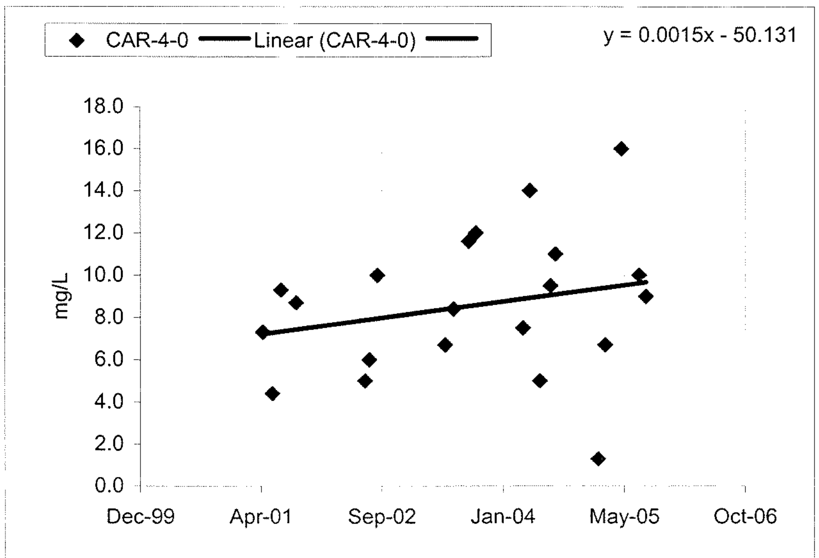


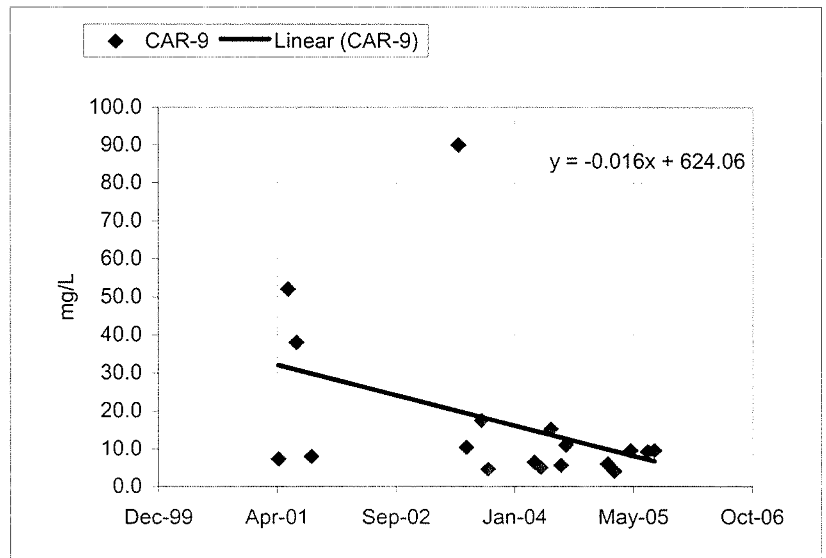


Volatile Suspended Solids (VSS)

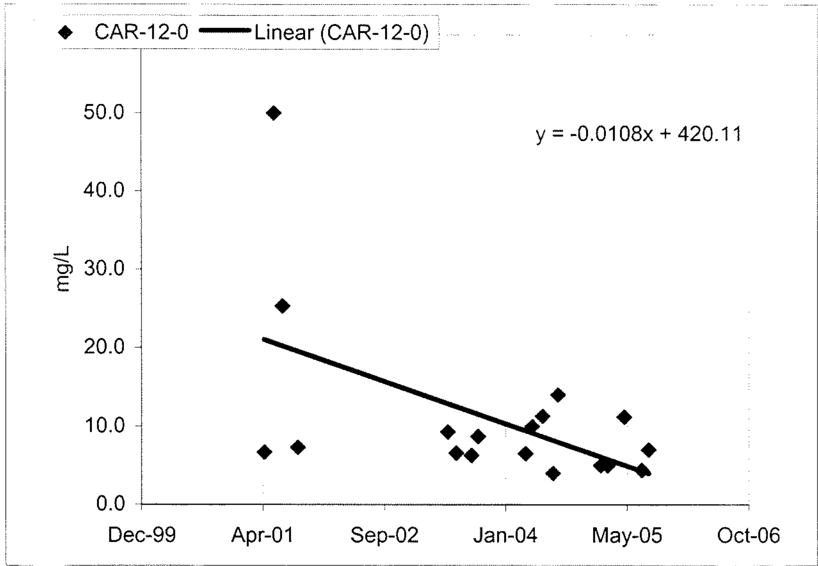


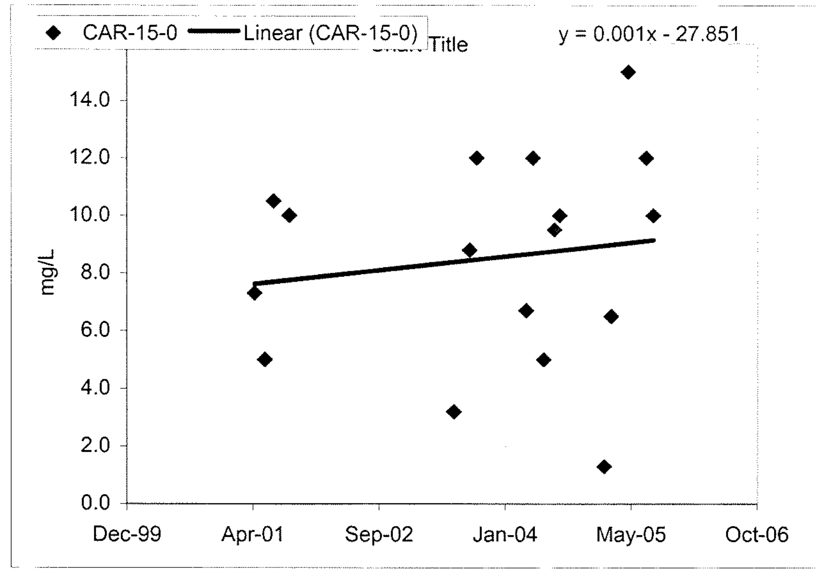


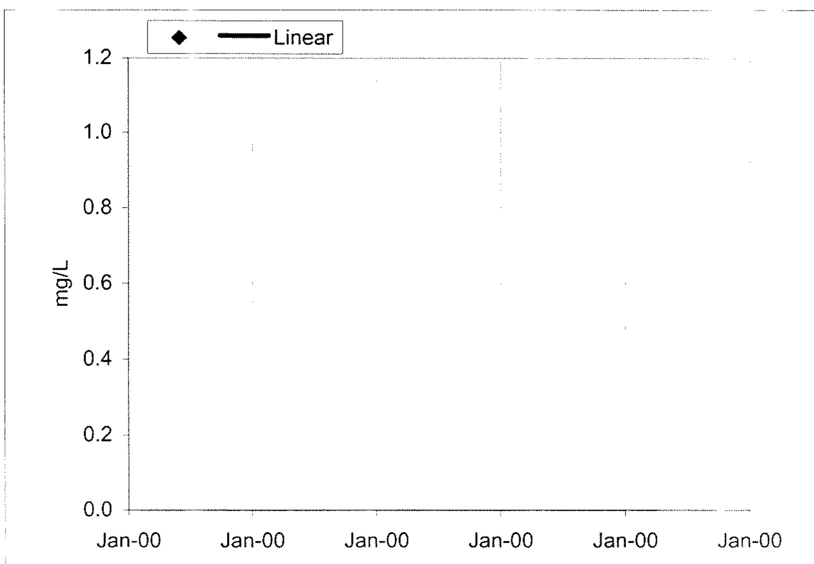


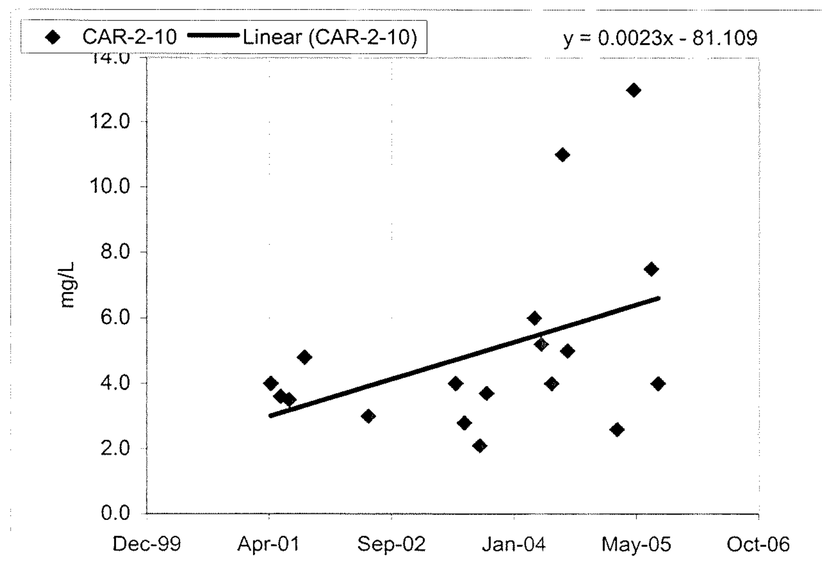


Volatile Suspended Solids (VSS)

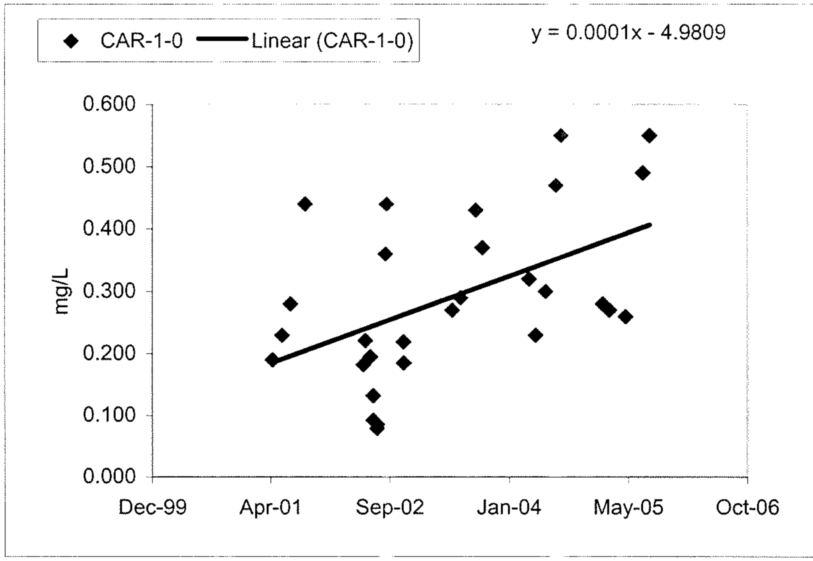


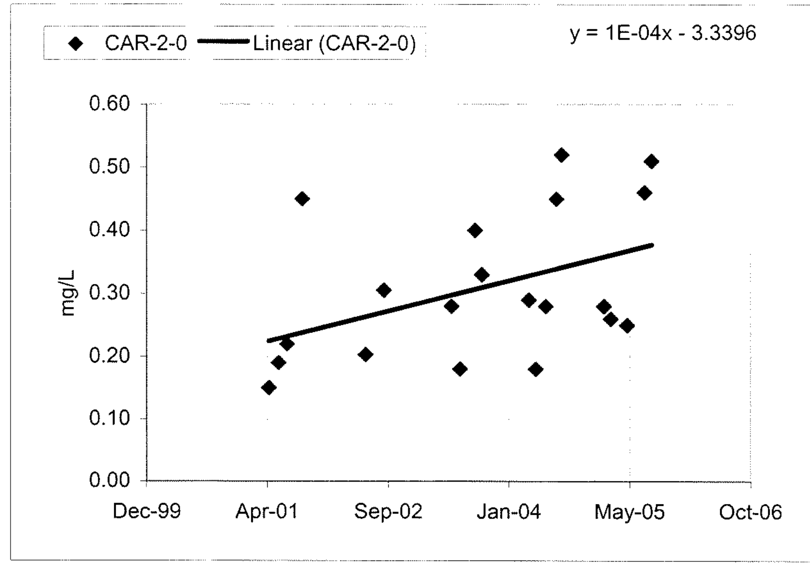


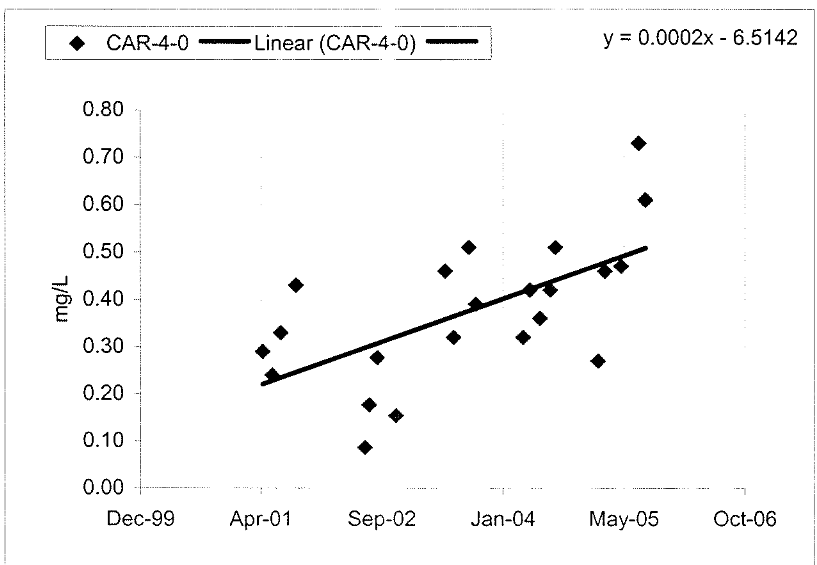


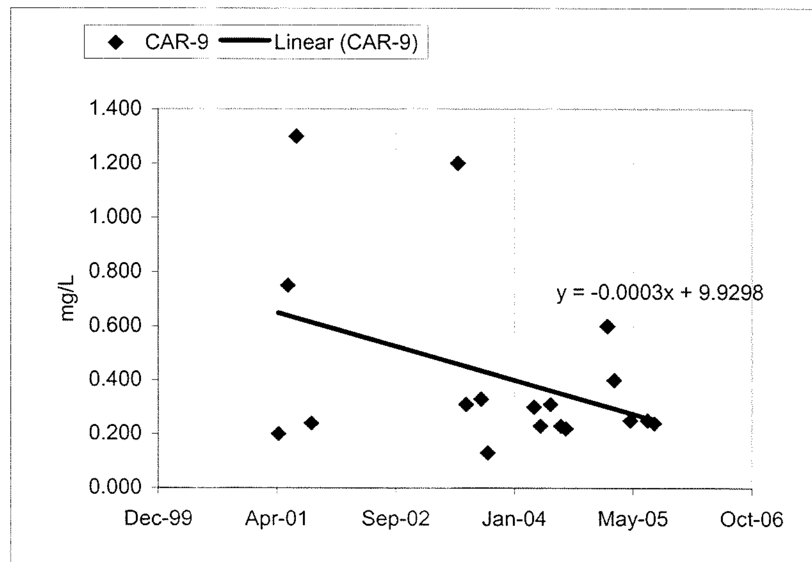


Total Phosphorus

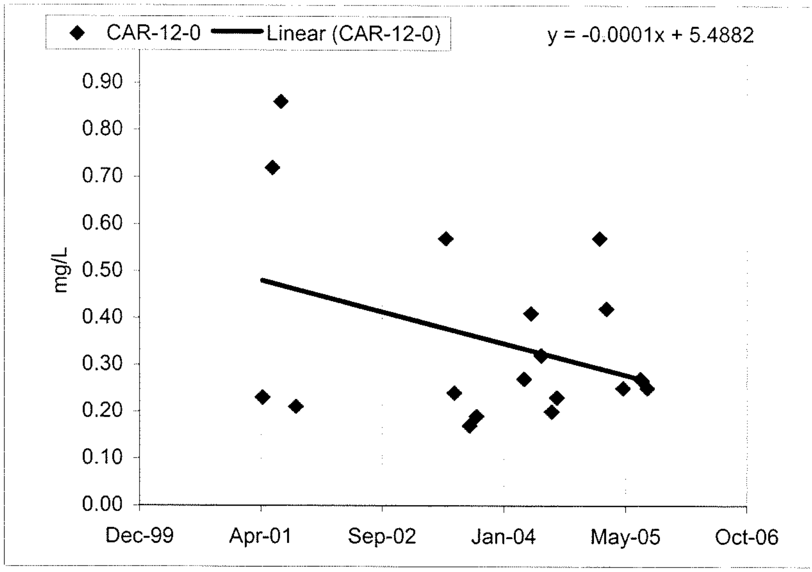


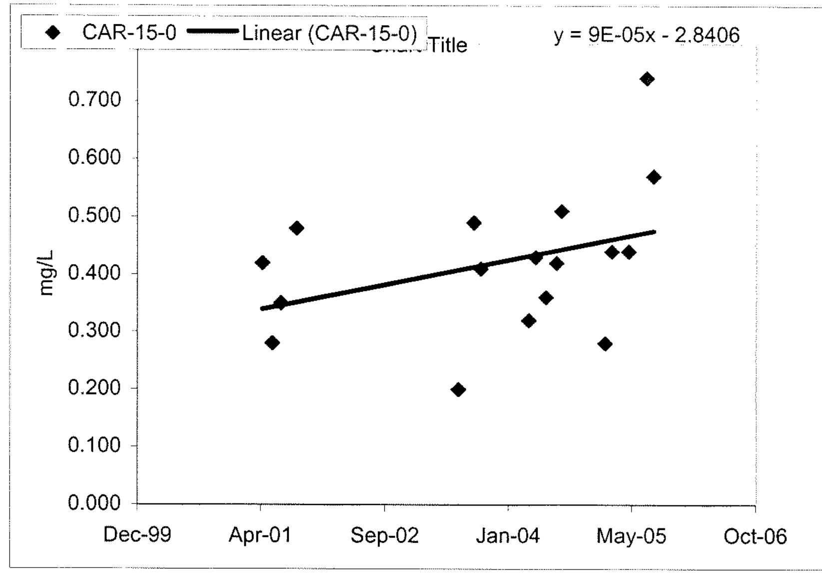


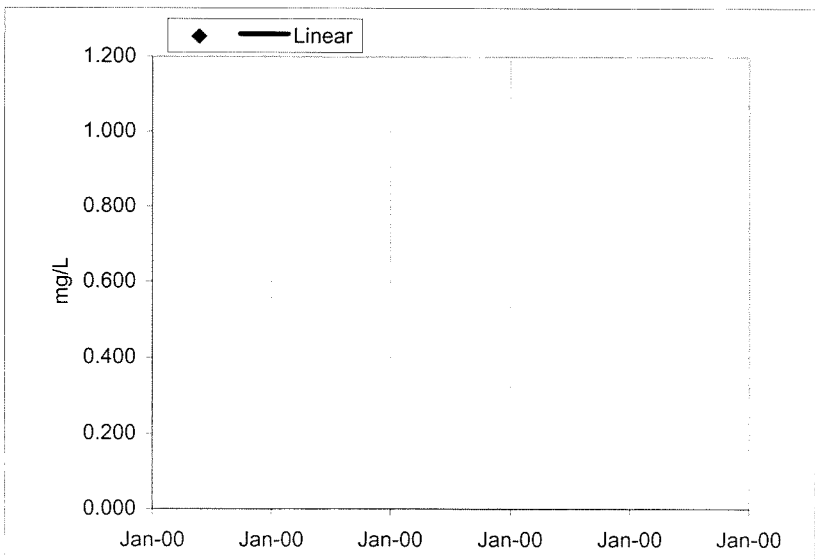


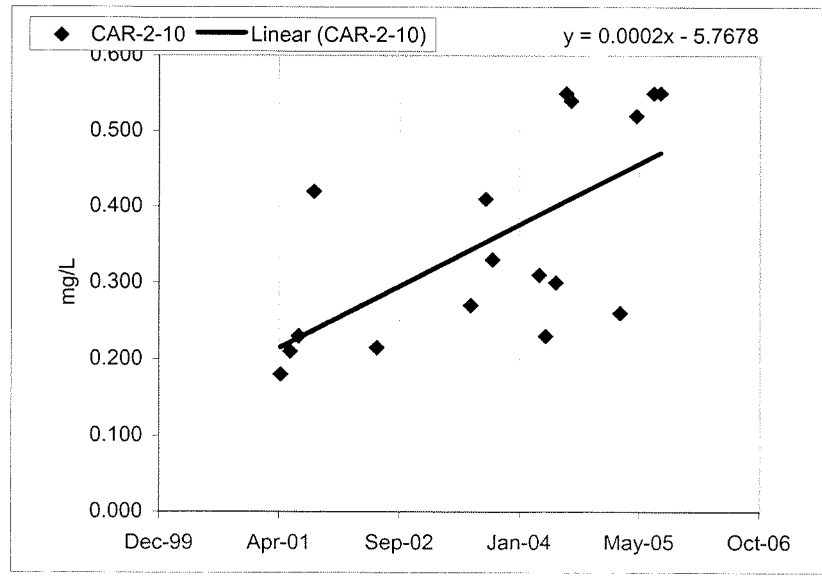


Total Phosphorus

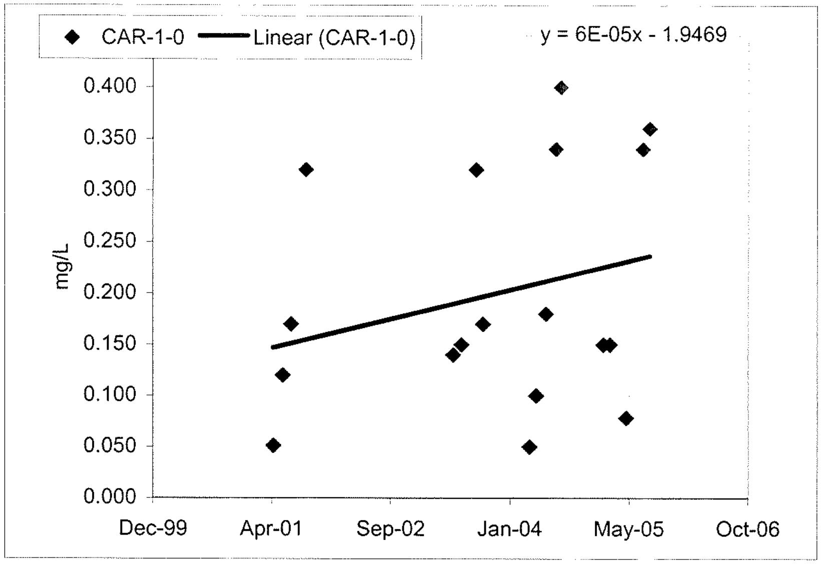


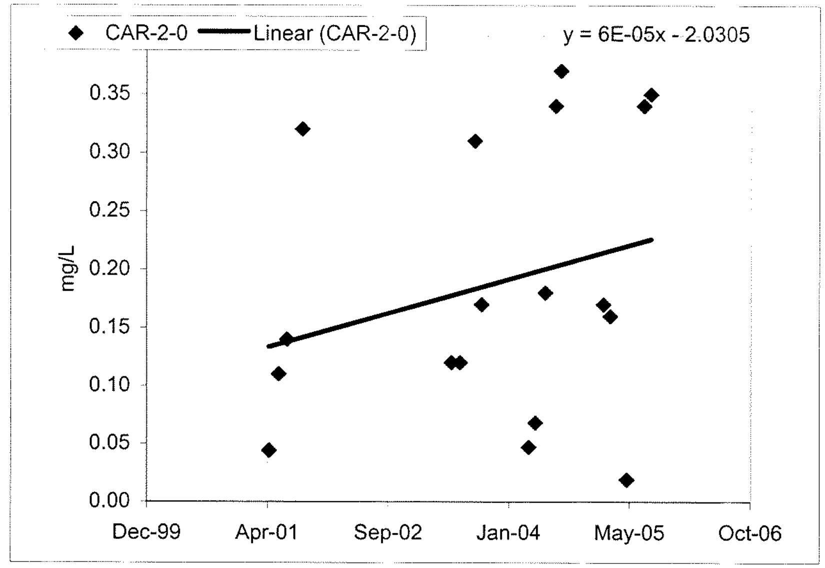


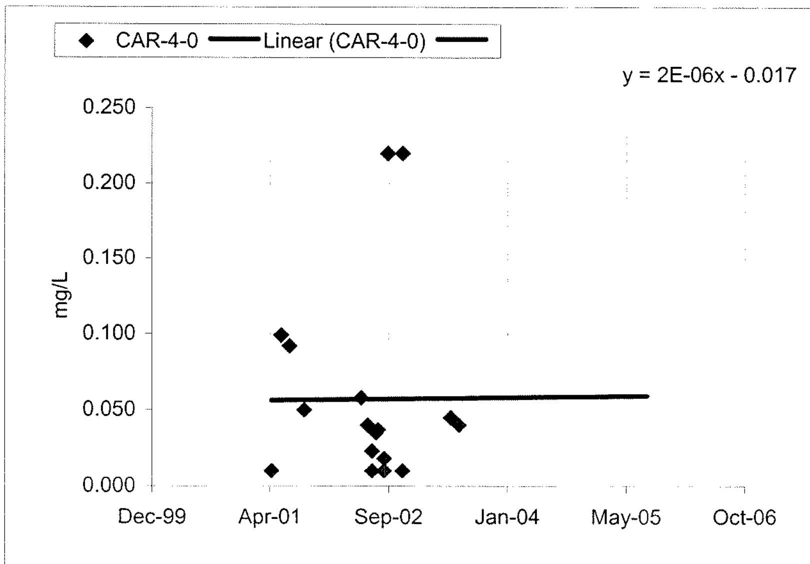


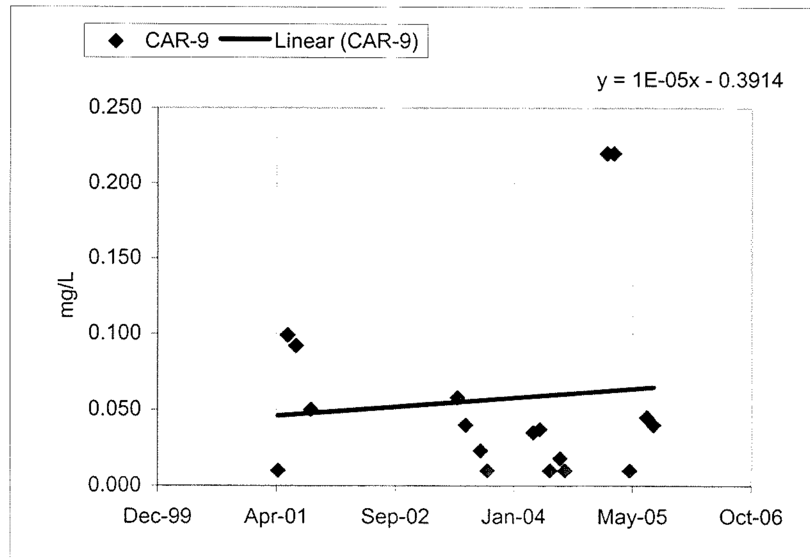


Soluble Phosphorus (ortho-Phosphate)

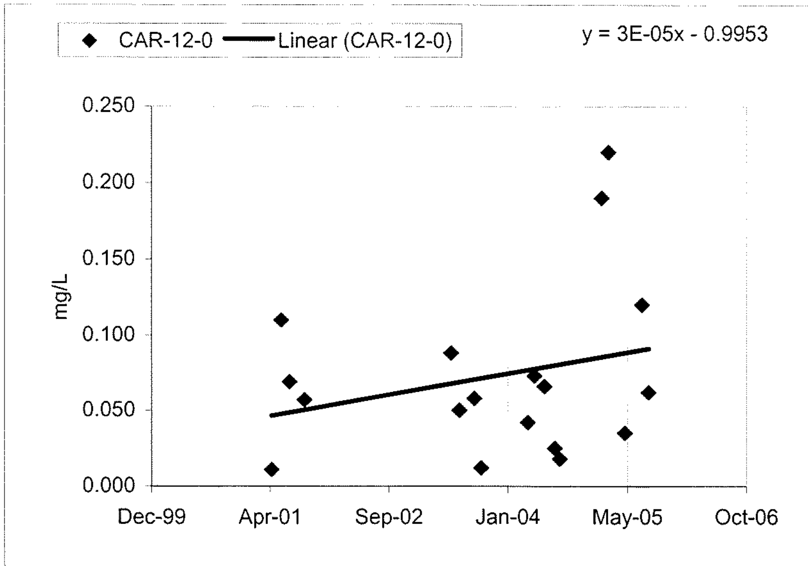


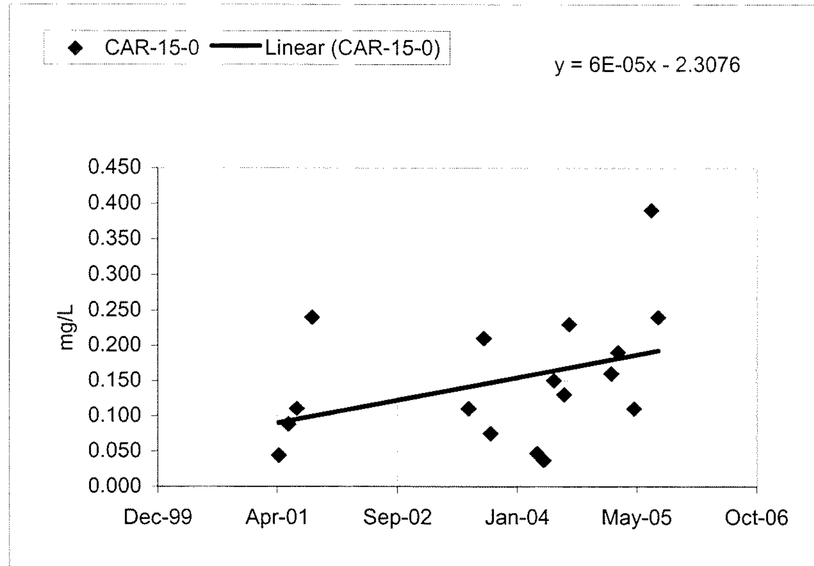


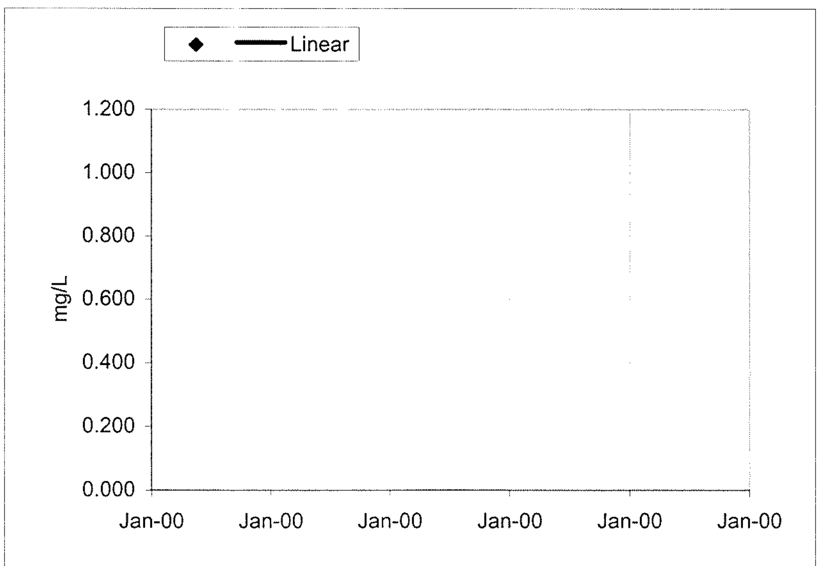


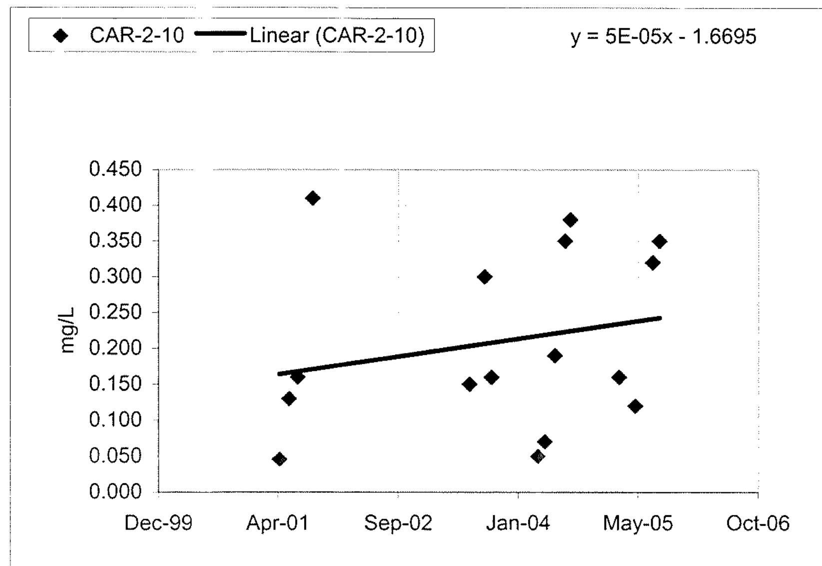


Soluble Phosphorus (ortho-Phosphate)

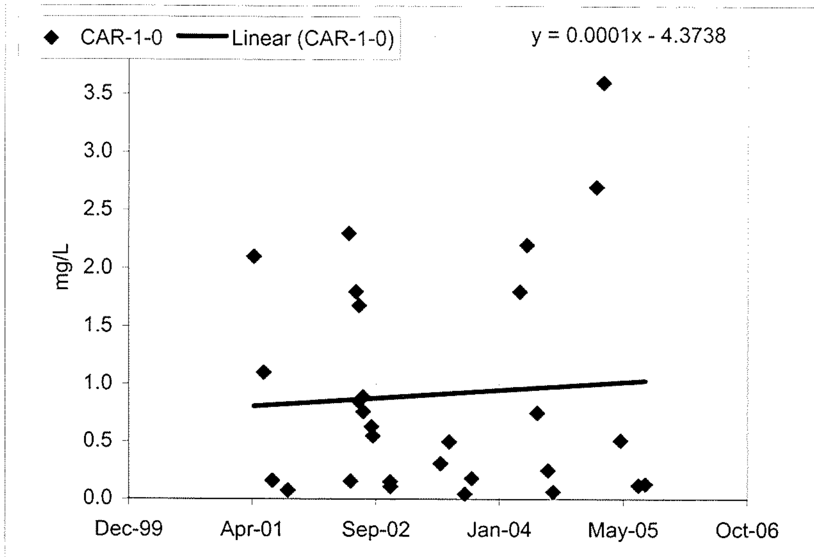




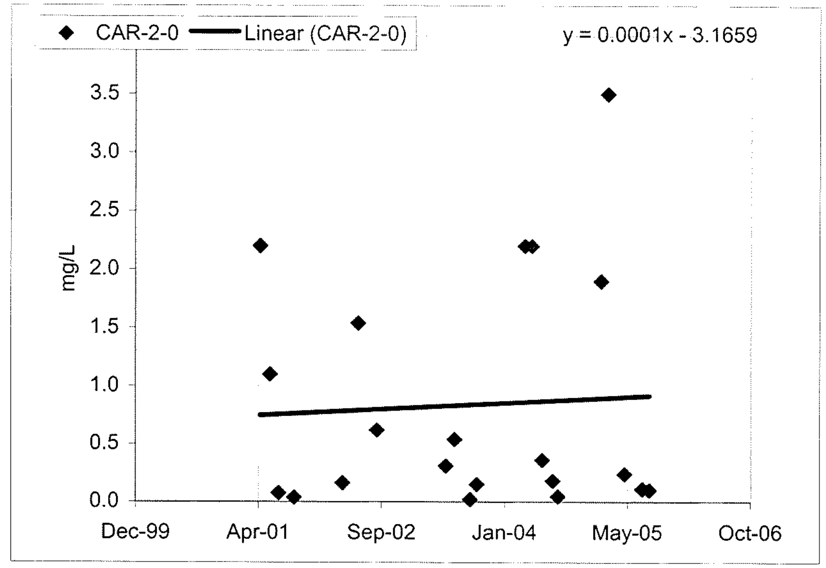




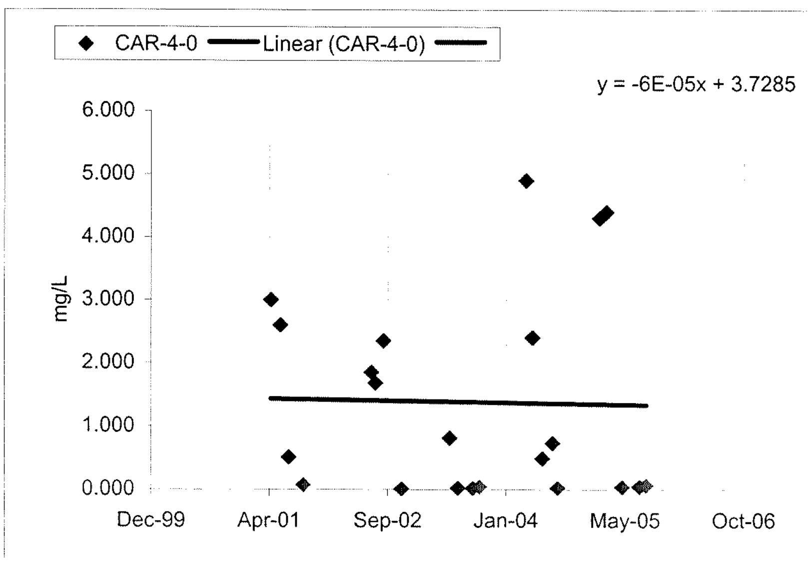
Nitrate



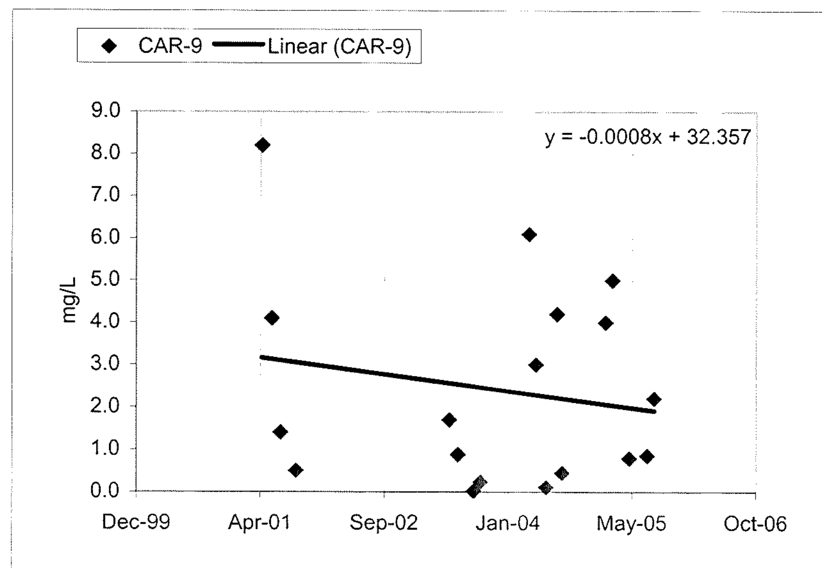
CAR-1-0
Linear (CAR-1-0)
y = 0.0001x - 4.3738
mg/L
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



CAR-2-0
Linear (CAR-2-0)
y = 0.0001x - 3.1659
mg/L
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

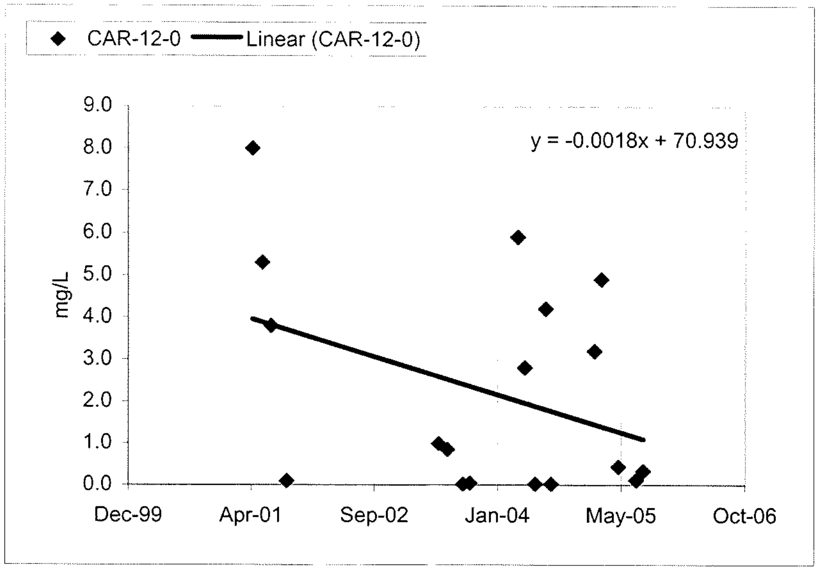


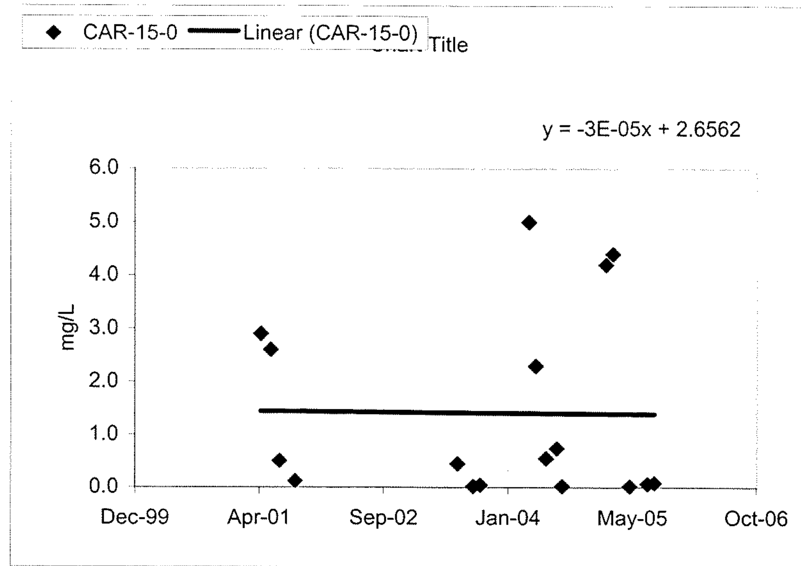
CAR-4-0
Linear (CAR-4-0)
y = -6E-05x + 3.7285
mg/L
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

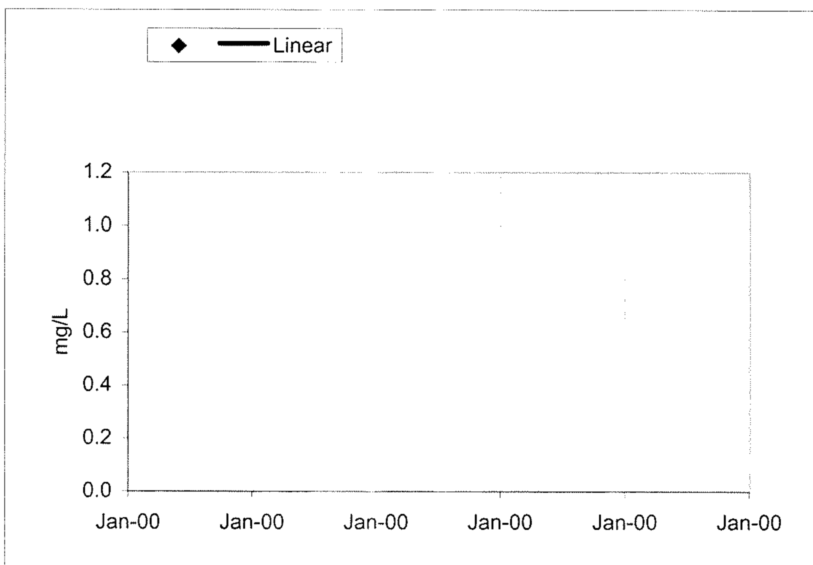


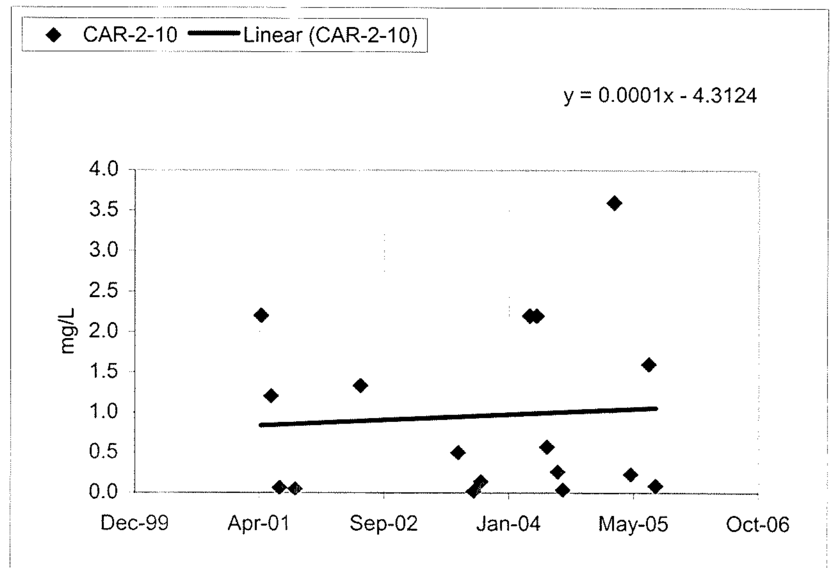
CAR-9
Linear (CAR-9)
y = -0.0008x + 32.357
mg/L
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

Nitrate

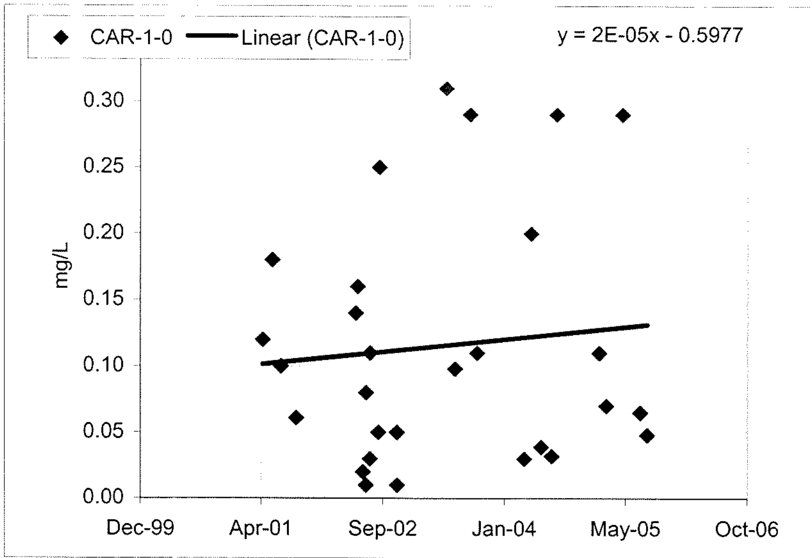

CAR-12-0
Linear (CAR-12-0)
y = -0.0018x + 70.939
mg/L
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


CAR-15-0
Linear (CAR-15-0)
Title
y = -3E-05x + 2.6562
mg/L
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

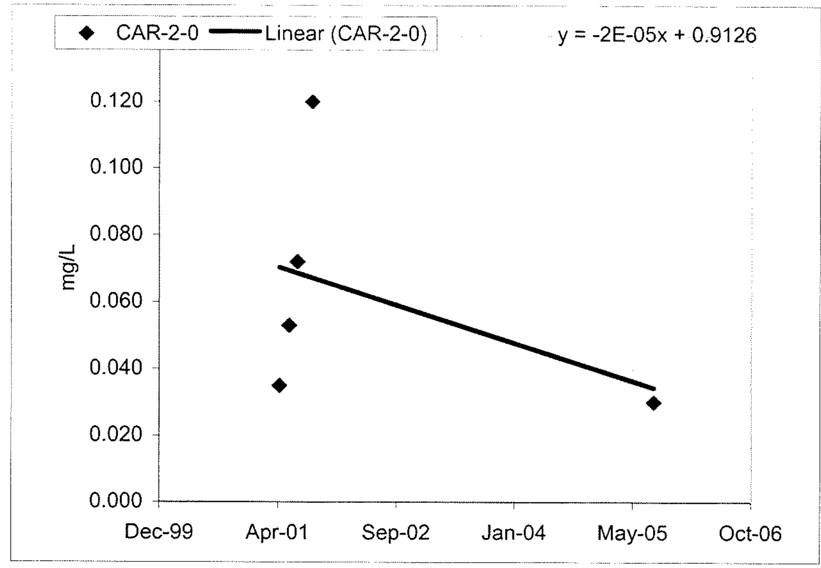

Linear
mg/L
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00


CAR-2-10
Linear (CAR-2-10)
y = 0.0001x - 4.3124
mg/L
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

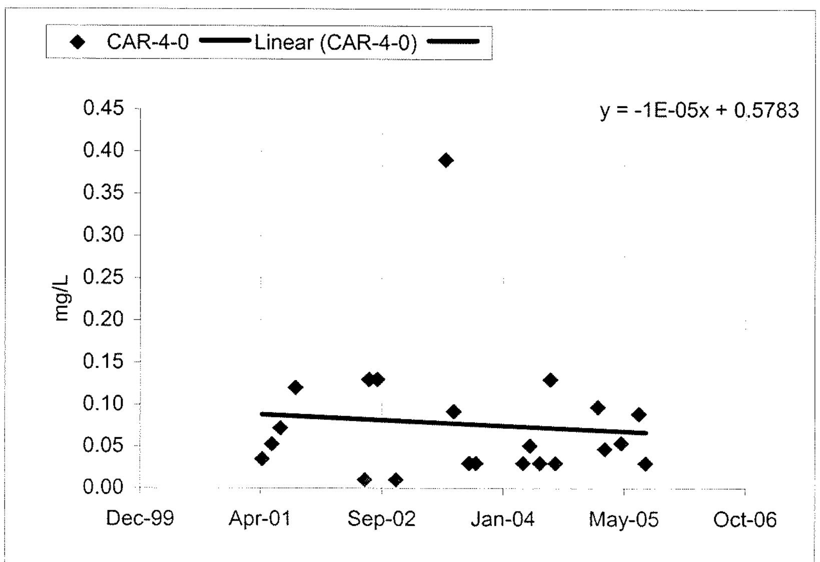
Ammonia



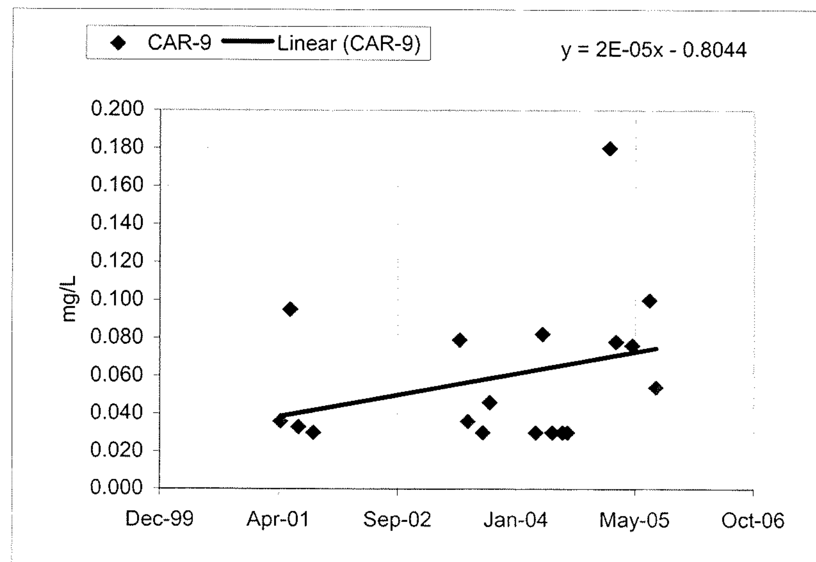
CAR-1-0
Linear (CAR-1-0)
y = 2E-05x - 0.5977
mg/L
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



CAR-2-0
Linear (CAR-2-0)
y = -2E-05x + 0.9126
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

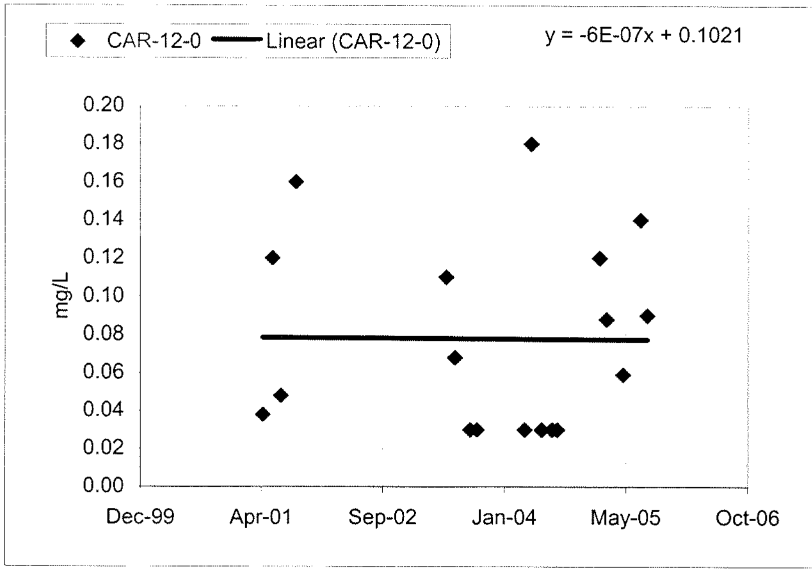


CAR-4-0
Linear (CAR-4-0)
y = -1E-05x + 0.5783
mg/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

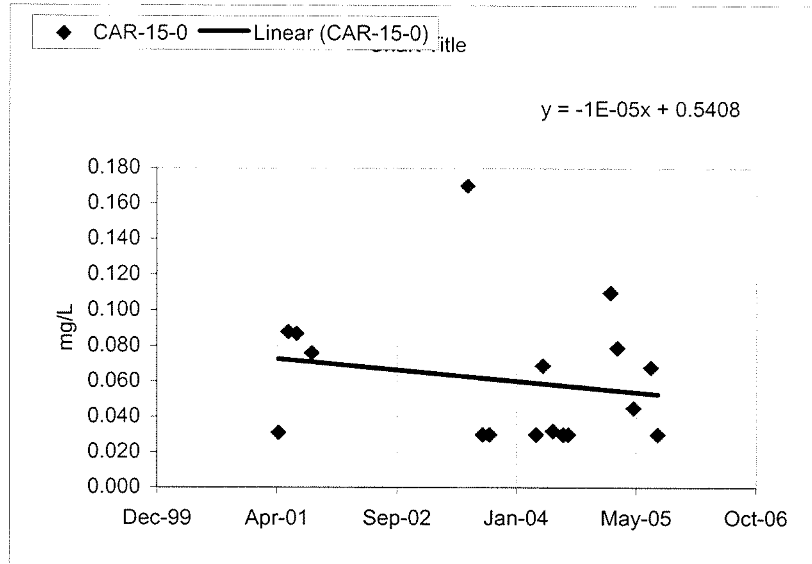


CAR-9
Linear (CAR-9)
y = 2E-05x - 0.8044
mg/L
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

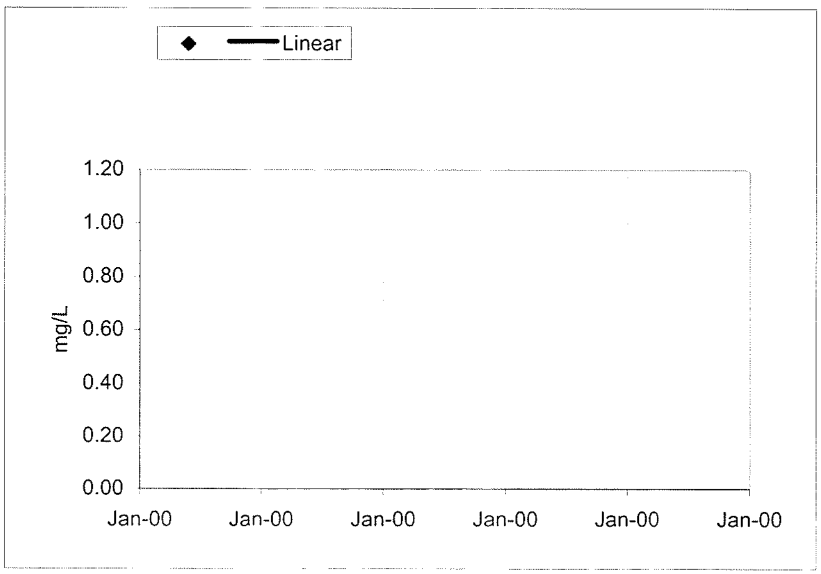
Ammonia



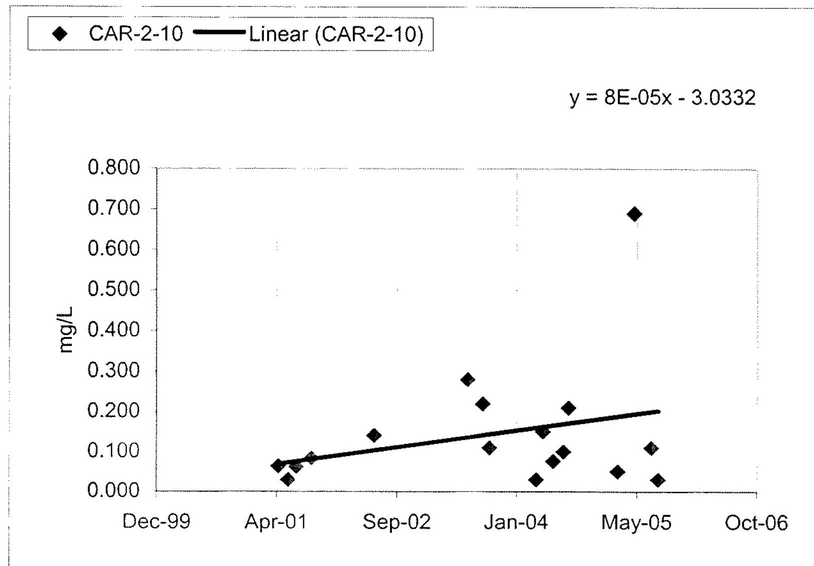
CAR-12-0
Linear (CAR-12-0)
y = -6E-07x + 0.1021
mg/L
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



CAR-15-0
Linear (CAR-15-0)
y = -1E-05x + 0.5408
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



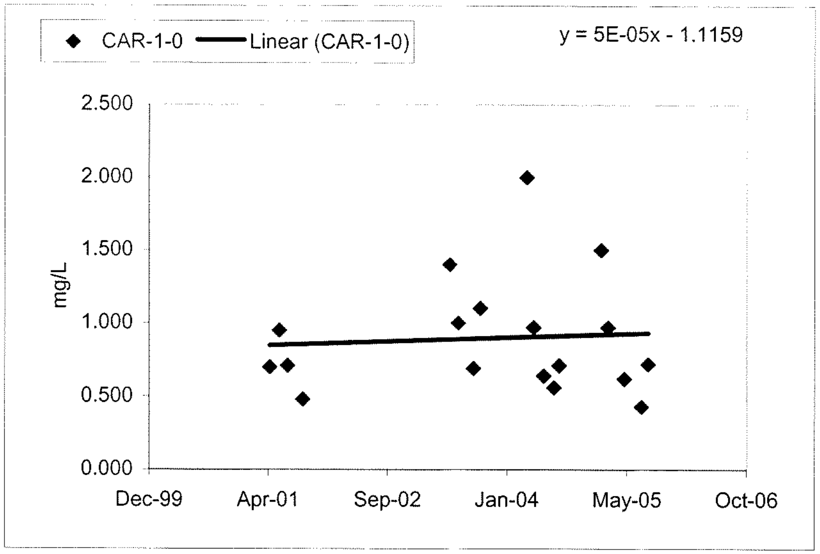
Linear
mg/L
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00

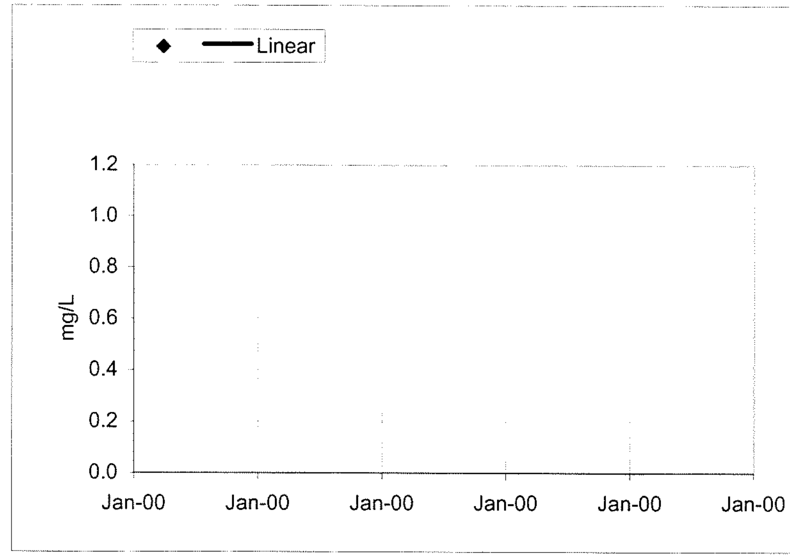


CAR-2-10
Linear (CAR-2-10)
y = 8E-05x - 3.0332
mg/L
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

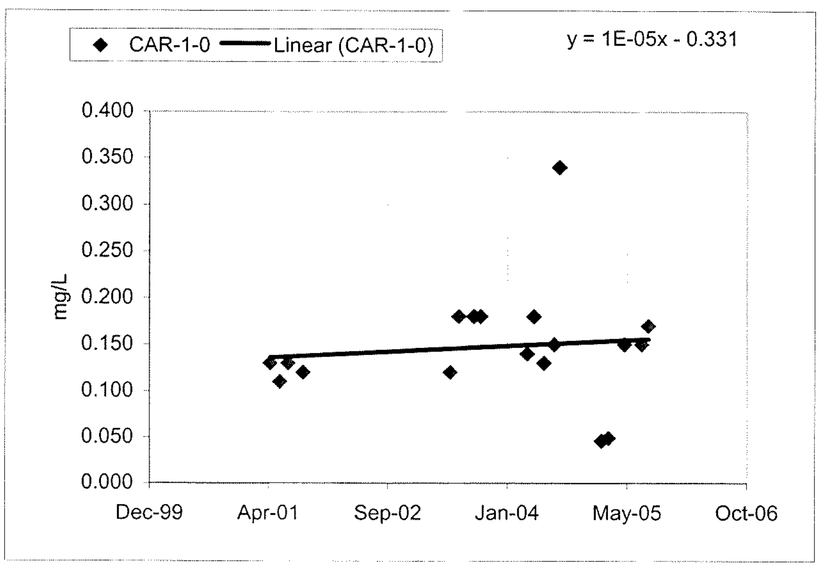
Iron and Manganese

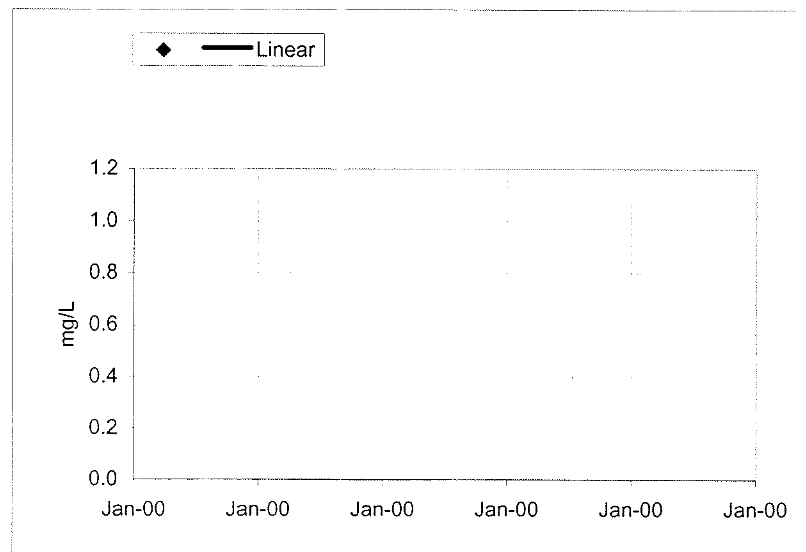
Iron



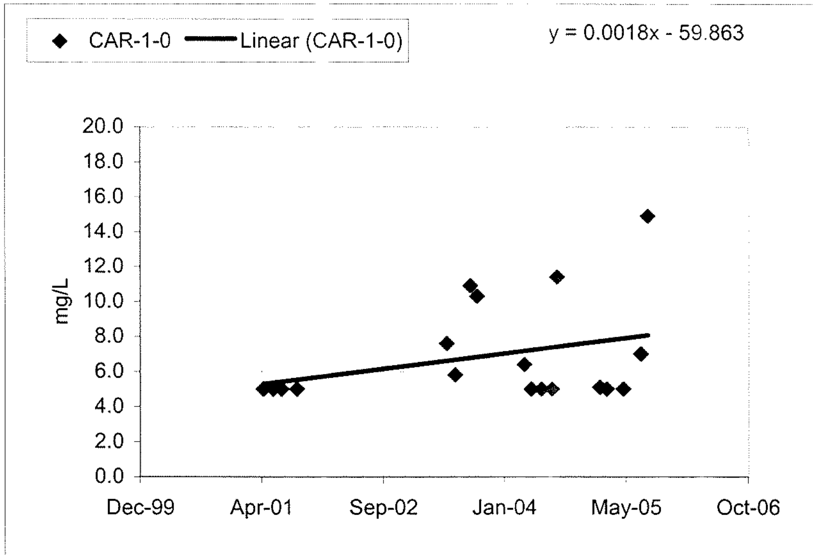


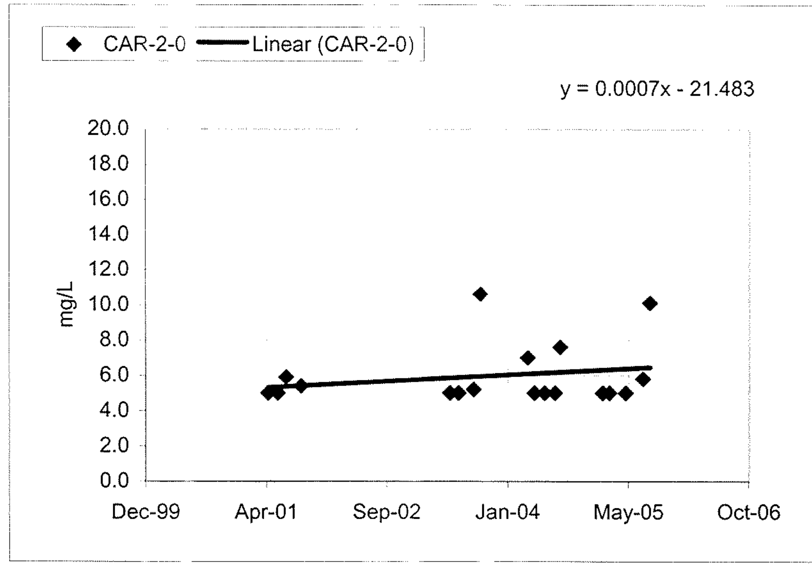
Manganese

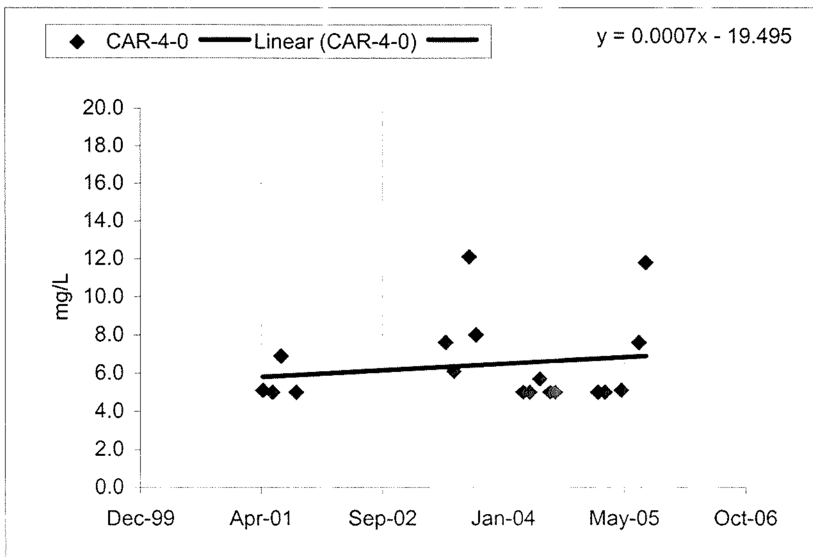


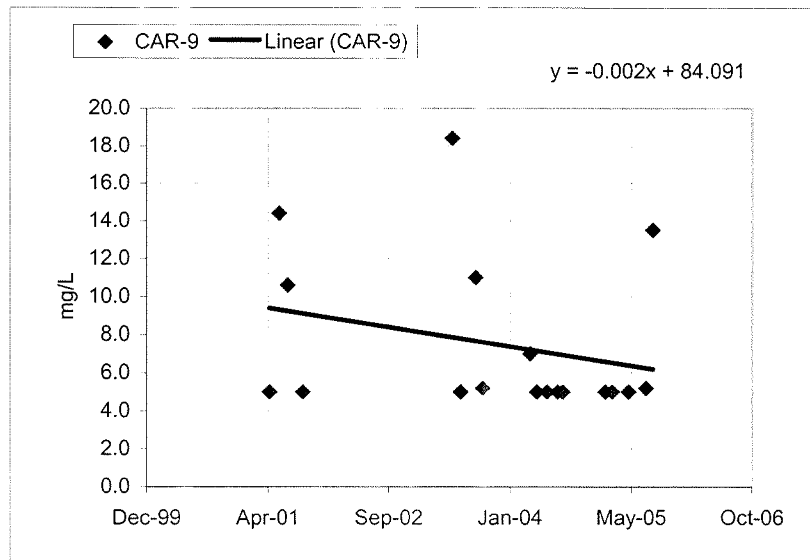


Total Organic Carbon (TOC)

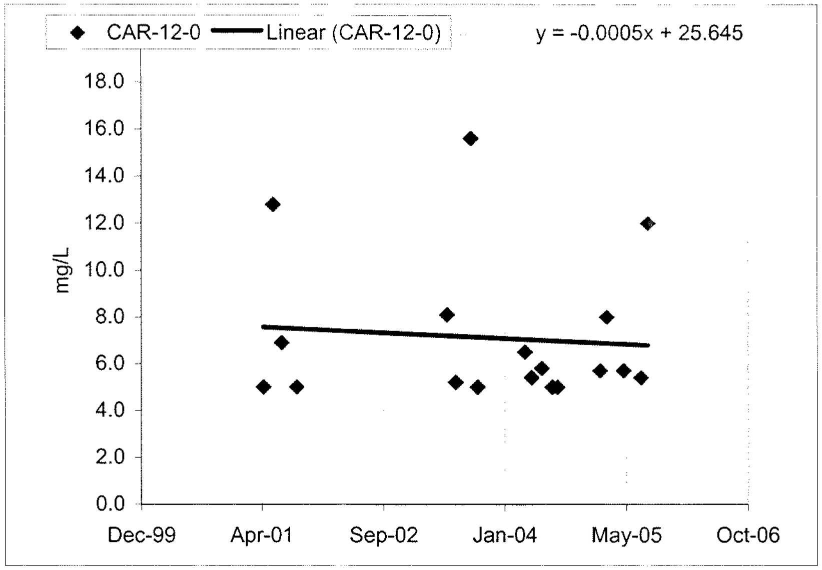


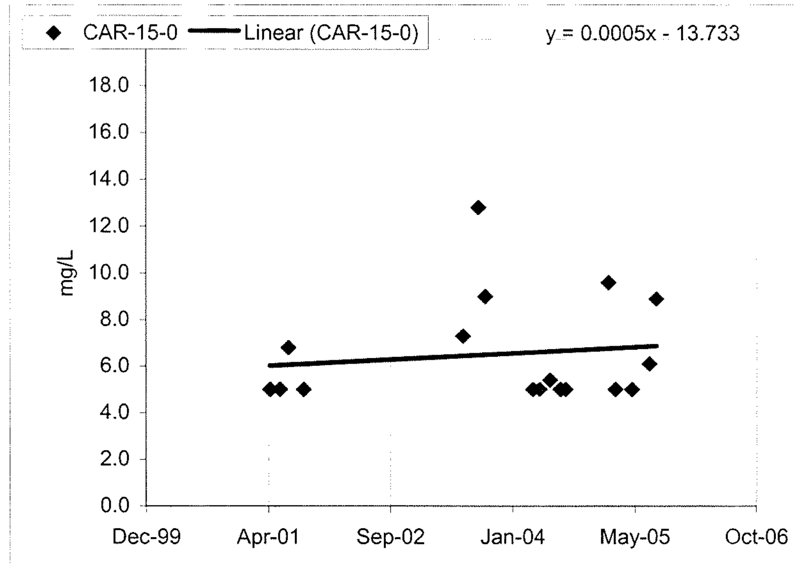


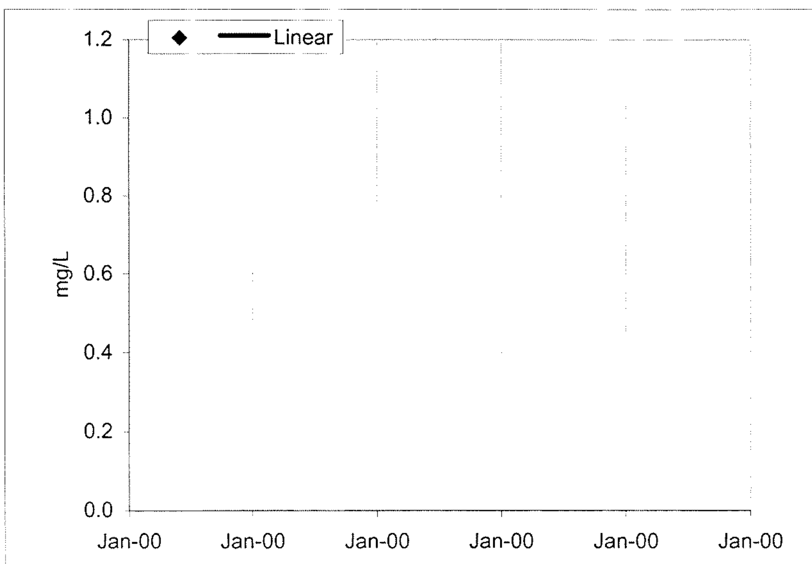


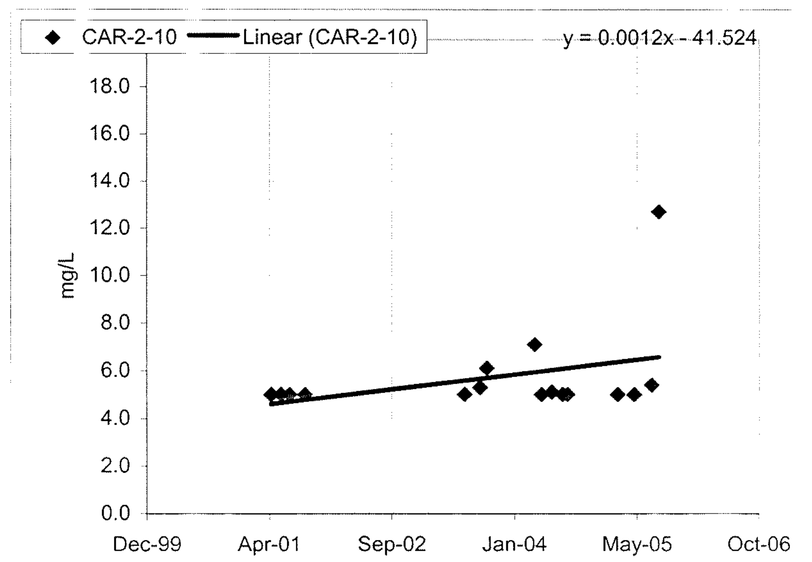


Total Organic Carbon (TOC)

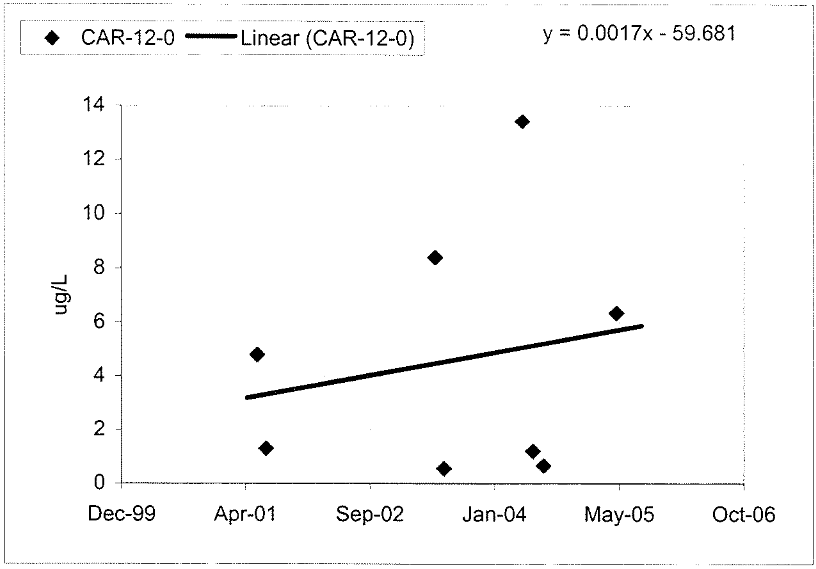




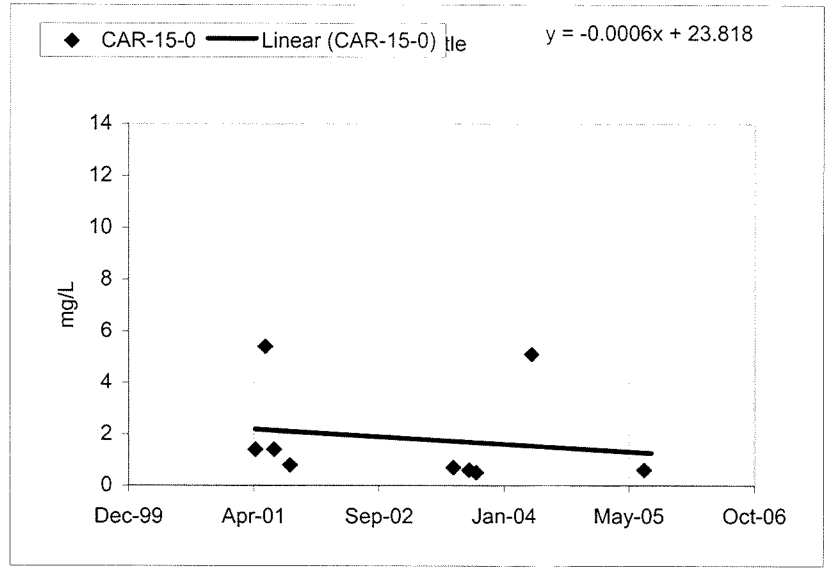




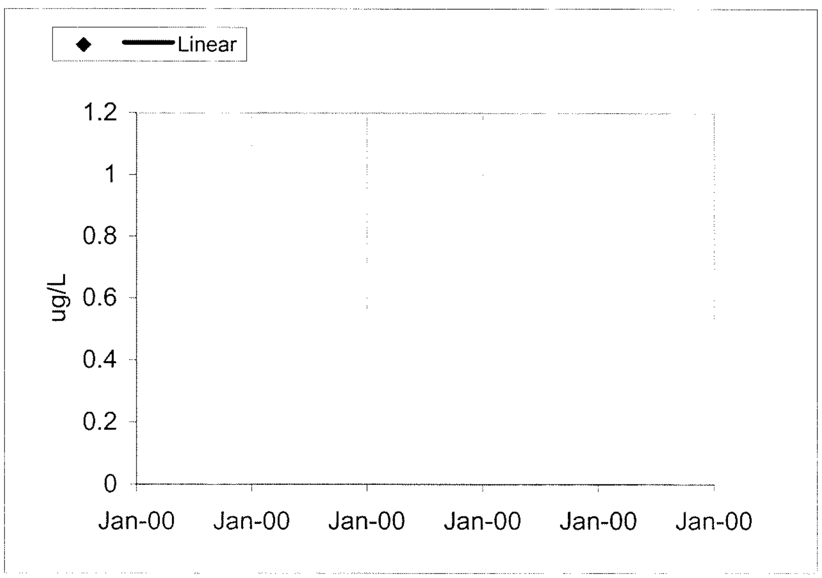
Atrazine



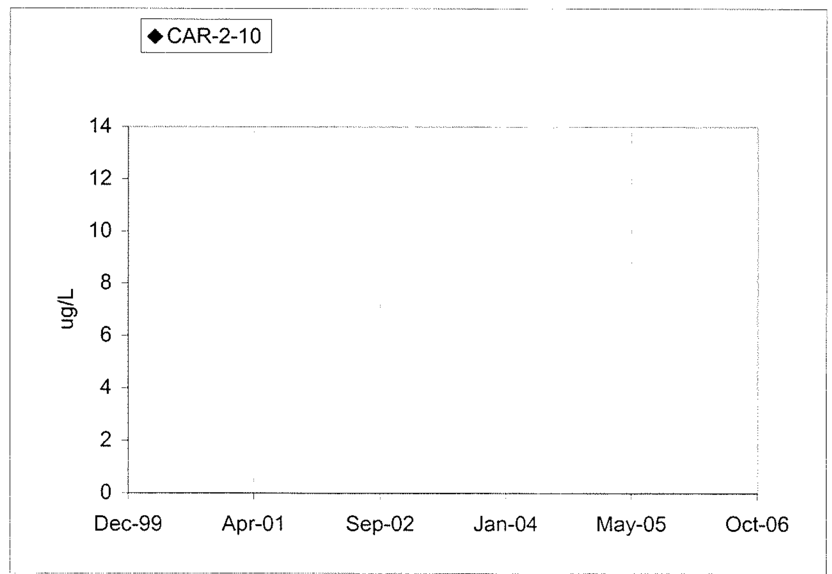
CAR-12-0
Linear (CAR-12-0)
y = 0.0017x - 59.681
ug/L
14
12
10
8
6
4
2
0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06



CAR-15-0
Linear (CAR-15-0)
y = -0.0006x + 23.818
mg/L
14
12
10
8
6
4
2
0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

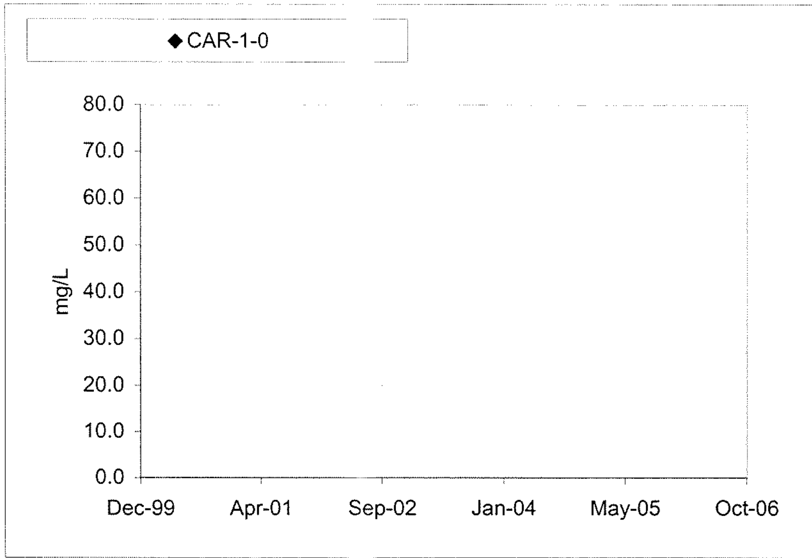


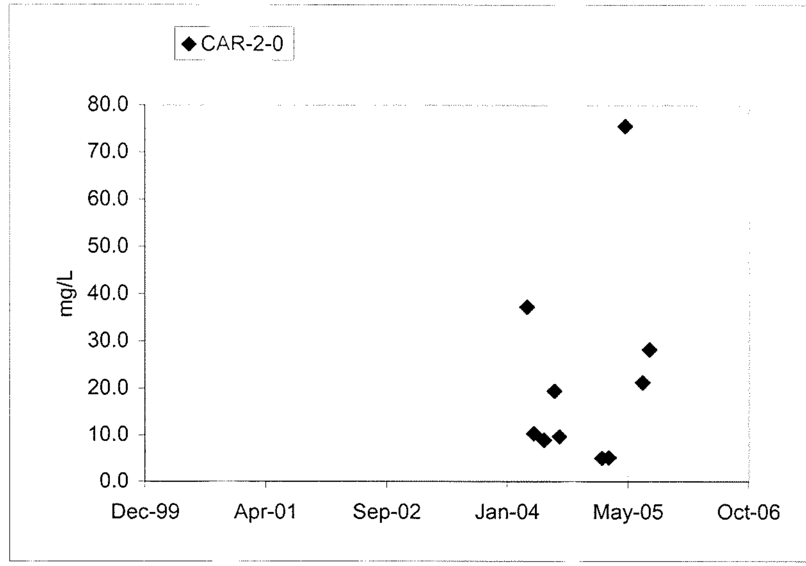
Linear
ug/L
1.2
1
0.8
0.6
0.4
0.2
0
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00

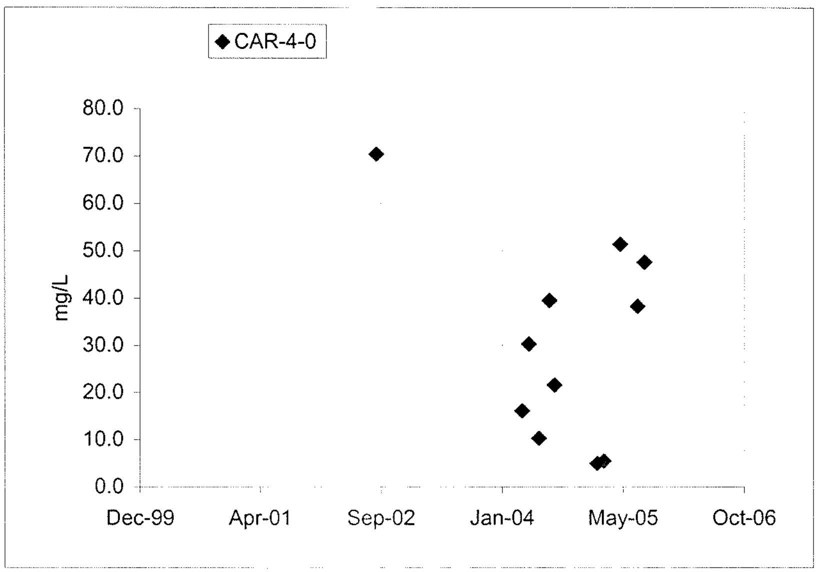


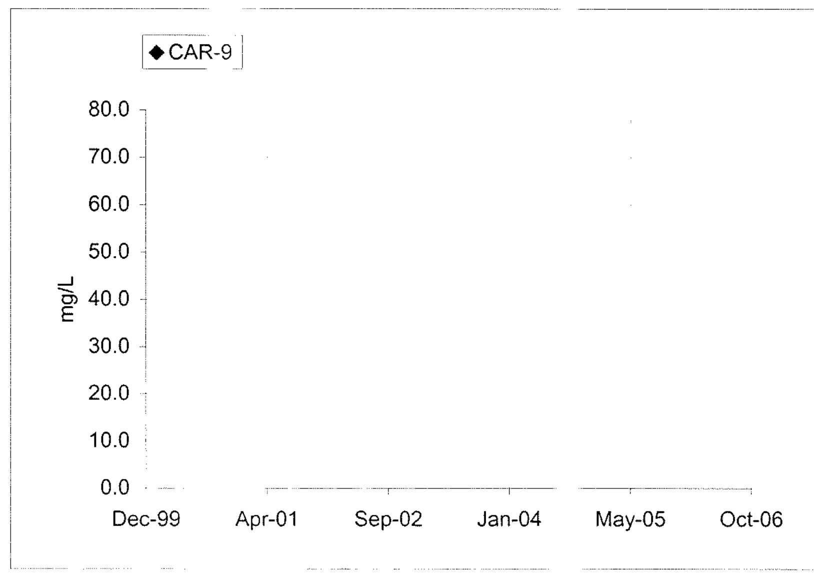
CAR-2-10
ug/L
14
12
10
8
6
4
2
0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

Chlorophyll

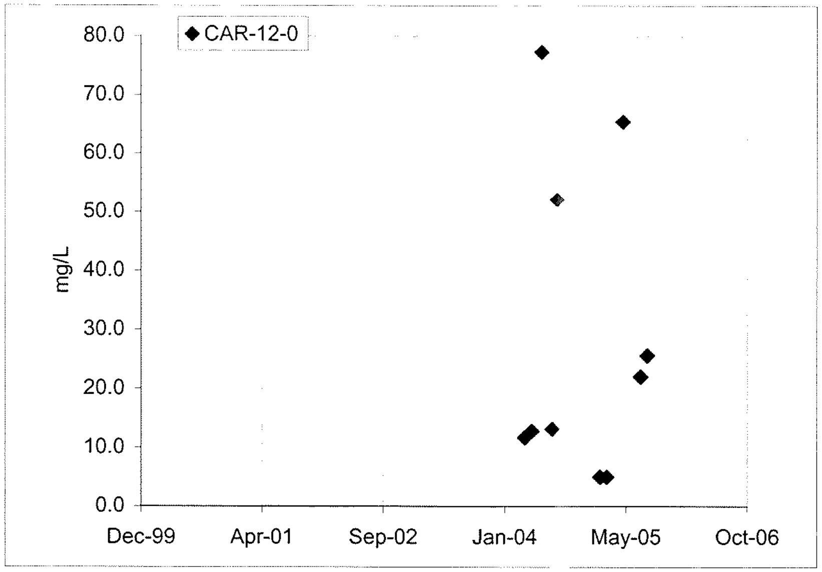


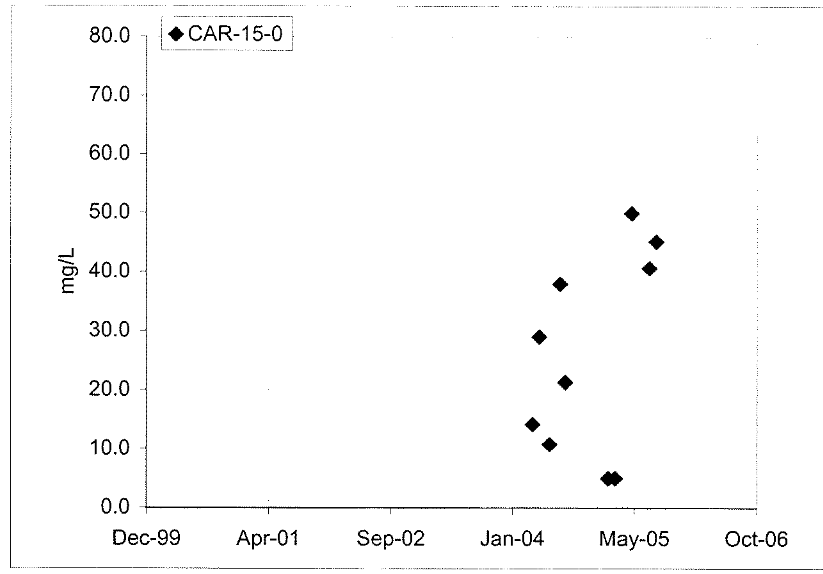


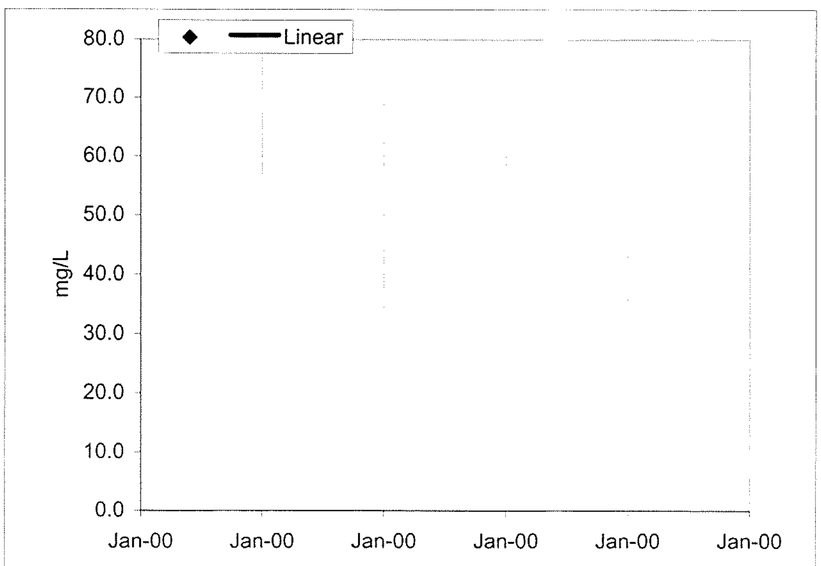


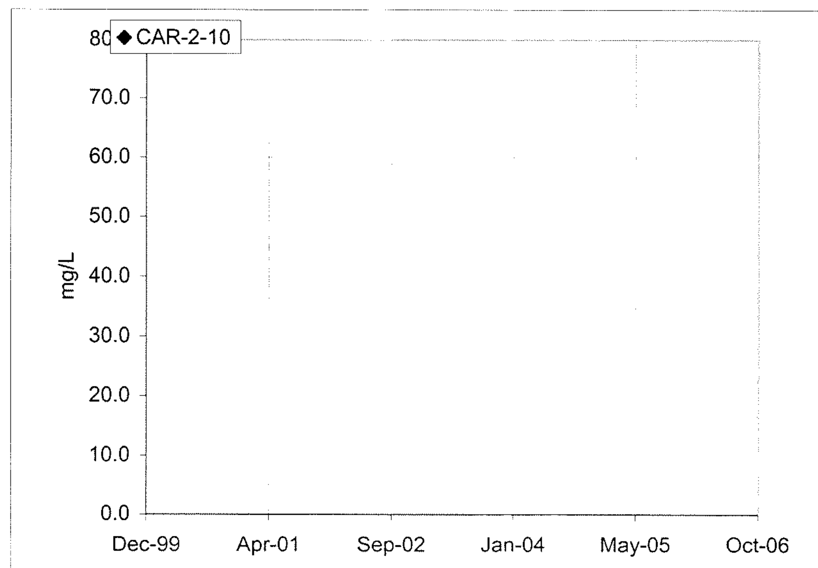


Chlorophyll

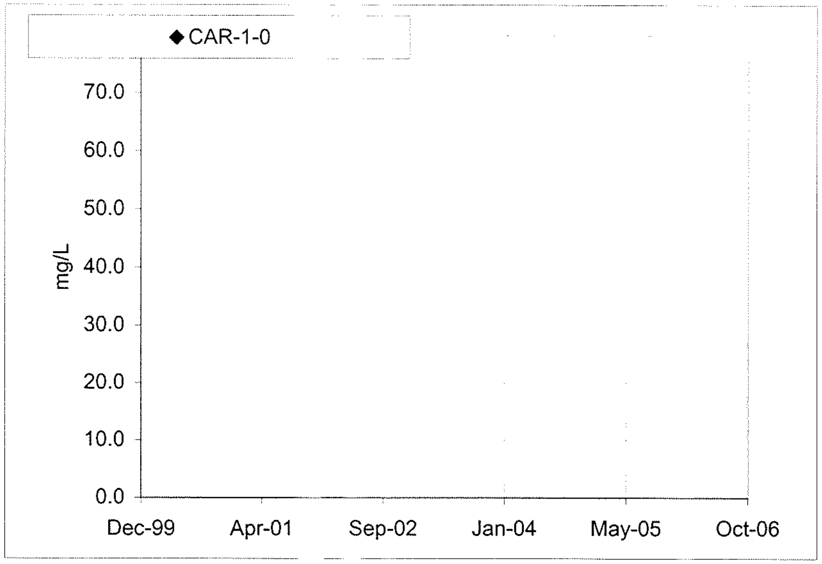


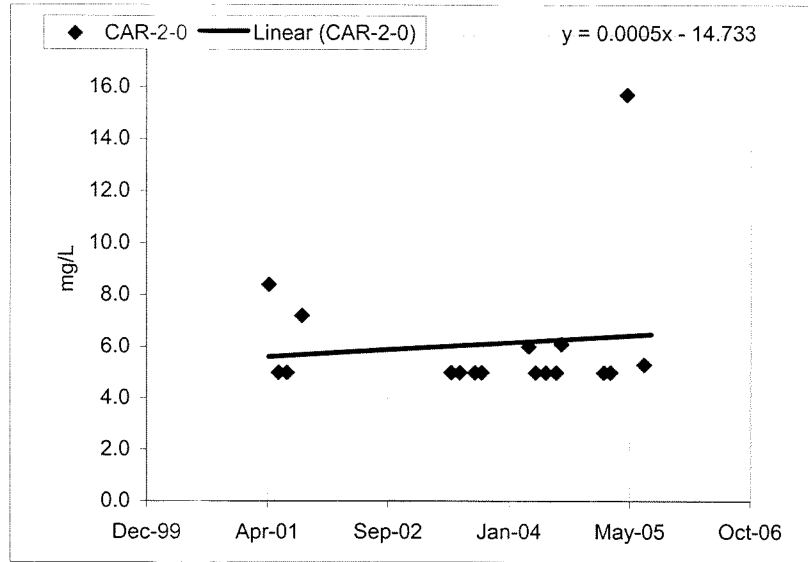


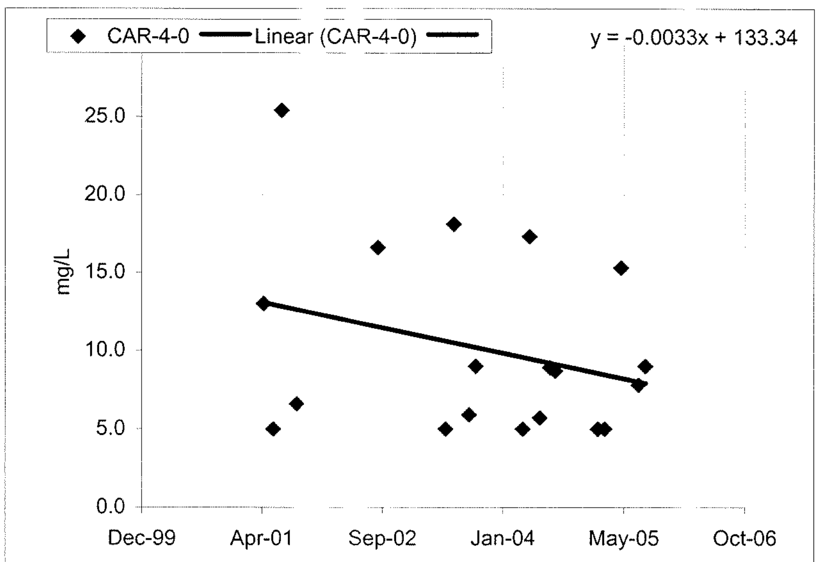


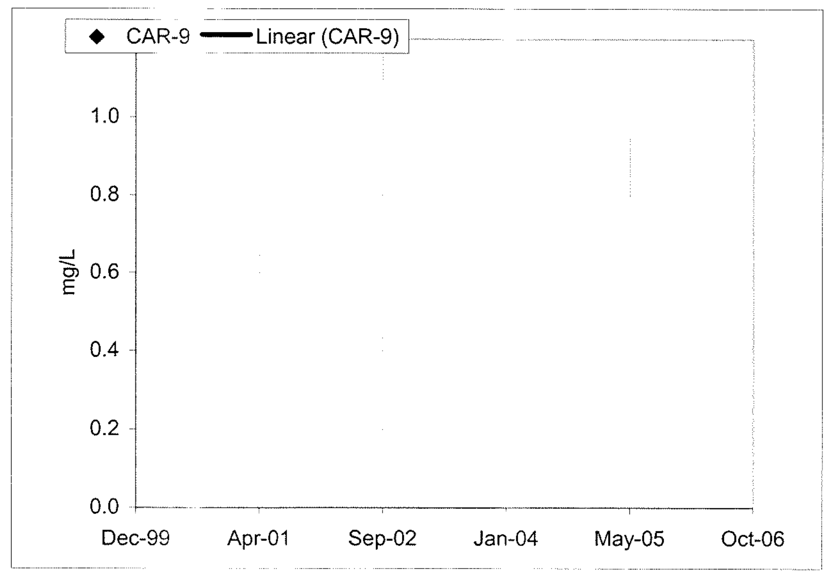


Pheophytin

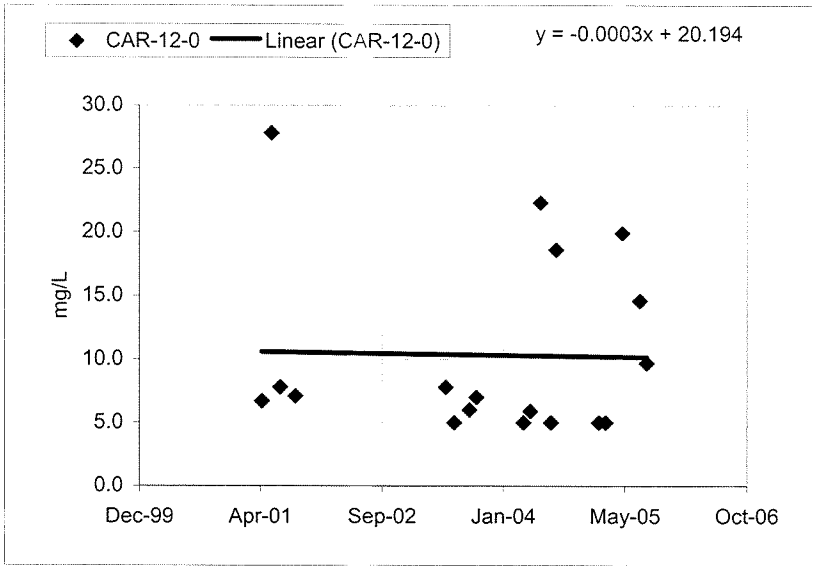

CAR-1-0
mg/L
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

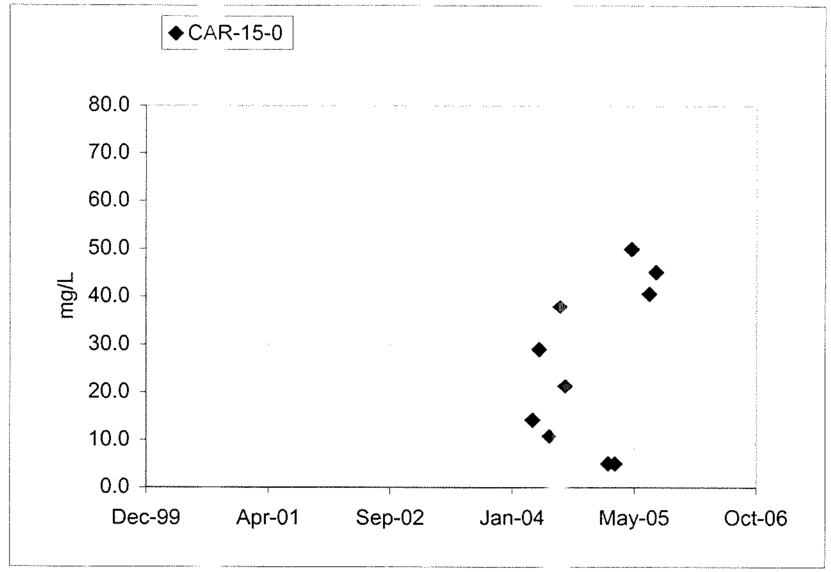

CAR-2-0
Linear (CAR-2-0)
y = 0.0005x - 14.733
mg/L
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

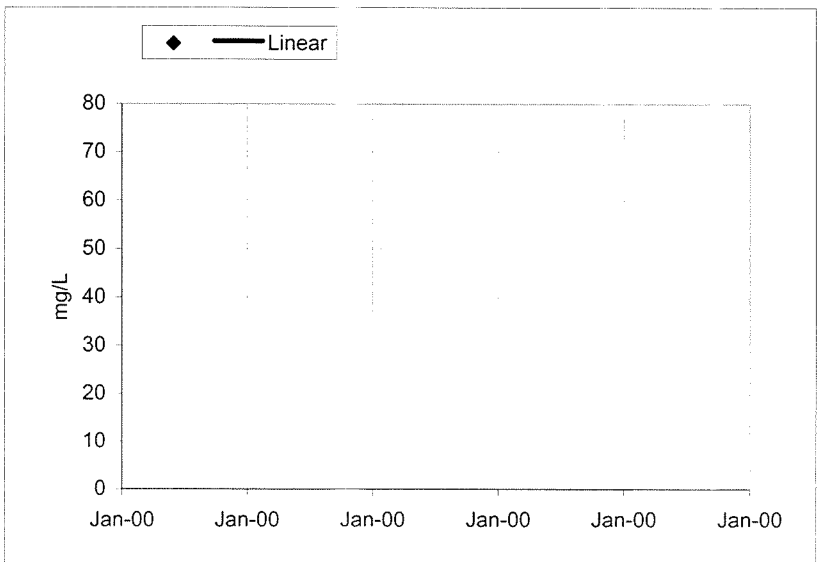

CAR-4-0
Linear (CAR-4-0)
y = -0.0033x + 133.34
mg/L
25.0
20.0
15.0
10.0
5.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

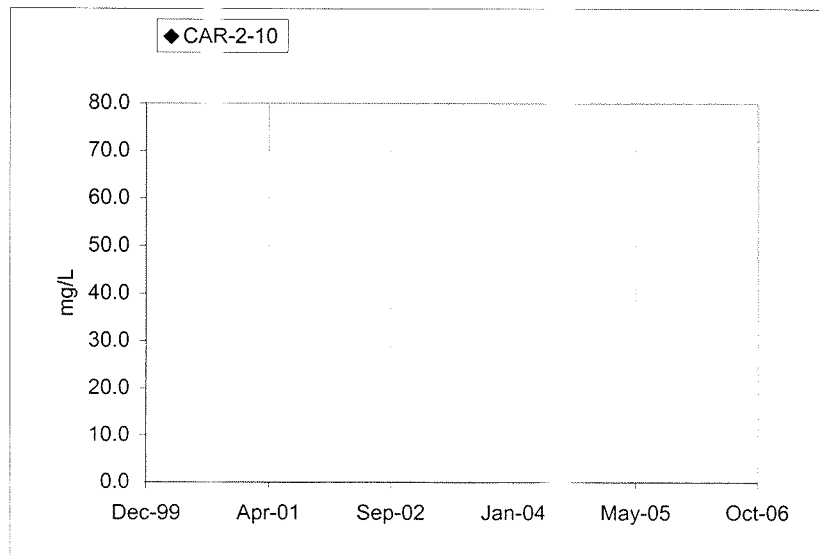

CAR-9
Linear (CAR-9)
mg/L
1.0
0.8
0.6
0.4
0.2
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

Pheophytin

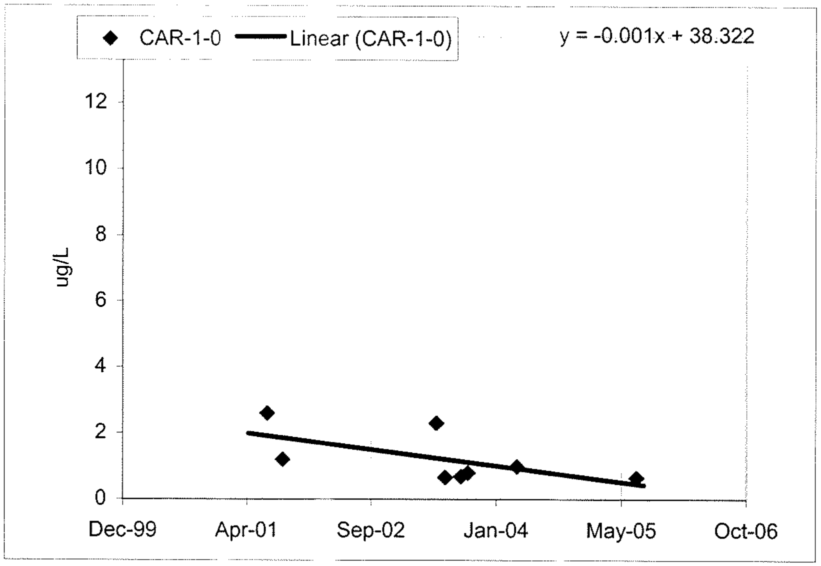

CAR-12-0
Linear (CAR-12-0)
y = -0.0003x + 20.194
mg/L
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

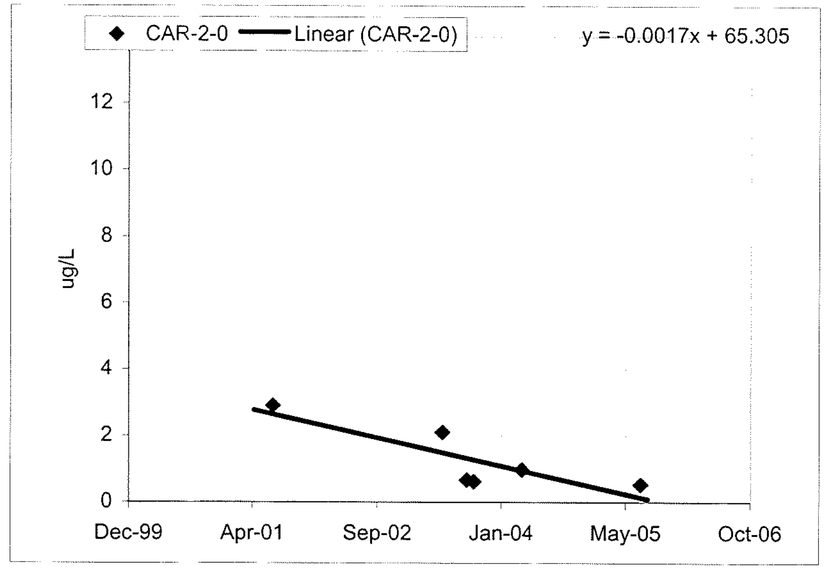

CAR-15-0
mg/L
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

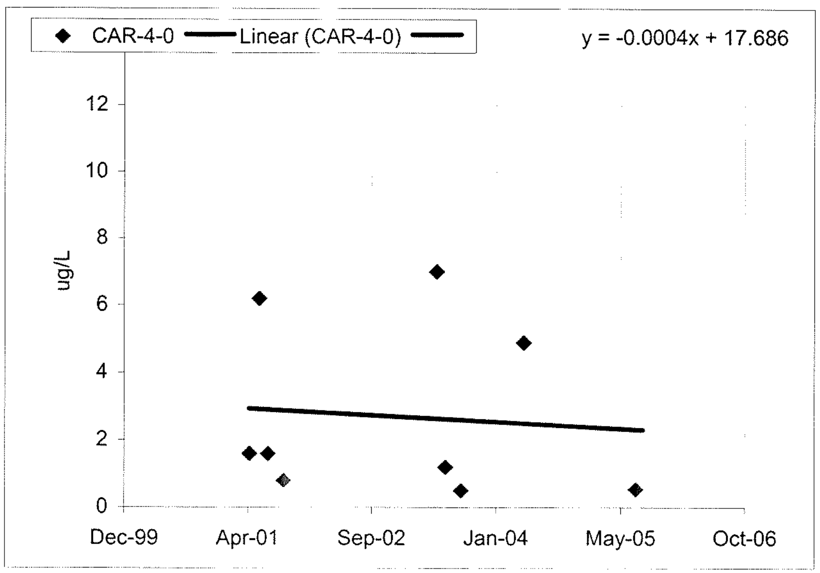

Linear
mg/L
80
70
60
50
40
30
20
10
0
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00
Jan-00

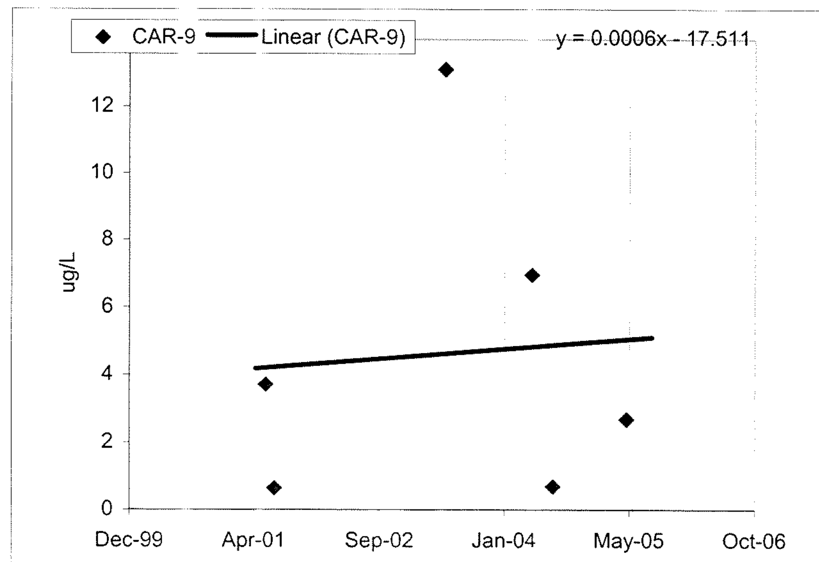

CAR-2-10
mg/L
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06

Atrazine


CAR-1-0
Linear (CAR-1-0)
y = -0.001x + 38.322
ug/L
12
10
8
6
4
2
0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


CAR-2-0
Linear (CAR-2-0)
y = -0.0017x + 65.305
ug/L
12
10
8
6
4
2
0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


CAR-4-0
Linear (CAR-4-0)
y = -0.0004x + 17.686
ug/L
12
10
8
6
4
2
0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06


CAR-9
Linear (CAR-9)
y = 0.0006x - 17.511
ug/L
12
10
8
6
4
2
0
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06