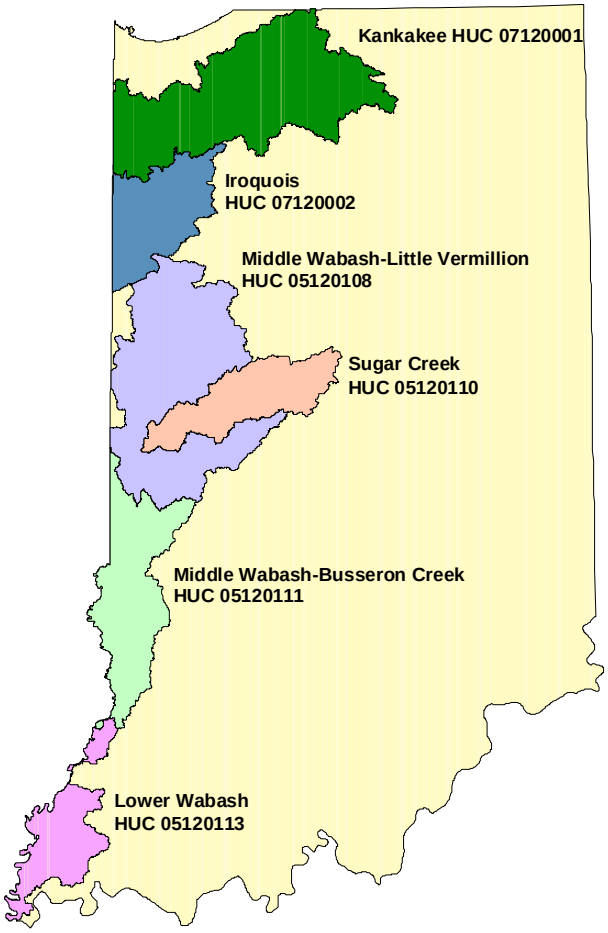
1999 Watershed Monitoring Program Study of the Kankakee River and Lower Wabash River Basins



Indiana Department of Environmental Management
Office of Water Quality
Assessment Branch
Surveys Section
IDEM 032/02/033/2001
June 2001

1999 Watershed Monitoring Program Study of the Kankakee River and Lower Wabash River Basins

By

Carl C. Christensen
Environmental Manager

Geographical Information Systems
Jim Butler
Environmental Scientist

Compilation and development of the final report was the primary responsibility of the Surveys Section
Arthur C. Garceau, Surveys Section Chief

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Christensen C. 2001. *1999 Watershed Monitoring Program Study of the Kankakee River and Lower Wabash River Basins*. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Surveys Section, Indianapolis, Indiana.
IDEM 032/02/033/2001

Executive Summary

In 1999, the Surveys Section, Assessment Branch, Office of Water Quality (formerly Office of Water Management), sampled 71 sites in the Kankakee River Basin and 72 sites in the Lower Wabash River Basin. These sites were probabilistically selected by the USEPA's

USEPA National Health and Environmental Effects Research Laboratory (NHEERL),

assessing the entire study basin.

through August, and September through October. Some sites were discontinued due to

measurements and water samples analyzed for a battery of parameters including anions,

also monitored to evaluate how overall discharge levels fluctuated and if $7Q_{10}$ conditions occurred.

The data were evaluated using several different methodologies. The data were compared over time, season to season, and over geographic area, basin to basin. A classification metric was created to determine the high, upper ambient, ambient, lower ambient, and low ranges for the Kankakee River Basin and the Lower Wabash River Basin. The median observations for fifteen parameters at each location were characterized using this metric and plotted onto GIS maps. The data were evaluated to determine surface water quality violations. Summary statistics were also computed for the two study basins.

An examination of the stream discharge data determined that basin-wide stream discharges were below mean historical discharges during most of the sampling period. The USGS gage on the Kankakee River at Shelby dropped below the $7Q_{10}$ for 20 days in September. The overall below average stream discharge was a result of drought conditions which prevailed during 1999.

Seasonal examination of twelve water quality parameters over time in each of the two study basins determined:

- There was an overall decrease of TKN, nitrate + nitrite, total phosphorus, and total suspended solids in the Kankakee River Basin and an overall decrease of nitrate + nitrite in the Lower Wabash River Basin.
- There was an overall increase of alkalinity, COD, hardness, and total dissolved solids in both the Kankakee River and Lower Wabash River Basins.

Examination of twelve water quality parameters comparing the Kankakee River Basin to the Lower Wabash River Basin determined:

- COD, hardness, total dissolved solids, total solids, sulfate, and TOC were higher in the Kankakee River Basin compared to the Lower Wabash River Basin.
- Total phosphorus was higher in the Lower Wabash River Basin compared to the Kankakee River Basin.

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Acknowledgements

The author would like to acknowledge Sherry L. Martin, Environmental Scientist, Assessment Branch, Biological Studies Section, Office of Water Quality for her contribution to the stream discharge analysis and the editing of this report.

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INTRODUCTION

In 1996, the Assessment Branch, Office of Water Quality, began a five year rotating basin approach to study and assess the waters of the state of Indiana. During each year, roughly one-fifth of the state is assessed using a variety of sampling programs. The fourth year of the program assessed the waters in the Lower Wabash River Basin and the Kankakee River Basin.

In 1999, the Surveys Section, Assessment Branch, Office of Water Quality, conducted a surface water quality study known as the Watershed Monitoring Program in the Kankakee River and Lower Wabash River Basins. The goal of this program was to collect a data set from May through October which would accurately represent the ambient surface water quality of the Kankakee River and Lower Wabash River Basins and support federally mandated programs such as the Federal 305(b) report and subsequent listing of 303(d) impaired surface waterbodies. To accomplish this, the Watershed Monitoring Program worked collaboratively with the United States Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP) through the staff of the USEPA National Health and Environmental Effects Research Laboratory (NHEERL), Corvallis, Oregon. The USEPA generated randomly selected stream sampling locations which were designed to be representative of the study basins but not biased to anthropogenic features such as towns, farms, bridges, or roads.

Materials and Methods

PROGRAM DESIGN AND SAMPLING METHODS

The probabilistic monitoring program was designed to use the statistically-based approach for site selection developed by the USEPA EMAP (Stevens, 1997). This approach uses a probability-based model to generate a statistically representative group of sampling locations which are used to characterize the condition of a resource. To ensure adequate representation, the site selection draw was stratified by stream order. Sites were drawn in each basin at a ratio of 25% 1st, 2nd, 3rd, and 4th and higher order streams.

The northern portion of the sampling area was the Kankakee River Basin. The Kankakee River Basin is comprised of two 8 digit hydrologic units, the Kankakee River Watershed, 07120001, and the Iroquois River Watershed, 07120002. These watersheds drain about 2,989 square miles in northwestern Indiana, roughly 8 percent of the total land area of Indiana. About 90% of the land is dominated by agriculture and artificial drainage networks, with small percentages of forest and urban areas. Although there are approximately 1200 miles of stream within the basin, only about 16 miles remain in their natural state (IDNR, 1990).

The Lower Wabash River Basin is located south of the Kankakee River Basin and extends along the western border of Indiana. It includes five 8 digit hydrologic units. These are: the Middle Wabash River-Little Vermilion River Watershed, 05120108, the Vermilion River Watershed, 05120109, the Sugar Creek Watershed, 05120110, the Middle Wabash River-

Busseron Creek Watershed, 05120111, and the Lower Wabash River Watershed, 05120113. The Lower Wabash River Basin has a drainage area of approximately 4,736 square miles (adapted from IDNR, 1980). Approximately 84% of the basin is comprised of agricultural land, with a small percentage of coal mines (active and abandoned), forests, and urban areas (adapted from USGS, 1994). Plate 1 depicts these watersheds and their location with Indiana's boundaries. No sampling sites were drawn within the Vermilion River Watershed due to it's small geographic area inside Indiana's state boundaries.

A goal of sixty-four random sites were set for both the Kankakee River and Lower Wabash River Basins for a specific set of general chemical, nutrient, organic, and metallic analytes. When sixty-four observations are taken for a normal distributed variable the observer is 95% confident the population's average value is within one-fourth the standard deviation of the observation set's average value. Tables 1 lists the chemical and physical parameters measured at each sampling location.

The program initially had 143 approved sampling sites, with 71 in the Kankakee River Basin and 72 in the Lower Wabash River Basin. A complete list of these sites can be found in Appendix A. Most of the sampling locations were sampled three times during 1999, although some of these sites were discontinued throughout the course of the year because they became dry or inaccessible due to various factors. Sampling was divided into three distinct sampling periods. These sampling periods were: May through June, July through August, and September through October. Grab samples were taken prior to other activity in the waterbody to prevent sediments and detritus from mixing in the water. Grab samples were collected from the visual center of flow using techniques to prevent contamination from outside sources. They were then preserved in the field and stored on ice in accordance with current operating procedures (Beckman and Hall 1998). All samples were analyzed by Test America, formerly NET, Inc. in Indianapolis, Indiana. In-situ field measurements were also collected at each site using a Hydrolab™ multi-parameter water quality analysis instrument.

STREAM DISCHARGE ANALYSIS

The daily mean discharge at four United States Geological Survey (USGS) discharge stations were compiled to determine: how stream discharge compared to the average historical discharge for the period of record, how discharge varied throughout the sampling period, and if and when baseflow, $7Q_{10}$, conditions occurred. The four stations utilized were: Kankakee River at Shelby, #005518000, Iroquois River at Foresman, #05524500, Wabash River at Covington, #03336000, and Wabash River at Mount Carmel, Illinois, #03377500.

Table 1 Parameters Analyzed in Study

	PARAMETER	METHOD	REPORTING LIMIT
FIELD PARAMETERS	Dissolved Oxygen	SM 4500-OG	0.03 mg/L
	Turbidity	SM 2130	0.3 NTU
	Specific Conductance	SM 2510	3 umhos/cm
	Temperature	SM 2550	-5° Celsius
	PH	SM 4500-H	+/-0.01 SU
ANIONS AND PHYSICAL PARAMETERS	Alkalinity	310.1	10 mg/L
	Total Solids	160.3	1.0 mg/L
	Suspended Solids	160.2	4.0 mg/L
	Dissolved Solids	160.1	1.0 mg/L
	Sulfate	375.2	1.0 mg/L
	Chloride	325.2	1.0 mg/L
	Hardness	130.1	1.0 mg/L
NUTRIENTS AND ORGANIC PARAMETERS	Total Kjeldahl Nitrogen (TKN)	351.2	.05 mg/L
	Ammonia-N	350.1	.01 mg/L
	Nitrate+Nitrite-N	353.2	.01 mg/L
	Total Phosphorus	356.2	1.0 mg/L
	Total Organic Carbon (TOC)	415.1	1.0 mg/L
	Carbonaceous Oxygen Demand (COD)	410.4	3.0 mg/L
	Cyanide – Total	335.3	.005 mg/L
METAL PARAMETERS	Arsenic	206.2	4.0 ug/L
	Cadmium	213.2	1.0 ug/L
	Chromium	218.2	3.0 ug/L
	Copper	200.7	3.0 ug/L
	Lead	239.2	2.0 ug/L
	Mercury	245.1	0.2 ug/L
	Nickel	249.2	2.0 ug/L

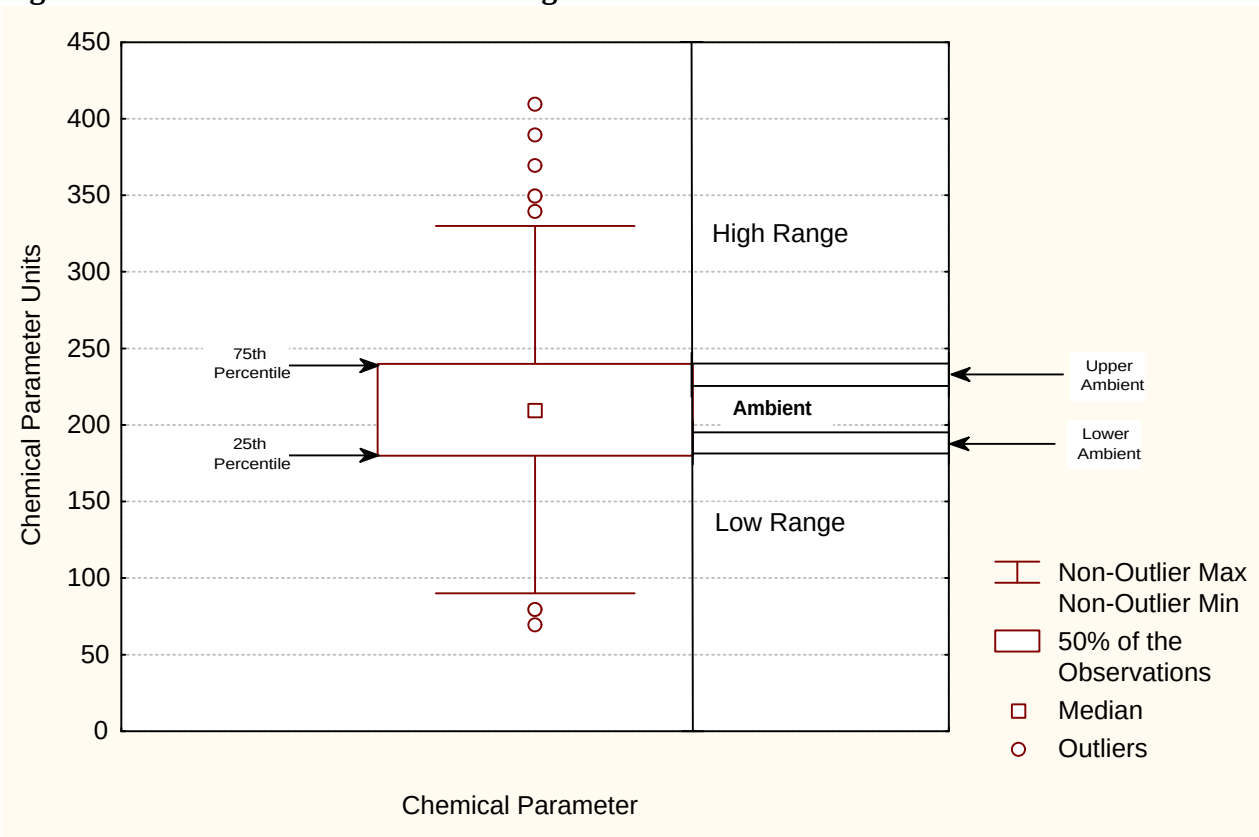
STATISTICAL ANALSYSIS

The data for fifteen of the surface water quality parameters collected during the three sampling events were compiled to create a classification metric. These parameters were: alkalinity, COD, chloride, copper, hardness, ammonia, nitrate + nitrite, TKN, total phosphorus, total dissolved solids, total suspended solids, total solids, sulfate, TOC, and zinc. Other parameters were measured, but more than 50% of their observations were below the reporting limit. Since the 50th percentile was a crucial component in creating the metric ranges, these additional parameters were not used in the development of the final metric.

The metric was composed of five different classifications based on a standard box and whisker plot using the quartile ranges of the compiled data set. The classification ranges were

high, upper ambient, ambient, lower ambient, and low. The high classification range was defined as any observation above the 75th percentile of the compiled data set. The ambient classification range was divided into three sections. The upper ambient range was composed of the values greater than half the distance from the median to and including the 75th percentile. The ambient classification range consisted of the values that were between half the distance from the median to both the 75th and 25th percentiles. The lower ambient range was composed of the values less than half the distance from the median to and including the 25th percentile. The low classification range was composed of values less than the 25th percentile. Figure 1 illustrates how the quartiles were used to delineate these classifications.

Figure 1 Classification Metric and Ranges



This metric was used to assign the sampling points a classification for each of the fifteen chemical parameters. This was accomplished by comparing the median observation of a parameter at a site to the classification metric for that specific parameter. These classifications were then plotted onto GIS maps to illustrate the character of an individual sampling point.

The observations for this study were gathered both over space and time. The data were compared by basin and by sampling period to determine how the basins were different from each other and how the water chemistry changed as the year progressed. The primary method for doing this was Mann-Whitney U-Tests and visual observations of box-whisker plots of the data for the various parameters.

In order to summarize the Lower Wabash River Basin and Kankakee River Basin, summary statistics were calculated for each basin to determine shape, spread, and central tendency of the chemical and field analytes. The summary statistics are listed in Appendix B. The data were also compared to the state of Indiana's surface water quality standards. A summary of the sites and violations can be found in Appendix C.

Results and Discussion

STREAMFLOW CONDITIONS

Discharge records collected, in cubic feet per second (cfs), at four USGS gage stations were used to evaluate stream flow conditions within the study basins. This data will be used to correlate information collected during future studies. These index stations were the Kankakee River at Shelby (USGS #05518000), the Iroquois River near Foresman (USGS #05524500), the Wabash River at Covington (USGS #03336000), and the Wabash River at Mount Carmel (USGS #03377500). They were chosen for their spatial representation through the study area and are shown in Figure 2. Maximum and minimum flow values, as well as the $7Q_{10}$ flow value for each of the stations are presented in Table 2.

Daily average discharges between April and October 1999 were compared to historical daily average discharges at each particular station. To determine the applicability of water quality standards, flow measurements were also compared to the lowest average flow over seven consecutive days with a probable recurrence interval of ten years ($7Q_{10}$). In accordance with the Indiana Environmental Rules Title 327 IAC 2-1-5, Water quality standards: exception to applicability, "All surface water quality standards… will cease to be applicable when the stream flows are less than the average minimum seven (7) consecutive day low flow which occurs once in ten (10) years."

Figure 2 USGS Gage Locations Monitored during 1999

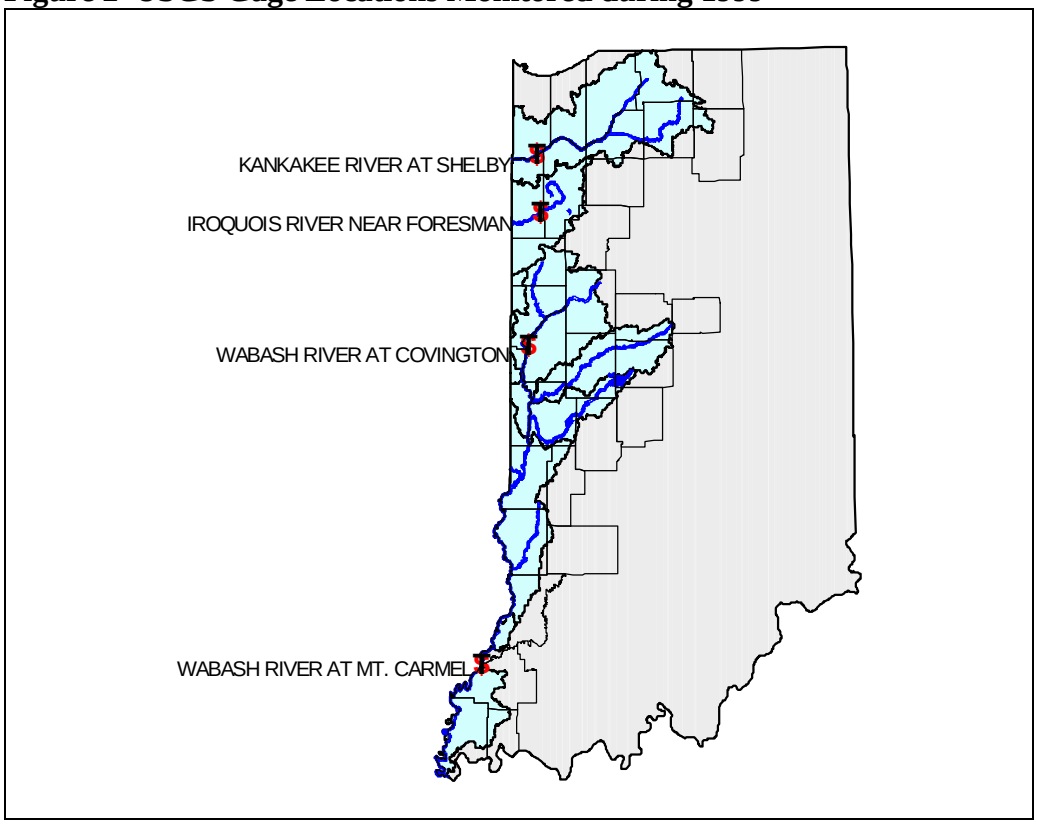
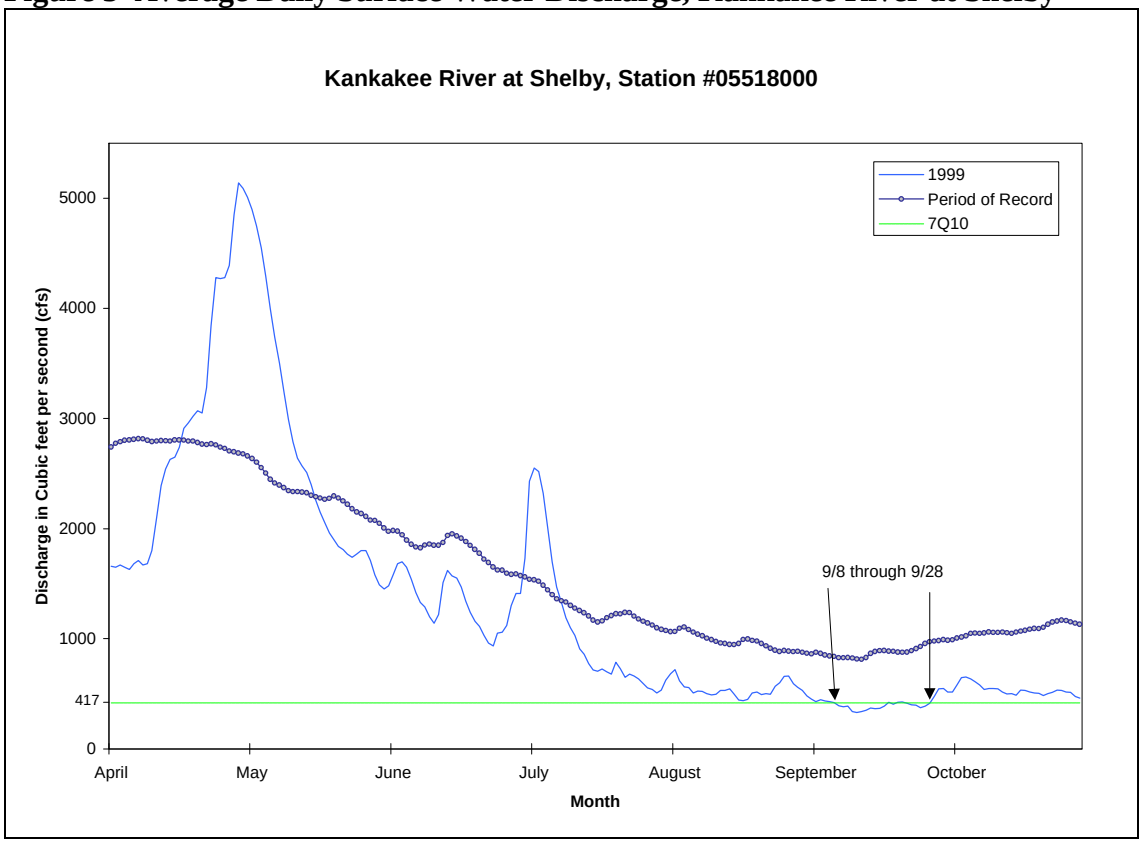


Table 2 USGS Stations and Discharge Statistics

USGS STATION ID	DRAINAGE (MI^2)	PERIOD OF RECORD	MAXIMUM FLOW (CFS)	MINIMUM FLOW (CFS)	$7Q_{10}$ (CFS)
Kankakee at Shelby	1,779	1922-current	5,140 (Apr. 29)	330 (Sept. 12)	417
Iroquois near Foresman	449	1949-current	1,530 (Apr. 18)	16 (Sept. 27 & 28)	11
Wabash at Covington	8,218	1939-current	29,000 (Apr. 19)	1,060 (Sept. 12)	1040
Wabash at Mt. Carmel	28,635	1927-current	61,600 (Apr. 30)	2,880 (Sept. 16)	2420

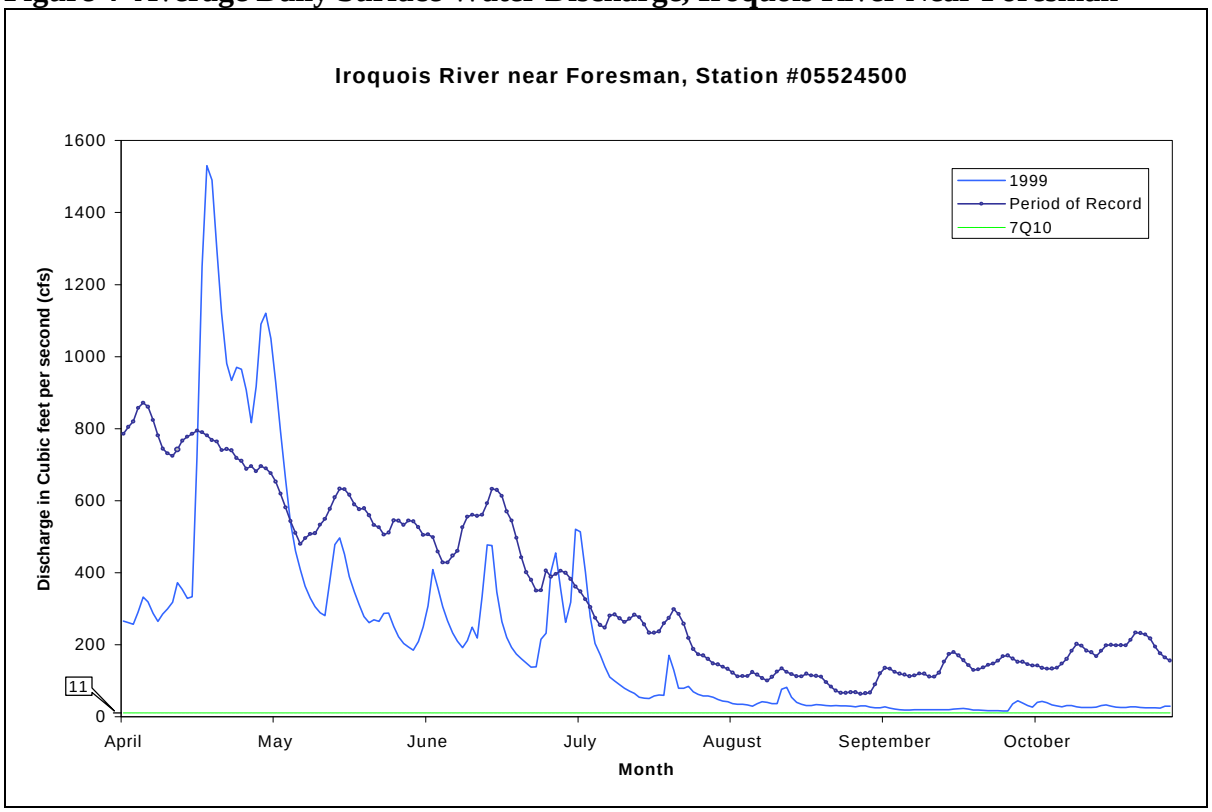
The index station on the Kankakee River at Shelby is located in Lake County and represents the discharge of the Kankakee River Watershed. Average daily discharges were lower than the average daily discharges for the period of record, with the exception of increased flows at the end of April and the beginning of July (Figure 3). The flow dropped below the $7Q_{10}$ for twenty days, from September 8 through September 28 (Table 2).

Figure 3 Average Daily Surface Water Discharge, Kankakee River at Shelby



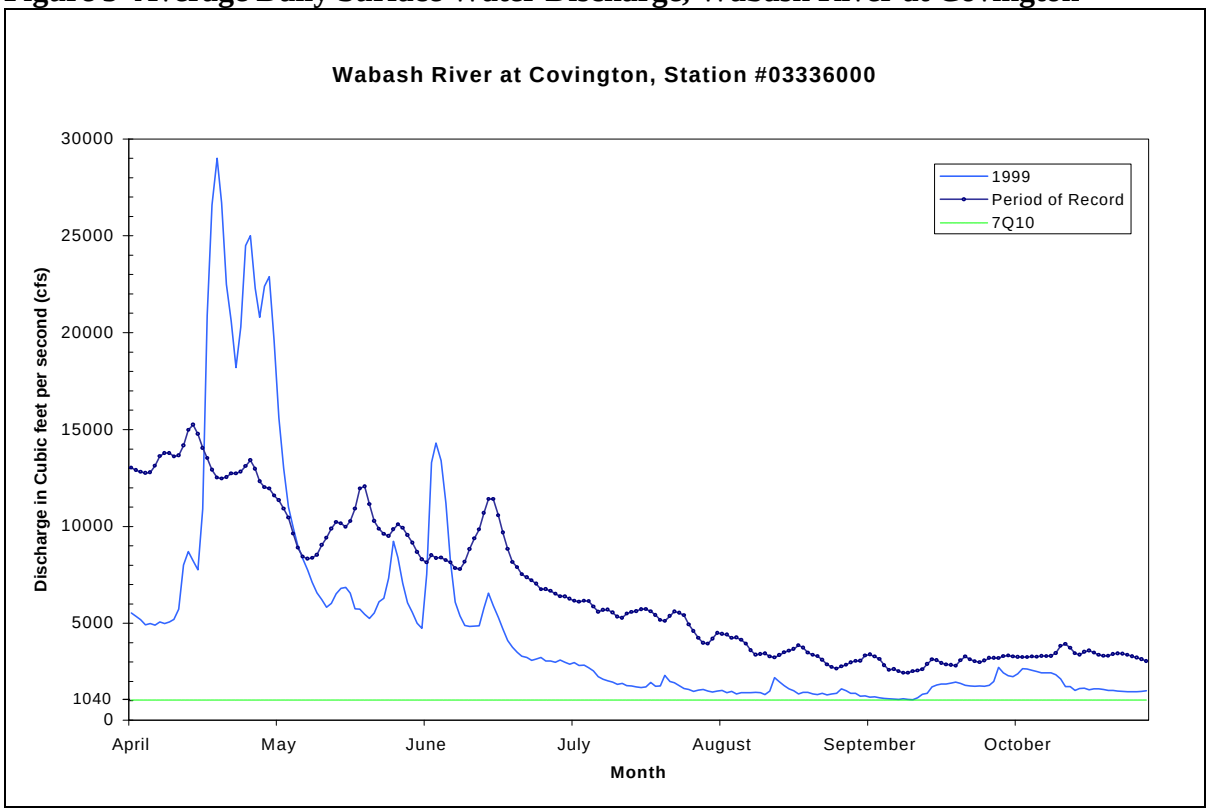
The Iroquois River near the Foresman index station is located in Newton County and represents the discharge of the Iroquois River Watershed. Average daily discharges during the study period were lower than normal (historical average daily discharges), with the exception of increased flows at the end of April and the beginning of July (Figure 4). The flow did not drop below the $7Q_{10}$ during the study period (Table 2).

Figure 4 Average Daily Surface Water Discharge, Iroquois River Near Foresman



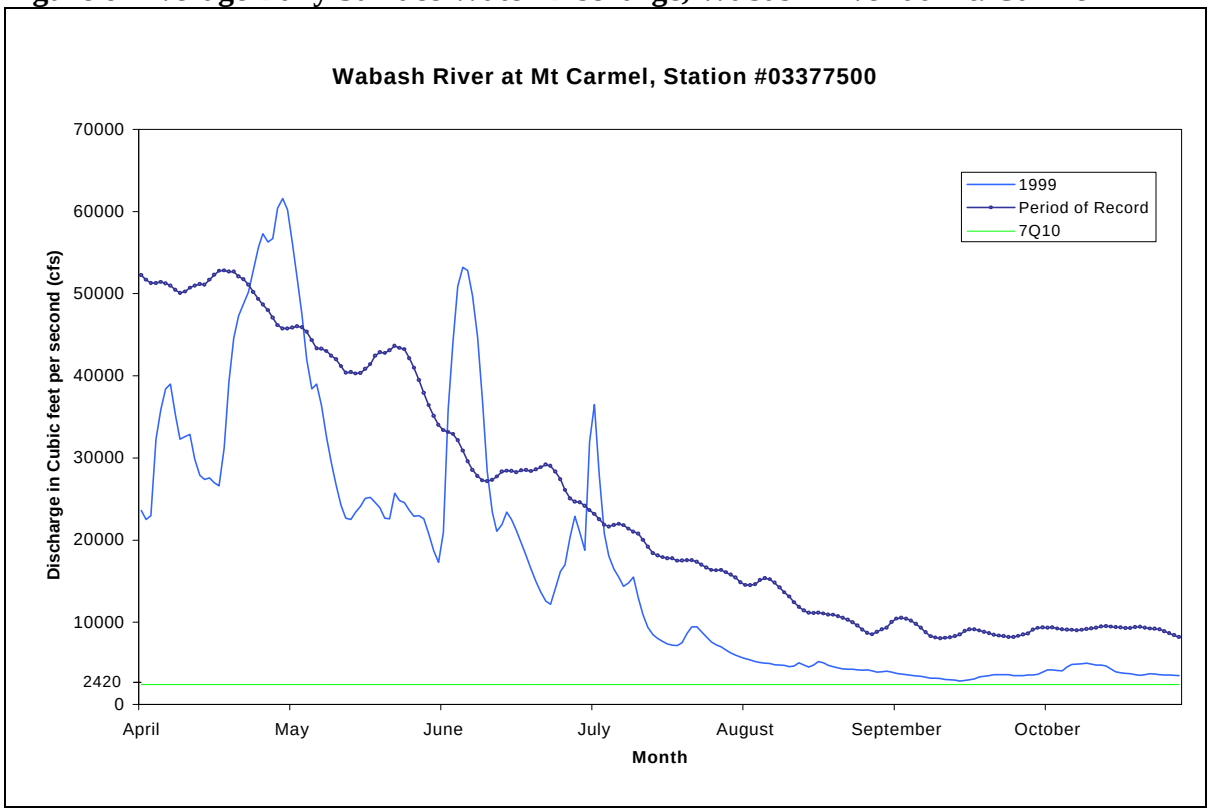
The Wabash River at the Covington index station is located in Warren County and represents the discharge of the northern portion of the Lower Wabash Basin. Average daily discharges during the study period were lower than normal, with the exception of high flow events at the end of April and the beginning of June (Figure 5). Above average discharges were sustained for 19 days, from April 17 through May 5. Stream flow then dropped below normal until a brief increase again in early June. The flow did not drop below the $7Q_{10}$ during the study period (Table 2).

Figure 5 Average Daily Surface Water Discharge, Wabash River at Covington



The Wabash River at Mount Carmel, located in Wabash County, Illinois, represents the discharge of the southern portion of the Lower Wabash Basin. Average daily discharges during the study period were lower than normal, with the exception of high flow events at the end of April, the beginning of June, and beginning of July (Figure 6). Above average stream discharges were sustained for 11 days (April 24 through May 4) and 9 days (June 3 through June 11). Flow rate briefly increased above normal in early July as well. The average discharge rate at this station remained above the $7Q_{10}$ during the entire study period (Table 2).

Figure 6 Average Daily Surface Water Discharge, Wabash River at Mt. Carmel



All of the index stations recorded high discharge rates at the end of April. The Kankakee and Iroquois River Watersheds experienced high flow rates during early July where as the two stations in the Lower Wabash had above normal flows in early June. The Wabash River at Mount Carmel index station also had high flows at the beginning of July. Overall, drought conditions prevailed throughout the study causing below normal surface water discharges.

SEASONAL VARIATION IN WATER CHEMISTRY

Mann Whitney U-Tests were done on 12 water chemistry parameters to statistically compare the sampling periods to each other. The parameters tested were: alkalinity, Carbonaceous Oxygen Demand (COD), chloride, hardness, nitrate + nitrite, total Kjeldahl nitrogen (TKN), total phosphorus, total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), sulfate, and total organic carbon (TOC). Statistical comparisons were not done on parameters that had more than 25% of the observations below the reporting limit because the Mann-Whitney U-Test loses validity when a significant portion of the observations are censored data. Visual interpretation of box-whisker plots were then used to determine if the changes were increases or decreases from sampling event to sampling event.

The hypothesis for the Mann Whitney U-Test can be expressed as:

H_o: Sampling Event A = Sampling Event B
and
H_a: Sampling Event A Sampling Event B.

The Mann Whitney U-Test generates a p-value. If the p-value is less than 0.05, the null hypothesis is rejected and the alternate hypothesis is concluded.

The results of the Mann Whitney U-Test and the visual interpretation of box-whisker plots are listed below for both basins in Tables 3 and 4. All of these box-whisker plots are illustrated in Appendix D.

Table 3 Statistical Water Chemistry Changes In The Kankakee River Basin

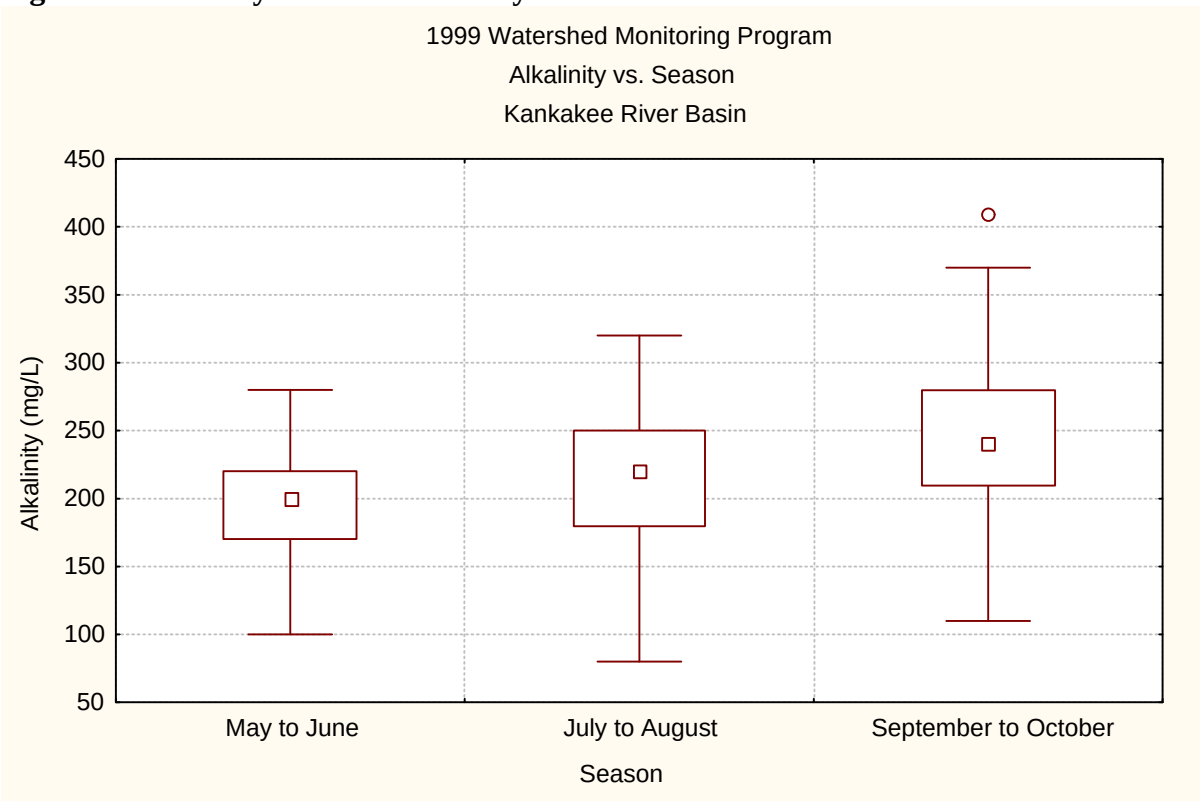
PARAMETER	MAY TO JUNE VS. JULY TO AUGUST	JULY TO AUGUST VS. SEPTEMBER TO OCTOBER	MAY TO JUNE VS. SEPTEMBER TO OCTOBER
Alkalinity	Increase, p=0.14	Increase, p=0.00	Increase, p=0.00
Chloride	No Change	No Change	No Change
COD	No Change	Increase, p=0.00	Increase, p=0.00
Hardness	Increase, p=0.00	No Change	Increase, p=0.00
Nitrate + Nitrite	Decrease, p=0.00	Decrease, p=0.01	Decrease, p=0.00
TKN	No Change	Decrease, p=0.00	Decrease, p=0.00
Total Phosphorus	Decrease, p=0.00	No Change	Decrease, p=0.01
Total Dissolved Solids	Increase, p=0.00	No Change	Increase, p=0.03
Total Suspended Solids	No Change	Decrease, p=0.00	Decrease, p=0.03
Total Solids	No Change	Decrease, p=0.02	No Change
Sulfate	No Change	No Change	No Change
Total Organic Carbon	No Change	Decrease, p=0.04	No Change

Table 4 Statistical Water Chemistry Changes in the Lower Wabash River Basin

PARAMETER	MAY TO JUNE VS. JULY TO AUGUST	JULY TO AUGUST VS. SEPTEMBER TO OCTOBER	MAY TO JUNE VS. SEPTEMBER TO OCTOBER
Alkalinity	No Change	Increase, p=0.00	Increase, p=0.00
Chloride	No Change	No Change	No Change
COD	Increase,p=0.02	No Change	Increase,p=0.00
Hardness	Increase, p=0.00	No Change	Increase, p=0.00
Nitrate + Nitrite	Decrease, p=0.00	No Change	Decrease, p=0.00
TKN	Increase, p=0.00	Decrease, p=0.00	No Change
Total Phosphorus	No Change	No Change	No Change
Total Dissolved Solids	No Change	No Change	Increase, p=0.04
Total Suspended Solids	Increase, p=0.04	Decrease, p=0.00	No Change
Total Solids	No Change	No Change	No Change
Sulfate	No Change	No Change	No Change
Total Organic Carbon	Increase, p=0.00	No Change	No Change

In some cases, changes were obvious by both visual interpretation of box-whisker plots, and the low p-values of the Mann Whitney U-test. For example, Figure 7 shows the alkalinity observations for the Kankakee River Basin. A steady increase in alkalinity over time is visably noticeable from the box-whisker plot. The Mann Whitney U-test was also very conclusive with all p-values of less than 0.02.

Figure 7 Alkalinity Concentrations by Season



Four of the parameters in the Kankakee River Basin, alkalinity, hardness, TDS, and COD were higher when comparing the September through October sampling period to the May through June sampling period. The alkalinity, hardness, and TDS increases from the beginning to the end of the study period were probably due to the higher relative percentage of groundwater in the stream due to the lack of dilution from rainwater and surface water inputs.

In agricultural areas, fertilizer application occurs mainly during the spring months. The decrease of observed nutrients; total phosphorus, TKN, and nitrate + nitrite in the Kankakee River Basin were probably due to both an initial application of fertilizers prior to and during the intital sampling period, and a general decrease in surface water runoff as the study progressed from sampling period to sampling period. Of these three nutrients, only nitrate + nitrite was observed to decrease in the Lower Wabash River Basin.

Alkalinity, hardness, TDS, and COD in the Lower Wabash River Basin were also higher when comparing September through October to May through June concentrations. The increases in concentrations of alkalinity, hardness and TDS are also probably due to the prevalence of groundwater as surface and rainwater inputs decreased throughout the year (Todd, 1980)

COMPARISON OF BASINS

The basins were compared to each other by the same two methodologies used with the seasonal data; the Mann-Whitney U-Test and visual interpretation of box-whisker plots. The large number of observations for each basin allow for strong statistical comparisons to be made. Twelve parameters were used to compare the two basins. These were: alkalinity, chloride, COD, hardness, nitrate + nitrite, TKN, total phosphorus, total dissolved solids, total suspended solids, total solids, sulfate, and TOC. Other parameters had more than 25% of their observations below the reporting limit, making the Mann-Whitney U-Test inappropriate.

The hypothesis for the Mann Whitney U-Test can be expressed for a given parameter as:

H_o: Kankakee River Basin = Lower Wabash River Basin
and
H_a: Kankakee River Basin Lower Wabash River Basin.

In the same manner as the comparison of the sampling periods, if the p value is less than 0.05, the null hypothesis is rejected and the alternate hypothesis is concluded. The results where statistical differences between the basins were concluded are listed in Table 5.

Table 5 Statistically Different Parameters in the 1999 Study Area.

PARAMETER	HIGHER BASIN	LOWER BASIN
COD, p=0.00	Kankakee	Lower Wabash
Hardness, p=0.00	Kankakee	Lower Wabash
Total Phosphorus, p=0.01	Lower Wabash	Kankakee
Total Dissolved Solids, p=0.00	Kankakee	Lower Wabash
Total Solids, p=0.00	Kankakee	Lower Wabash
Sulfate, p=0.00	Kankakee	Lower Wabash
TOC, p=0.00	Kankakee	Lower Wabash

Of the twelve parameters tested by basin, seven were different. The Kankakee River Basin had higher concentrations for six of the seven parameters. These were: COD, hardness, TDS, TS, sulfate, TOC. Total phosphorus was higher in the Lower Wabash River Basin compared to the Kankakee River Basin.

CLASSIFICATION METRICS AND APPLICATION

The data were compiled and used to create classification metrics for fifteen parameters. The following tables list the classification metrics for the Kankakee River Basin and the Lower Wabash River Basin.

Graphic representation of the sampling sites and how they were classified for the water quality parameters creates a picture of the character of the water. Plates 2 through 31 show the sampling locations, land use in the watersheds, and how the classification metrics characterized the site for the various parameters. Because comparisons of one site to the next are not true statistical tests, differences of only one classification metric, or differences within the ambient classification range should be considered minor, i.e., a high classification compared to an upper ambient, or an upper ambient compared to a lower ambient. Because of the large number of sites, and the local affects that riparian land use have that are not projected onto GIS maps, discussion of all of the sites sampled during 1999 would be lengthy and vague. It can be generalized that most of the sites are largely influenced by agricultural land use, although the reasons why a particular site was much higher or lower for a given parameter than another cannot usually be explained because specific activities present or absent affect the water quality.

The metric created by this report is a useful tool. A sample taken by other programs, agencies, or individuals can be compared to the metric created by this report. This comparison would indicate how the character of any given sample compares to the overall water quality in the respective basin.

Table 6 Kankakee River Basin Classification Metrics

PARAMETER	HIGH	UPPER AMBIENT	AMBIENT	LOWER AMBIENT	LOW
Alkalinity (mg/L)	> 250	250-236	235-200	199-180	< 180
COD (mg/L)	> 22.0	22-19.6	19.5-14.5	14.4-12.0	< 12.0
Chloride (mg/L)	> 42.0	42.0-34.1	34-24	23.9-22.0	< 22
Copper (ug/L)	> 6.0	6.0-3.0	Below Reporting Limit	N/A	N/A
Hardness (mg/L)	> 400	400-366	365-305	304-280	< 280
Ammonia (mg/L as N)	> 0.15	0.15-0.10	Below Reporting Limit	N/A	N/A
Nitrate + Nitrite (mg/L as N)	> 2.80	2.8-1.83	1.82-0.56	0.55-0.27	< 0.27
TKN (mg/L as N)	> 0.96	0.96-0.80	0.79-0.46	0.45-0.29	< 0.29
Total Phosphorus (mg/L as P)	> 0.16	0.16-0.13	0.12-.067	0.066-0.048	< 0.048
Total Dissolved Solids (mg/L)	> 530	530-481	480-405	404-380	< 380
Total Suspended Solids (mg/L)	> 23	23-18	17-9	8-6	< 6
Total Solids (mg/L)	> 590	590-551	550-475	474-440	< 440
Sulfate (mg/L)	> 99	99-86	85-63	62-53	< 53
TOC (mg/L)	> 6.2	6.2-5.4	5.3-3.7	3.6-2.9	< 2.9
Zinc (ug/L)	> 28.0	28.0-21.6	21.5-10.2	10.1 Below Reporting Limit	N/A

Table 7 Lower Wabash River Basin Classification Metrics

PARAMETER	HIGH	UPPER AMBIENT	AMBIENT	LOWER AMBIENT	LOW
Alkalinity (mg/L)	> 240	240-226	225-190	189-170	< 170
COD (mg/L)	> 24.0	24-18.8	18.7-10.7	10.6-7.8	< 7.8
Chloride (mg/L)	> 46.0	46.0-37.6	37.5-11.5	11.4-21.0	< 21.0
Copper (ug/L)	> 5.6	5.6-3.7	3.6-3.0	Below Reporting Limit	N/A
Hardness (mg/L)	> 350	350-326	325-280	279-260	< 260
Ammonia (mg/L as N)	> 0.17	0.17-0.12	0.11-0.10	Below Reporting Limit	N/A
Nitrate + Nitrite (mg/L as N)	> 4.00	4.00-2.60	2.50-0.58	0.57-0.16	< 0.16
TKN (mg/L as N)	> 1.30	1.3-0.92	0.91-0.36	0.35-0.20	< 0.20
Total Phosphorus (mg/L as P)	> 0.20	0.20-0.16	0.15-0.08	0.07-0.06	< 0.06
Total Dissolved Solids (mg/L)	> 470	470-431	430-375	375-360	< 360
Total Suspended Solids (mg/L)	> 35	35-24.6	24.5-9	8-5	< 5
Total Solids (mg/L)	> 530	530-486	485-415	414-390	< 390
Sulfate (mg/L)	> 61	61-54	53-39	38-33	< 33
TOC (mg/L)	> 4.8	4.8-3.9	3.8-2.5	2.4-2.1	< 2.1
Zinc (ug/L)	> 29.0	29-19.3	19.2-14.7	14.8-10.0	Below Reporting Limit

Summary

In 1999, the Surveys Section, Assessment Branch, Office of Water Quality, sampled 71 sites in the Kankakee River Basin and 72 sites in the Lower Wabash River Basin. These sites were selected in a probabilistic manner by the USEPA's Environmental Monitoring and Assessment Program. Sites selected in this manner creates a statistically valid method of assessing the entire study area. Most sites were sampled once during three sampling periods, unless they became dry or access became prohibitive. Field measurements and analytic chemical parameters were evaluated during each sampling event. Stream discharge conditions at four USGS gages were monitored throughout the sampling season.

The data were evaluated using several different methodologies. The data were compared over time, sampling period to sampling period, and over geographic area, basin to basin. A classification metric was created to determine the high, upper ambient, ambient, lower ambient, and low ranges for the Kankakee River Basin and the Lower Wabash River Basin. The median observations for these parameters at each sampling site were compared to this metric and plotted onto GIS maps. The data compiled by this study were compared to the surface water quality standards to determine water quality violations. Summary statistics were also computed for the two study basins and each watershed.

Examination of the water quality parameters over time in each of the two study basins determined:

- There was an overall decrease, from the May through June sampling period to September through October sampling period, of TKN, nitrate + nitrite, total phosphorus, and total suspended solids in the Kankakee River Basin and an overall decrease, from May through June to September through October of nitrate + nitrite in the Lower Wabash River Basin.
- There was an overall increase, from May through June sampling period to the September through October sampling period, of alkalinity, hardness, and total dissolved solids in both the Kankakee River and Lower Wabash River Basins. This was attributed to the lack of dilution from surface water runoff and the relatively greater contribution of groundwater for alkalinity, hardness and total dissolved solids.

Examination of twelve water quality parameters comparing the Kankakee River Basin to the Lower Wabash River Basin determined:

- COD, hardness, total dissolved solids, total solids, sulfate, and TOC were higher in the Kankakee River Basin compared to the Lower Wabash River Basin.
- Total phosphorus was higher in the Lower Wabash River Basin compared to the Kankakee River Basin.

Literature cited

Allan J. 1995. *Stream Ecology, Structure and Function of Running Waters*
Hall, London.

Field Procedure Manual.
Environmental Management, Office of Water Management, Assessment Branch, Surveys

Fowler K, Wilson J. 1996. : U.S. Geological

Indiana Department of Environmental Management. 1998.
Water

Indiana Department of Natural Resources. 1980.
Uses, and Needs. Governor's Water Resource Study Commission, State of Indiana, Indiana Department of Natural Resources, Division of Water, Indianapolis, Indiana.

Indiana Department of Natural Resources. 1990. *Water Resource Availability in the Kankakee River Basin, Indiana*. State of Indiana, Indiana Department of Natural Resources, Division of Water, Indianapolis, Indiana. Water Resource Assessment 90-3.

Stevens D. 1997. *Variable Density Grid-Based Sampling Designs for Continuous Spatial Populations*. Environmetrics. Vol. 8, 167-195 (1997).

Stewart J, Keeton C, Hammil L, Nguyen H, Majors D. *2000. Water Resources Data-Indiana, Water Year 1999.* USGS Water-Data Report IN-99-1.

Todd D. 1980. *Groundwater Hydrology, Second Edition*. John Wiley and Sons, New York, Chichester, Brisbane, Toronto.

USGS. 1994. *USGS Lab Use and Land Cover (LULC) Data Geospatial Data Presentation Form: Map: Sioux Falls, South Dakota.* U.S. Geological Survey.

Appendix A Sampling Sites and Locations

Corvallis Number	Site Name	Stream Name	Hydrologic Unit	County	Location
134-001		Big Raccoon Creek	05120108190020		1/2 mile downstream Mecca Covered Bridge
134-002	UMI040-0002	Hunter Ditch	07120002040090	Newton	CR 550 E
134-003	UMK070-0009	Bogus Run	07120001070050	Starke	CR 400 W
134-004	WBU150-0003	Turtle Creek	05120111150030	Sullivan	SR 58
134-005*	WLV090-0003	Jordan Creek	05120108090030	Vermilion	SR 63
134-006	WSU060-0005	Sugar Mill Creek	05120110060020	Fountain	Lutheran Church Road
134-007	UMK130-0003	Cedar Creek	07120001130070	Lake	Colfax St
134-008	UMK060-0004	Yellow River	07120001060050	Marshall	W 14 B Rd
134-009	WLV030-0004	Opossum Hollow	05120108030090	Fountain	CR 600 E
134-010*	UMI030-0001	Tributary of Claude May Ditch	07120002030070	Jasper	CR 1500 S
134-011	UMK090-0015	Crooked Creek	07120001090070	Porter	CR 300 S
134-014	UMI030-0002	Slough Creek	07120002030050	Jasper	SR 231
134-015	UMI150-0001	Beaver Creek	07120002150030	Newton	US 41
134-016	UMK020-0001	Potato Creek	07120001020050	St. Joseph	Walnut Rd
134-017	WLV050-0002	Mud Pine Creek	05120108050040	Warren	Near SR 26 and US 41
134-020	UMK060-0005	Eagle Creek	07120001060090	Starke	CR 800 E
134-021	WLV120-0001	Mill Creek	05120108120020	Fountain	Tangier Rd
134-022	UMI020-0003	Tributary of Rowan Ditch	07120002020010	Jasper	CR 1000 W
134-023	UMK050-0007	Anthony Ditch	07120001050020	St. Joseph	ELM RD
134-024***	WLW110-0001	Big Creek	05120113110160	Posey	CR 350 W
134025	WSU030-0003	Armentrout Dredge Ditch	05120110030040	Montgomery	CR 500 E
134-026	WSU020-0005	Sugar Creek	05120110020070	Montgomery	CR 800 E
134-027**	UMK120-0004	Tributary of Kankakee River	07120001120040	Newton	SR 41
134-028	UMK030-0006	Tributary of Kingsbury Creek	07120001030070	Laporte	SR 39
134-029	WLV170-0004	Big Raccoon Creek	05120108170040	Parke	Bridgeton Covered Br
134-030	WLV040-0004	Vanatta Ditch	05120108040010	White	CR 900 S
134-032*	WBU180-0001	Trib of Lower Shaker Prairie	05120111180020	Knox	CR 25 E
134-034	WSU040-0001	Walnut Fork of Sugar Creek	05120110040060	Montgomery	Cambell St

Corvallis Number	Site Name	Stream Name	Hydrologic Unit	County	Location
134-035	UMK110-0003	Williams Ditch	07120001110030	Lake	125th Av
134-036	UMK030-0007	Kankakee River	07120001030080	Laporte	CR 50 E
134-037	WLV030-0005	Little Pine Creek	05120108030080	Warren	CR 450 N
134-038	UMI030-0003	Slough Creek	07120002030020	Jasper	CR 800 S
134-039**	UMK140-0002	Bull Run	07120001140010	Lake	101ST AVE
134-041**	WLV050-0003	Tributary of Mud Pine Creek	05120108050030	Benton	CR 50 W
134-042	WBU030-0003	Otter Creek	05120111030080	Vigo	Penn Central RR
134-043	UMI020-0004	Iroquois River	07120002020060	Jasper	CR 400 W
134-044	UMK050-0008	Dausman Ditch	07120001050110	Kosciusko	D/S of SR 19
134-045	WLV090-0004	Wabash River	05120108090010	Fountain	D/S I-74
134-046	WSU020-0006	Prairie Creek	05120110020020	Boone	I 65
134-047	UMK140-0003	West Creek	07120001140030	Lake	SR 2
134-048	UMK030-0008	Kankakee River	07120001030030	Laporte	Kingsbury Public Access
134-049*	WBU010-0001	Tributary of Goose Creek	05120111010120	Vermilion	CR 700 S
134-050	UMI050-0007	Kent Ditch	07120002050060	Newton	SR 41
134-051	UMK080-0005	Kankakee River	07120001080020	Laporte	CR 650 W
134-052	WBU200-0001	Wabash River	05120111200030	Knox	Henderson Rd
134-053	WLV080-0006	Wabash River	05120108080060	Warren	SR 263
134-054**	WSU010-0003	Browns Wonder Creek	05120110010090	Boone	CR 250 E
134-055	UMI050-0008	Thompson Ditch	07120002050020	Newton	CR 800 S
134-056	UMK010-0005	Kankakee River	07120001010130	Laporte	SR 4
134-057	WLV180-0010	Little Raccoon Creek	05120108180050	Parke	CR 200 S
134-058**	WLV030-0006	Flint Creek	05120108030040	Tippecanoe	CR 600 S
134-059	UMK090-0017	Cobb Creek	07120001090150	Porter	SR 8
134-060	WLW080-0002	Wabash River	05120113080010	Posey	CR 900 N
134-061	WSU060-0006	Roaring Creek	05120110060070	Parke	SR 41
134-062	WSU030-0004	Little Potato Creek	05120110030010	Clinton	CR 300 S
134-063	UMK090-0018	Crooked Creek	07120001090090	Porter	CR 300 E

Corvallis Number	Site Name	Stream Name	Hydrologic Unit	County	Location
134-064**	WLW110-0002	Tributary of Pond Flat Ditch	05120113110010	Vanderburg	Mosquito RD
134-066	UMI040-0004	Iroquois River	07120002040070	Newton	SR 55
134-067	UMK090-0019	Crooked Creek	07120001090090	Porter	CR 700 S
134-068***	WBU040-0004	Wabash River	05120111040050	Vigo	Fairbanks Park
134-069	WLV070-0002	Wabash River	05120108070010	Fountain	SR 41
134-070	UMI030-0004	Ringeisen Ditch	07120002030020	Jasper	McCoysburg Rd (CR 175 E)
134-071	UMK130-0004	East Branch Stony Run	07120001130010	Lake	157TH AVE
134-072	UMK010-0006	Geyer Ditch	07120001010060	St. Joseph	INWOOD RD
134-073	WBU040-0005	Lost Creek	05120111040040	Vigo	SR 41
134-074**	UMI030-0005	Tributary of Carpenter Creek	07120002030070	Jasper	CR 1800 S
134-075	UMK080-0006	Kankakee River	07120001080070	Laporte	SR 421
134-077**	WLV080-0007	Tributary of Opossum Run	05120108080050	Warren	CR 600 S
134-078	UMI070-0001	Sugar Creek	07120002070020	Benton	7th St
134-081	WLV100-0003	Turkey Run	05120108100030	Fountain	CR 200 E
134-082	UMI030-0006	Keefe Ditch	07120002030030	Jasper	CR 900 S
134-083	UMK140-0004	West Creek	07120001140020	Lake	Mongoon Road
134-084	UMK020-0002	Potato Creek	07120001020040	St. Joseph	PEAR RD
134-085**	WLV160-0004	Tributary of Big Raccoon Creek	05120108160100	Putnam	CR 880 W
134-086	WLV010-0004	Burnett Creek	05120108010010	Tippecanoe	COUNTY LINE RD
134-087	UMK130-0005	Singleton Ditch	07120001130030	Lake	I 65
134-088	WBU200-0002	Smalls Creek	05120111200010	Knox	CAMP ARTHUR
134-089**	WLV060-0002	Fall Creek	05120108060020	Warren	CR 200 N
134-090**	UMI030-0007	Claude May Ditch	07120002030070	Jasper	CR 1500 S
134-091	UMK090-0021	Sievers Creek	07120001090100	Porter	CR 100 W
134-092	WBU160-0004	Busseron Creek	05120111160040	Sullivan	CR 500 E
134-093	WLV180-0011	Williams Creek	05120108180060	Parke	CR 80 E, 200 meters north CR 160 S
134-095	UMK100-0001	Wolf Creek	07120001100020	Jasper	CR 300 W
134-096	WLW060-0001	Wabash River	05120113060010	Gibson	Crawleyville Boat Ramp

Corvallis Number	Site Name	Stream Name	Hydrologic Unit	County	Location
134-098	WSU010-0004	Sugar Creek	05120110010030	Clinton	CR 500 S
134-100**	WLW110-0003	Wolf Creek	05120113110100	Posey	CR 100 E
134-101	WSU060-0008	Sugar Creek	05120110060090	Parke	CR 550 W
134-102	WSU020-0007	Wolf Creek	05120110020040	Boone	CR 500 N
134-103	UMK080-0007	Kankakee River	07120001080090	Jasper	CR 400 E
134-104	WLW050-0001	Coffee Bayou	05120113050020	Gibson	CR 1300 W
134-105	UMI070-0002	Tributary of Mud Creek	07120002070030	Benton	SR 18
134-106	WBU030-0004	Otter Creek	05120111030030	Vigo	23 E RD
134-107	UMI030-0008	Tributary of Slough Creek	07120002030050	Jasper	CR 635 W
134-108	UMK050-0009	Yellow River	07120001050140	Marshall	N Hickory Rd
134-110	UMK140-0005	West Creek	07120001140020	Lake	White Oak Av
134-111	UMK050-0010	Yellow River	07120001050080	Marshall	N Filbert Rd
134-112**	WLW110-0004	Little Creek	05120113110120	Posey	CR 575 E
134-113	UMI070-0003	Mud Creek	07120002070070	Benton	State Line
134-114	WLV180-0012	Little Raccoon Creek	05120108180020	Parke	100 m below Waveland Rd.
134-115	UMI020-0005	Iroquois River	07120002020010	Jasper	SR 14
134-116	UMK060-0006	Yellow River	07120001060060	Marshall	W 14 B Rd
134-117	WBU020-0002	Brouillets Creek	05120111020040	Vermilion	CR 00-Rangeland Rd.
134-118	UMI050-0009	Iroquois River	07120002050010	Newton	S MERIDIAN RD
134-120**	WBU150-0004	Tributary of Clear Pond Ditch	05120111150010	Sullivan	CR 900 W
134-121	WSU050-0007	Black Creek	05120110050030	Montgomery	SR 55
134-122**	WSU050-0008	Indian Creek	05120110050080	Montgomery	CR 700 S
134-123	UMK130-0006	Griesel Ditch	07120001130050	Lake	GRANT ST
134-124	UMK010-0007	Fish Creek	07120001010130	Laporte	CR 200 S
134-125	UMI050-0010	Morrison Ditch No 2	07120002050070	Newton	CR 1400 S
134-126	WSU050-0009	Sugar Creek	05120110050090	Parke	CR 740 E
134-127	UMK130-0007	Bruce Ditch	07120001130080	Lake	189 PLACE
134-129**	WLV180-0013	Tributary of Little Raccoon Cr	05120108180040	Parke	SR 236

Corvallis Number	Site Name	Stream Name	Hydrologic Unit	County	Location
134-130	WLV040-0005	Big Pine Creek	05120108040080	Benton	CR 600 S
134-131	UMK090-0022	Tributary of Cobb Creek	07120001090150	Porter	SR 231
134-134**	UMI150-0002	Narrows Ditch	07120002150020	Newton	CR 300 E
134-135	UMK050-0011	Yellow River	07120001050080	Marshall	N Grape Rd
134-136***	UMI030-0008	Wabash River	05120113130020	Posey	CR 1600 S
134-138	WBU030-0005	Otter Creek	05120111030020	Clay	14 W
134-139*	UMI030-0009	Tributary of Carpenter Creek	07120002030080	Jasper	CR 725 W
134-140	UMK060-0008	Yellow River	07120001060100	Starke	CR 300 E
134-141	WSU060-0009	Roaring Creek	05120110060070	Parke	CR 625 N
134-142	WSU030-0005	Little Potato Creek	05120110030020	Montgomery	CR 800 E
134-143	UMK090-0023	Heinold Ditch	07120001090090	Porter	CR 1050 S
134-144**	WLW110-0005	Fun Creek	05120113110150	Posey	CR 50 W
134-145	WLV030-0007	Wabash River	05120108030030	Tippecanoe	CR 700 W
134-146*	UMI040-0005	Jones Ditch	07120002040080	Newton	CR 800 S
134-147*	UMK130-0008	Griesel Ditch	07120001130050	Lake	163 D AVE
134-149	WLV090-0005	Spring Creek	05120108090020	Warren	SR 136
134-150	WSU050-0010	Keller Branch	05120110050100	Parke	CR 450 E
134-151	UMK130-0009	Cedar Creek	07120001130070	Lake	SEABOARD RR
134-154	WLV020-0001	Wea Creek	05120108020090	Tippecanoe	Lafayette STP
134-157**	WBU040-0006	Tributary of Coal Creek	05120111040010	Vigo	36 W RD
134-158	UMI030-0010	Carpenter Creek	07120002030060	Benton	CR 900 E
134-159	UMK080-0008	Kankakee River	07120001080030	Laporte	Toto Rd
134-161	WLV190-0005	Big Raccoon Creek	05120108190010	Parke	Thorpe Ford Br
134-163	UMK090-0025	Kankakee River	07120001090150	Porter	CR 625 W
134-164	WBU160-0006	Buck Creek	05120111160100	Sullivan	SR 54
134-165	WBU020-0003	Brouillets Creek	05120111020050	Vigo	SHIRLEY RD
134-166	UMI050-0011	Montgomery Ditch	07120002050070	Newton	SR 41
134-168	WLW020-0001	River Deshee	05120113020030	Knox	MOUTH

Corvallis Number		Stream Name	Hydrologic Unit		Location
134-171	UMK100-0003	Wolf Creek	07120001100020	Jasper	CR 100 W
134-172	WLW090-0001	Tributary of Black River	05120113090020	Gibson	I-65
134-176	UMK030-0010	Mill Creek	07120001030110	Laporte	SR 6

* Site became dry during the summer sampling period.
** Site became dry during the fall sampling period.
*** Site was only sampled once due to access problems.

Appendix B Summary Statistics

Lower Wabash River Basin

Parameter	n	Mean	-95% Confidence Interval	+95% Confidence Interval	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Standard Deviation
Alkalinity (mg/L)	186	209.03	201.49	216.58	210.00	70.00	390.00	170.00	240.00	2719.06	52.14
Chloride (mg/L)	186	40.66	34.40	46.92	29.00	4.90	430.00	21.00	46.00	1873.57	43.28
COD (mg/L)	186	17.66	15.40	19.93	13.50	2.50	113.00	7.80	24.00	245.11	15.66
Copper (ug/L)	186	3.98	3.48	4.48	1.50	1.50	19.00	1.50	5.60	11.83	3.44
Hardness (mg/L)	186	312.26	297.78	326.75	300.00	91.00	1000.00	260.00	350.00	10027.07	100.14
Ammonia (mg/L as N)	186	0.14	0.11	0.17	0.05	0.05	1.90	0.05	0.17	0.04	0.21
Nitrate + Nitrite (mg/L as n)	186	2.98	2.35	3.61	1.00	0.00	23.00	0.16	4.00	18.91	4.35
TKN (mg/L as N)	186	0.87	0.73	1.01	0.53	0.05	5.30	0.20	1.30	0.91	0.95
Total Phosphorus (mg/L)	186	0.18	0.15	0.21	0.11	0.01	1.60	0.06	0.20	0.05	0.23
Total Dissolved Solids (mg/L)	185	436.29	414.40	458.18	390.00	210.00	1400.00	360.00	470.00	22776.73	150.92
Total Suspended Solids (mg/L)	185	29.79	22.33	37.25	14.00	2.00	470.00	5.00	35.00	2647.03	51.45
Total Solids (mg/L)	185	484.11	460.81	507.41	440.00	220.00	1500.00	390.00	530.00	25803.68	160.64
Sulfate (mg/L)	186	62.89	52.12	73.67	45.00	2.50	700.00	33.00	61.00	5547.39	74.48
TOC (mg/L)	186	3.65	3.32	3.98	2.80	0.50	14.00	2.10	4.80	5.13	2.26
Zinc (ug/L)	186	22.54	20.03	25.05	19.50	5.00	93.00	10.00	29.00	300.49	17.33

Kankakee River Basin

Parameter	n	Mean	-95% Confidence Interval	+95% Confidence Interval	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Standard Deviation
Alkalinity (mg/L)	201	217.41	210.29	224.53	220.00	80.00	410.00	180.00	250.00	2619.27	51.18
Chloride (mg/L)	201	40.12	33.88	46.36	26.00	6.70	370.00	22.00	42.00	2014.46	44.88
COD (mg/L)	202	20.73	15.99	25.47	17.00	2.50	470.00	12.00	22.00	1168.08	34.18
Copper (ug/L)	202	3.88	3.29	4.47	1.50	1.50	30.00	1.50	6.00	17.83	4.22
Hardness (mg/L)	202	347.67	332.67	362.67	330.00	150.00	960.00	280.00	400.00	11691.57	108.13
Ammonia (mg/L as N)	202	0.14	0.09	0.18	0.05	0.05	4.30	0.05	0.15	0.10	0.32
Nitrate + Nitrite (mg/L as n)	202	4.18	1.81	6.56	0.85	0.00	230.00	0.27	2.80	292.81	17.11
TKN (mg/L as N)	202	0.74	0.64	0.84	0.63	0.05	5.80	0.29	0.96	0.53	0.72
Total Phosphorus (mg/L)	202	0.15	0.10	0.19	0.09	0.01	4.70	0.05	0.16	0.12	0.35
Total Dissolved Solids (mg/L)	197	492.69	448.89	536.49	430.00	190.00	4000.00	380.00	530.00	97182.01	311.74
Total Suspended Solids (mg/L)	197	18.26	15.24	21.28	12.00	2.00	180.00	6.00	23.00	462.06	21.50
Total Solids (mg/L)	197	554.57	509.53	599.60	510.00	240.00	4000.00	440.00	590.00	102734.12	320.52
Sulfate (mg/L)	202	94.50	75.11	113.89	72.50	2.50	1700.00	53.00	99.00	19534.86	139.77
TOC (mg/L)	202	4.88	4.51	5.25	4.40	0.90	17.00	2.90	6.20	7.03	2.65
Zinc (ug/L)	202	31.74	18.64	44.84	15.50	5.00	980.00	5.00	28.00	8912.94	94.41

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Appendix C Stream Standard Violations

Corvallis Number	Site Name	Waterbody	Date	Parameter	Level
134-002	UMI040-0002	Hunter Ditch	6/2/99	Nitrate + Nitrite	21.0 mg/L
134-002	UMI040-0002	Hunter Ditch	7/20/99	Dissolved Oxygen	3.46 mg/L
134-010	UMI030-0001	Tributary of Claude May Ditch	6/2/99	Nitrate + Nitrite	16.0 mg/L
134-017	WLV050-0002	Mud Pine Creek	6/9/99	Nitrate + Nitrite	11 mg/L
134-022	UMI020-0003	Tributary of Rowan Ditch	7/13/99	Zinc	860 ug/L
134-022	UMI020-0003	Tributary of Rowan Ditch	7/13/99	Dissolved Oxygen	0.25 mg/L
134-022	UMI020-0003	Tributary of Rowan Ditch	9/9/99	Dissolved Oxygen	0.5 mg/L
134-023	UMK050-0007	Anthony Ditch	9/1/99	Dissolved Oxygen	2.78 mg/L
134-030	WLV040-0004	Vanatta Ditch	6/1/99	Nitrate + Nitrite	12 mg/L
134-030	WLV040-0004	Vanatta Ditch	7/22/99	Dissolved Oxygen	2.84 mg/L
134-034	WSU040-0001	Walnut Fork of Sugar Creek	8/11/99	Total Dissolved Solids	760 mg/L
134-035	UMK110-0003	Williams Ditch	7/14/99	Dissolved Oxygen	1.27 mg/L
134-041	WLV050-0003	Tributary of Mud Pine Creek	6/8/99	Nitrate + Nitrite	14.0 mg/L
134-042	WBU030-0003	Otter Creek	8/9/99	Ammonia	0.27 mg/L
134-042	WBU030-0003	Otter Creek	8/9/99	pH	9.73
134-042	WBU030-0003	Otter Creek	8/9/99	Total Dissolved Solids	800 mg/L
134-042	WBU030-0003	Otter Creek	8/9/99	Sulfate	260 mg/L
134-042	WBU030-0003	Otter Creek	9/28/99	Total Dissolved Solids	820 mg/L
134-042	WBU030-0003	Otter Creek	9/28/99	Sulfate	460 mg/L
134-045	WLV090-0004	Wabash River	7/27/99	Ammonia	0.3 mg/L
134-045	WLV090-0004	Wabash River	7/27/99	pH	9.53
134-045	WLV090-0004	Wabash River	9/14/99	Ammonia	0.2 mg/L
134-045	WLV090-0004	Wabash River	9/14/99	pH	9.5
134-046	WSU020-0006	Prairie Creek	9/20/99	Total Dissolved Solids	800 mg/L
134-049	WBU010-0001	Tributary of Goose Creek	6/8/99	Nitrate + Nitrite	16.0 mg/L

Corvallis Number	Site Name	Waterbody	Date	Parameter	Level
134-050	UMI050-0007	Kent Ditch	6/2/99	Nitrate + Nitrite	16.0 mg/L
134-050	UMI050-0007	Kent Ditch	7/15/99	Zinc	980 ug/L
134-053	WLV080-0006	Wabash River	7/27/99	Ammonia	0.4 mg/L
134-053	WLV080-0006	Wabash River	7/27/99	pH	9.28
134-053	WLV080-0006	Wabash River	9/14/99	Ammonia	0.2 mg/L
134-053	WLV080-0006	Wabash River	9/14/99	pH	9.9
134-054	WSU010-0003	Browns Wonder Creek	6/8/99	Nitrate + Nitrite	15.2 mg/L
134-055	UMI050-0008	Thompson Ditch	6/2/99	Nitrate + Nitrite	12.0 mg/L
134-055	UMI050-0008	Thompson Ditch	7/19/99	Dissolved Oxygen	1.41 mg/L
134-058	WLV030-0006	Flint Creek	6/3/99	Nitrate + Nitrite	20.0 mg/L
134-058	WLV030-0006	Flint Creek	7/27/99	Dissolved Oxygen	1.29 mg/L
134-059	UMK090-0017	Cobb Creek	7/13/99	Lead	32.0 ug/L
134-062	WSU030-0004	Little Potato Creek	8/12/99	Dissolved Oxygen	3.88 mg/L
134-069	WLV070-0002	Wabash River	6/9/99	Dissolved Oxygen	3.35 mg/L
134-069	WLV070-0002	Wabash River	9/13/99	Ammonia	0.1 mg/L
134-069	WLV070-0002	Wabash River	9/13/99	pH	9.68
134-071	UMK130-0004	East Branch Stony Run	5/26/99	Total Dissolved Solids	850 mg/L
134-071	UMK130-0004	East Branch Stony Run	7/13/99	Chloride	280 mg/L
134-071	UMK130-0004	East Branch Stony Run	7/13/99	Total Dissolved Solids	1000 mg/L
134-071	UMK130-0004	East Branch Stony Run	9/15/99	Ammonia	4.3 mg/L
134-071	UMK130-0004	East Branch Stony Run	9/15/99	Chloride	370 mg/L
134-071	UMK130-0004	East Branch Stony Run	9/15/99	Total Dissolved Solids	1100 mg/L
134-073	WBU040-0005	Lost Creek	8/9/99	Total Dissolved Solids	880 mg/L
134-074	UMI030-0005	Tributary of Carpenter Creek	6/2/99	Nitrate + Nitrite	16.0 mg/L
134-075	UMK080-0006	Kankakee River	5/26/99	Dissolved Oxygen	3.39 mg/L
134-077	WLV080-0007	Tributary of Opossum Run	6/9/99	Nitrate + Nitrite	17.0 mg/L
134-078	UMI070-0001	Sugar Creek	5/25/99	Nitrate + Nitrite	11.0 mg/L

Corvallis Number	Site Name	Waterbody	Date	Parameter	Level
134-078	UMI070-0001	Sugar Creek	9/16/99	Dissolved Oxygen	3.71 mg/L
134-081	WLV100-0003	Turkey Run	9/21/99	Dissolved Oxygen	3.27 mg/L
134-082	UMI030-0006	Keefe Ditch	6/2/99	Nitrate + Nitrite	14.0 mg/L
134-083	UMK140-0004	West Creek	7/14/99	Total Dissolved Solids	830 mg/L
134-086	WLV010-0004	Burnett Creek	6/3/99	Nitrate + Nitrite	23.0 mg/L
134-087	UMK130-0005	Singleton Ditch	7/20/99	Total Dissolved Solids	790 mg/L
134-089	WLV060-0002	Fall Creek	6/9/99	Nitrate + Nitrite	13.0 mg/L
134-090	UMI030-0007	Claude May Ditch	6/2/99	Nitrate + Nitrite	15.0 mg/L
134-092	WBU160-0004	Busseron Creek	8/9/99	Sulfate	270 mg/L
134-092	WBU160-0004	Busseron Creek	9/29/99	Total Dissolved Solids	1400 mg/L
134-092	WBU160-0004	Busseron Creek	9/29/99	Sulfate	700 mg/L
134-093	WLV180-0011	Williams Creek	6/15/99	Dissolved Oxygen	2.88 mg/L
134-093	WLV180-0011	Williams Creek	8/10/99	Chloride	230 mg/L
134-093	WLV180-0011	Williams Creek	8/10/99	Nitrate + Nitrite	11 mg/L
134-093	WLV180-0011	Williams Creek	8/10/99	Total Dissolved Solids	800 mg/L
134-093	WLV180-0011	Williams Creek	9/28/99	Chloride	430 mg/L
134-093	WLV180-0011	Williams Creek	9/28/99	Nitrate + Nitrite	19 mg/L
134-093	WLV180-0011	Williams Creek	9/28/99	Total Dissolved Solids	1100 mg/L
134-098	WSU010-0004	Sugar Creek	6/8/99	pH	9.26
134-098	WSU010-0004	Sugar Creek	6/8/99	Nitrate + Nitrite	11.0 mg/L
134-100	WLW110-0003	Wolf Creek	8/11/99	pH	9.45
134-103	UMK080-0007	Kankakee River	6/2/99	Dissolved Oxygen	3.54 mg/L
134-105	UMI070-0002	Tributary of Mud Creek	5/25/99	Lead	34.0 ug/L
134-105	UMI070-0002	Tributary of Mud Creek	5/25/99	Nitrate + Nitrite	11.0 mg/L
134-106	WBU030-0004	Otter Creek	9/28/99	Sulfate	260 mg/L
134-112	WLW110-0004	Little Creek	8/3/99	pH	9.55

Corvallis Number	Site Name	Waterbody	Date	Parameter	Level
134-113	UMI070-0003	Mud Creek	5/25/99	Nitrate + Nitrite	15.0 mg/L
134-114	WLV180-0012	Little Raccoon Creek	9/22/99	Ammonia	0.24 mg/L
134-115	UMI020-0005	Iroquois River	6/2/99	pH	9.15
134-117	WBU020-0002	Brouillets Creek	6/8/99	Nitrate + Nitrite	12.0 mg/L
134-117	WBU020-0002	Brouillets Creek	7/28/99	Total Dissolved Solids	750 mg/L
134-117	WBU020-0002	Brouillets Creek	9/28/99	Total Dissolved Solids	830 mg/L
134-117	WBU020-0002	Brouillets Creek	9/28/99	Sulfate	380 mg/L
134-118	UMI050-0009	Iroquois River	6/2/99	Zinc	1600 ug/L
134-120	WBU150-0004	Tributary of Clear Pond Ditch	7/28/99	Ammonia	1.9 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	6/2/99	Dissolved Oxygen	3.8 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	6/2/99	Nitrate + Nitrite	20.0 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	7/19/99	Ammonia	0.2 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	7/19/99	Nitrate + Nitrite	64.0 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	7/19/99	Total Dissolved Solids	2100 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	7/19/99	Sulfate	950 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	9/14/99	Nitrate + Nitrite	230 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	9/14/99	Total Dissolved Solids	4000 mg/L
134-125	UMI050-0010	Morrison Ditch No 2	9/14/99	Sulfate	1700 mg/L
134-127	UMK130-0007	Bruce Ditch	7/19/99	Total Dissolved Solids	970 mg/L
134-127	UMK130-0007	Bruce Ditch	7/19/99	Chloride	310 mg/L
134-130	WLV040-0005	Big Pine Creek	6/8/99	Nitrate + Nitrite	11.0 mg/L
134-134	UMI150-0002	Narrows Ditch	5/27/99	Nitrate + Nitrite	18.0 mg/L
134-136	WLW130-0001	Wabash River	6/16/99	Lead	15.0 ug/L
134-139	UMI030-0009	Tributary of Carpenter Creek	6/1/99	Nitrate + Nitrite	12.0 mg/L
134-145	WLV030-0007	Wabash River	7/26/99	Ammonia	0.3 mg/L
134-145	WLV030-0007	Wabash River	9/21/99	pH	9.08

Corvallis Number	Site Name	Waterbody	Date	Parameter	Level
134-146	UMI040-0005	Jones Ditch	6/2/99	Nitrate + Nitrite	16.0 mg/L
134-149	WLV090-0005	Spring Creek	6/9/99	Nitrate + Nitrite	14.0 mg/L
134-149	WLV090-0005	Spring Creek	7/27/99	Ammonia	0.4 mg/L
134-150	WSU050-0010	Keller Branch	6/9/99	Dissolved Oxygen	2.6 mg/L
134-158	UMI030-0010	Carpenter Creek	5/25/99	Nitrate + Nitrite	14.0 mg/L
134-164	WBU160-0006	Buck Creek	7/28/99	Ammonia	1.0 mg/L
134-164	WBU160-0006	Buck Creek	9/28/99	Ammonia	1.4 mg/L
134-165	WBU020-0003	Brouillets Creek	7/29/99	Total Dissolved Solids	930 mg/L
134-165	WBU020-0003	Brouillets Creek	7/29/99	Sulfate	290 mg/L
134-165	WBU020-0003	Brouillets Creek	9/22/99	Total Dissolved Solids	770 mg/L
134-166	UMI050-0011	Montgomery Ditch	6/2/99	Nitrate + Nitrite	15.0 mg/L
134-166	UMI050-0011	Montgomery Ditch	7/19/99	Total Dissolved Solids	830 mg/L
134-166	UMI050-0011	Montgomery Ditch	7/19/99	Sulfate	270 mg/L
134-166	UMI050-0011	Montgomery Ditch	9/8/99	Total Dissolved Solids	930 mg/L
134-166	UMI050-0011	Montgomery Ditch	9/8/99	Sulfate	580 mg/L
134-176	UMK030-0010	Mill Creek	7/14/99	Lead	9.1 ug/L

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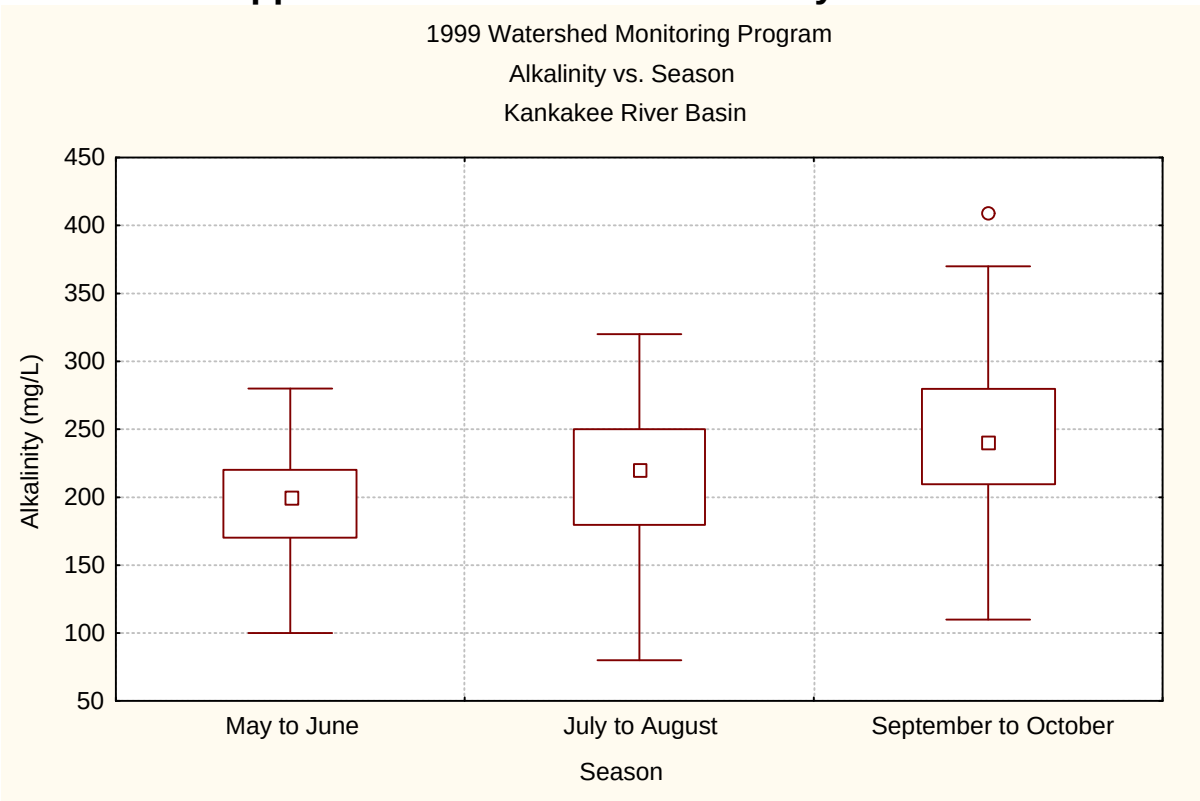
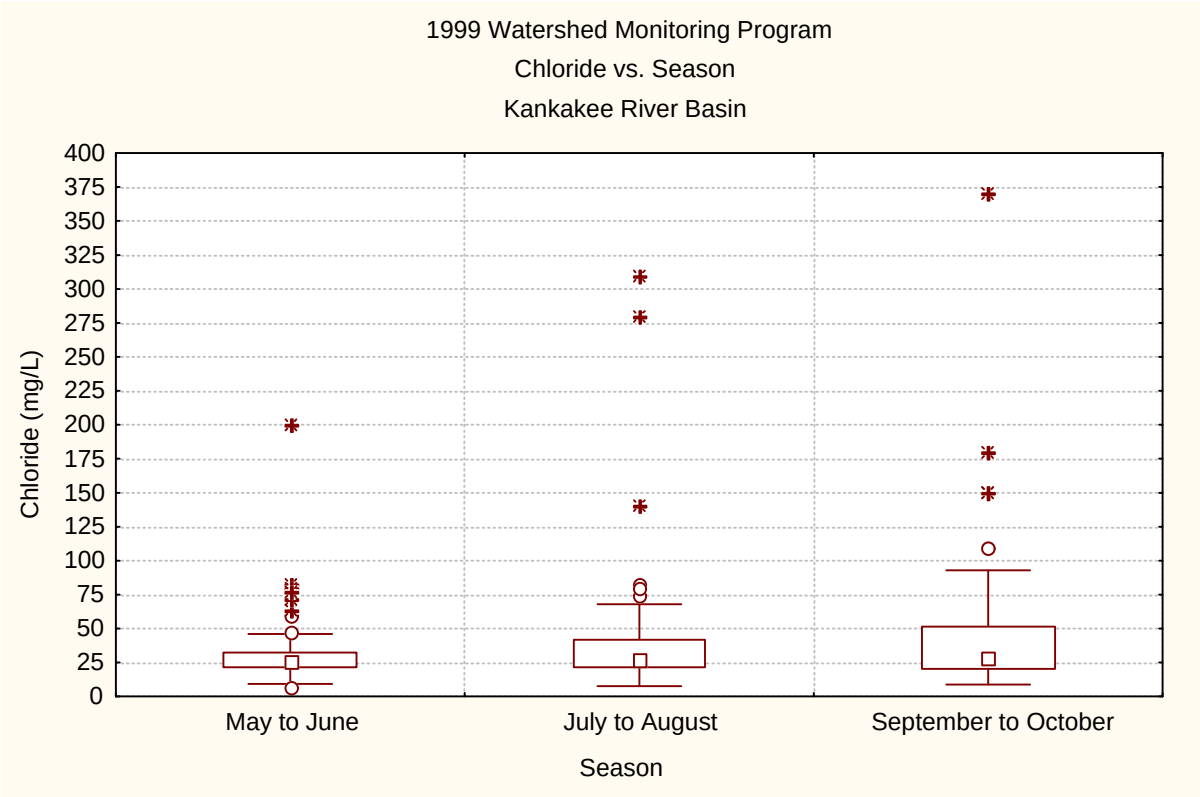
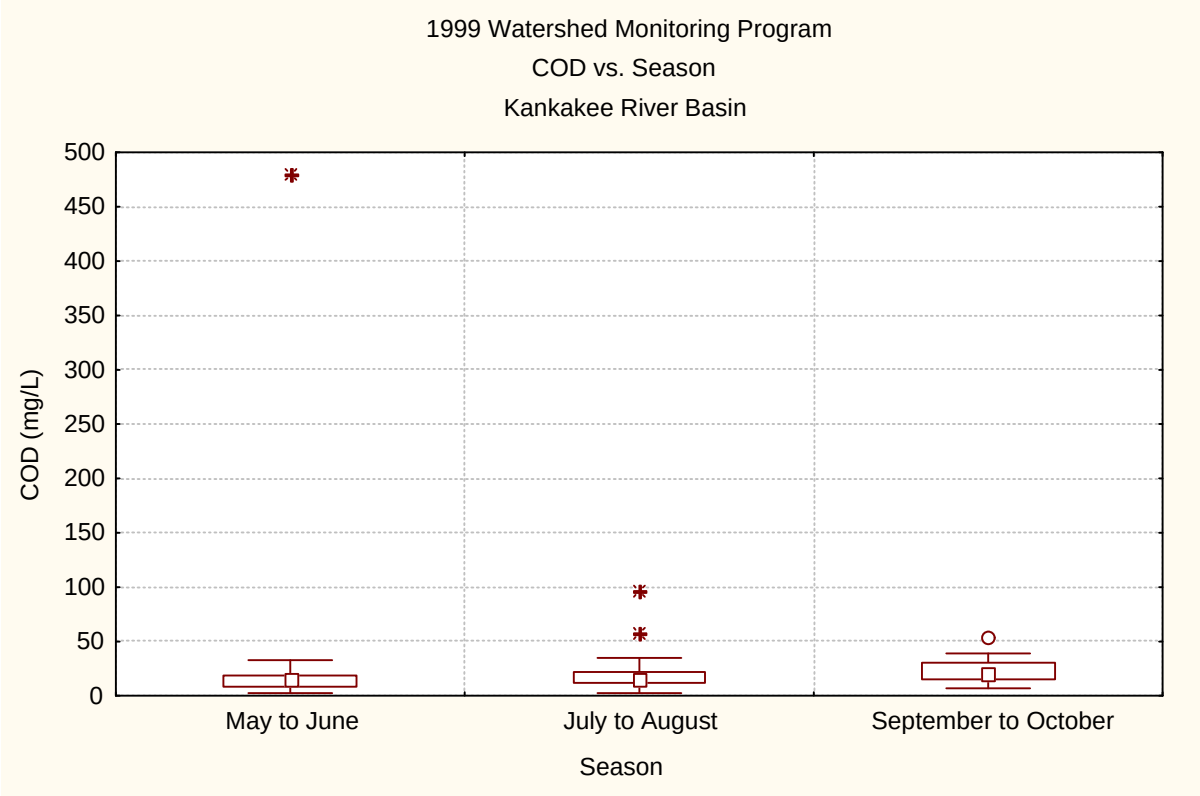
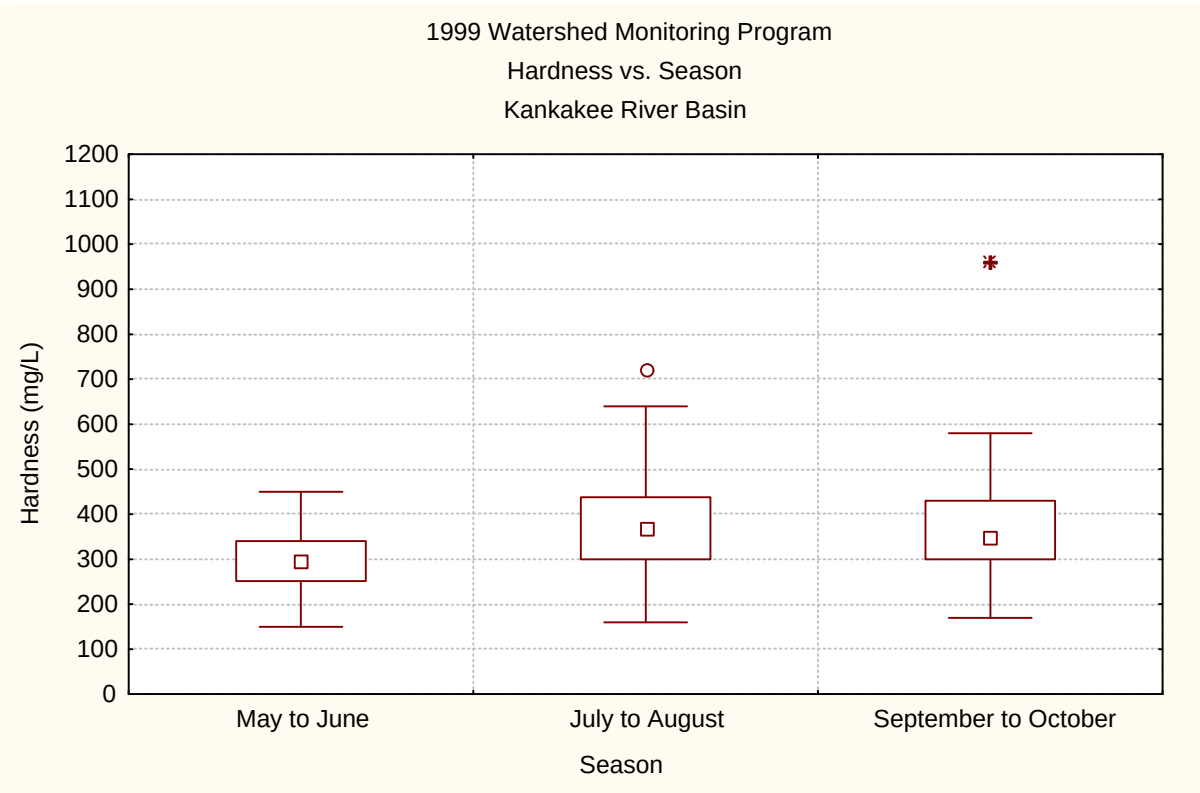
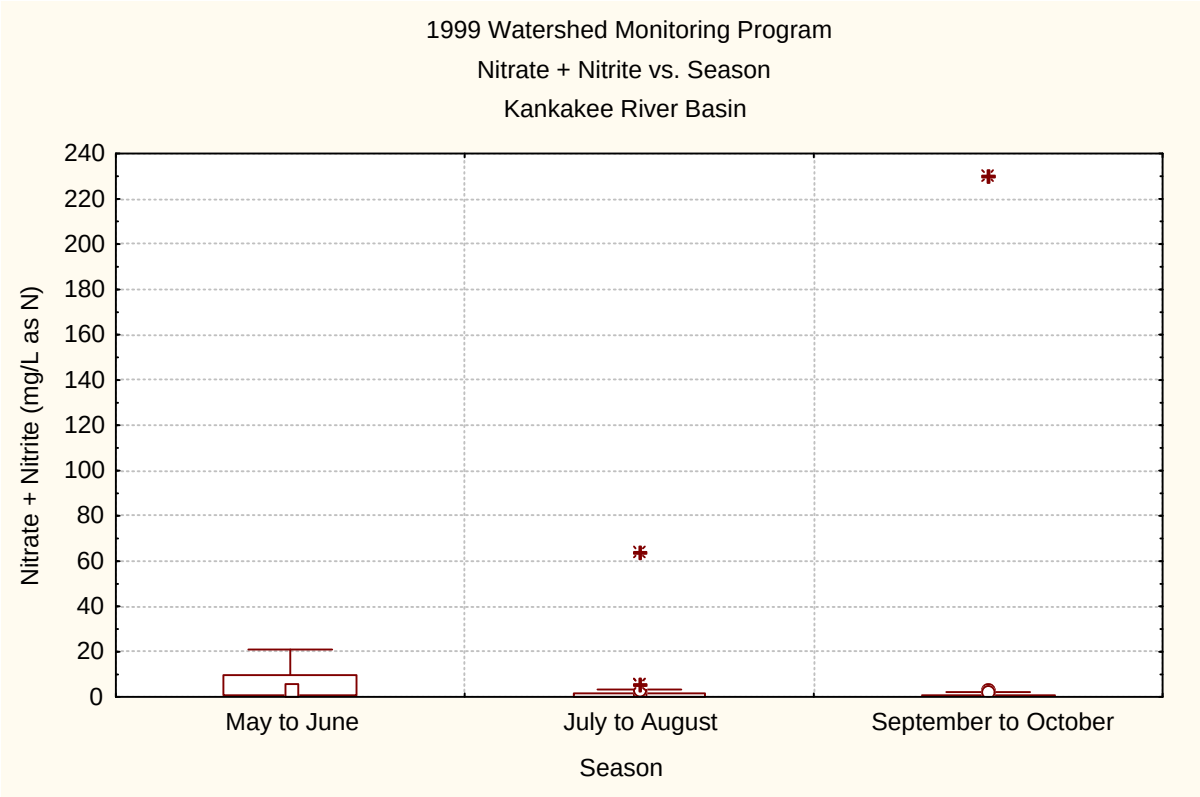
Appendix D Box-Whisker Plots by Season

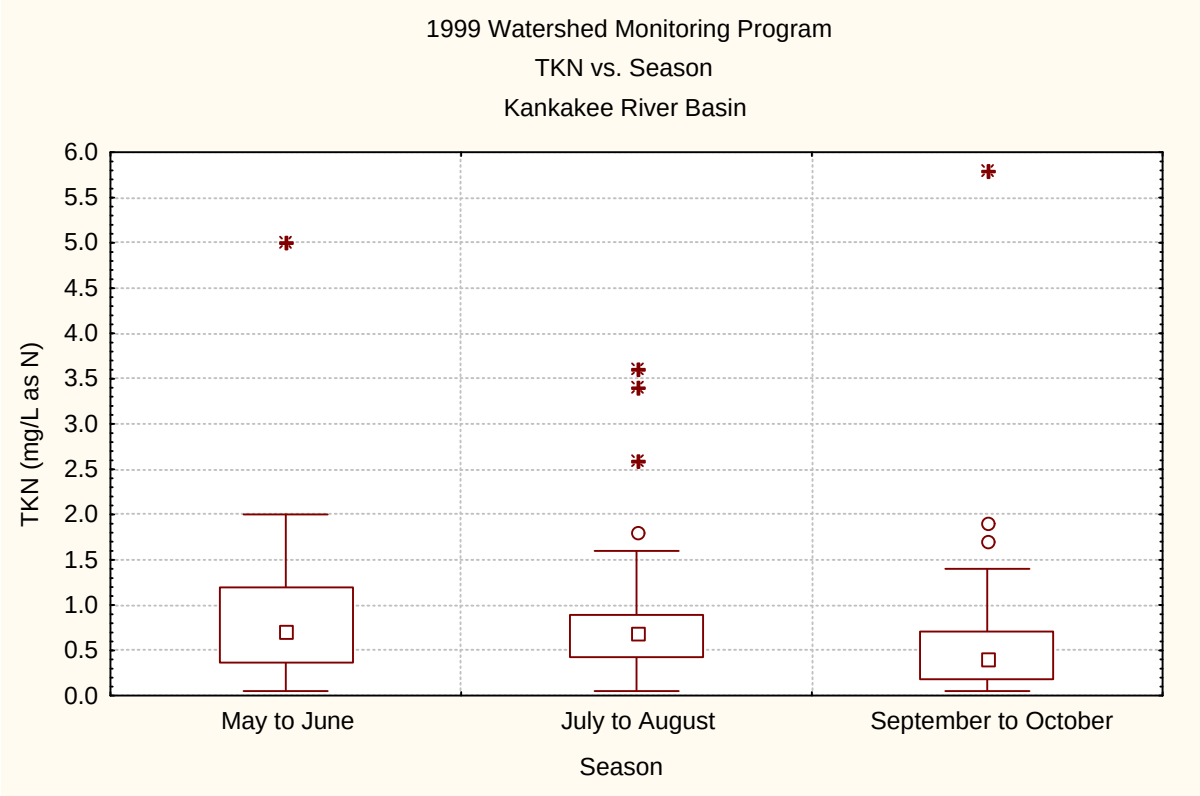


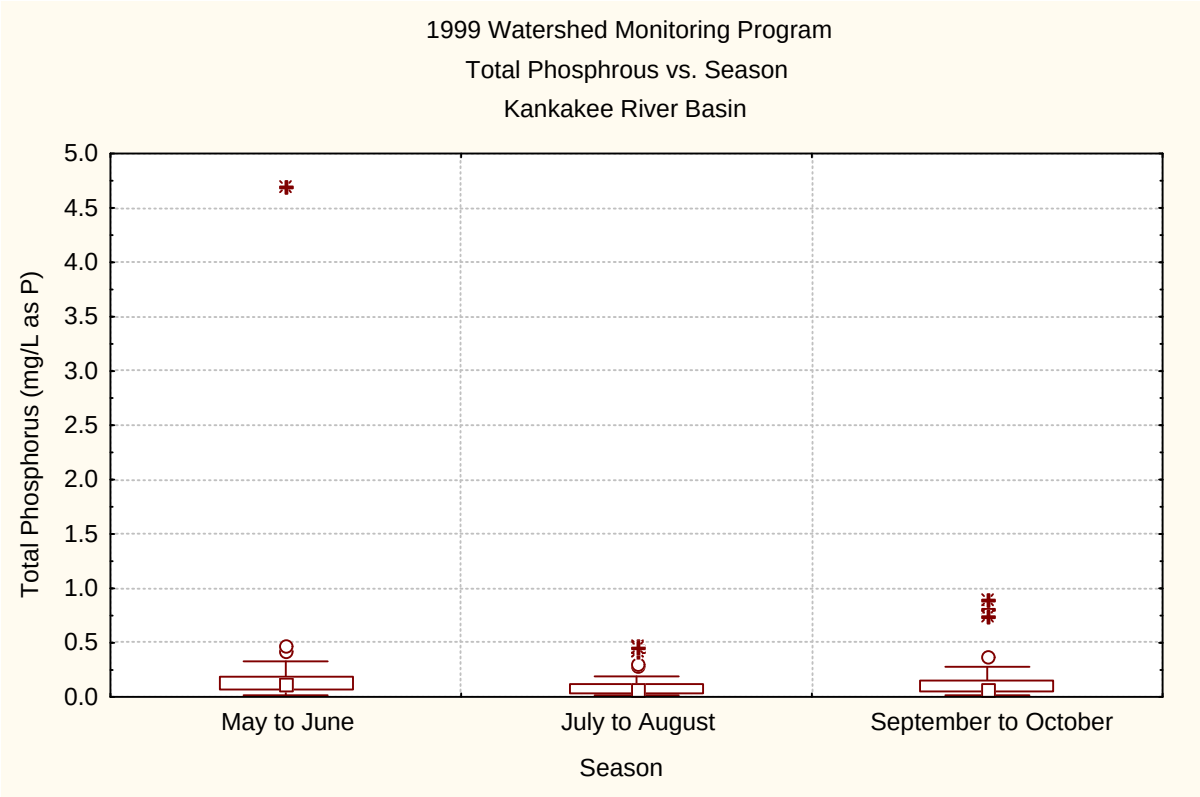


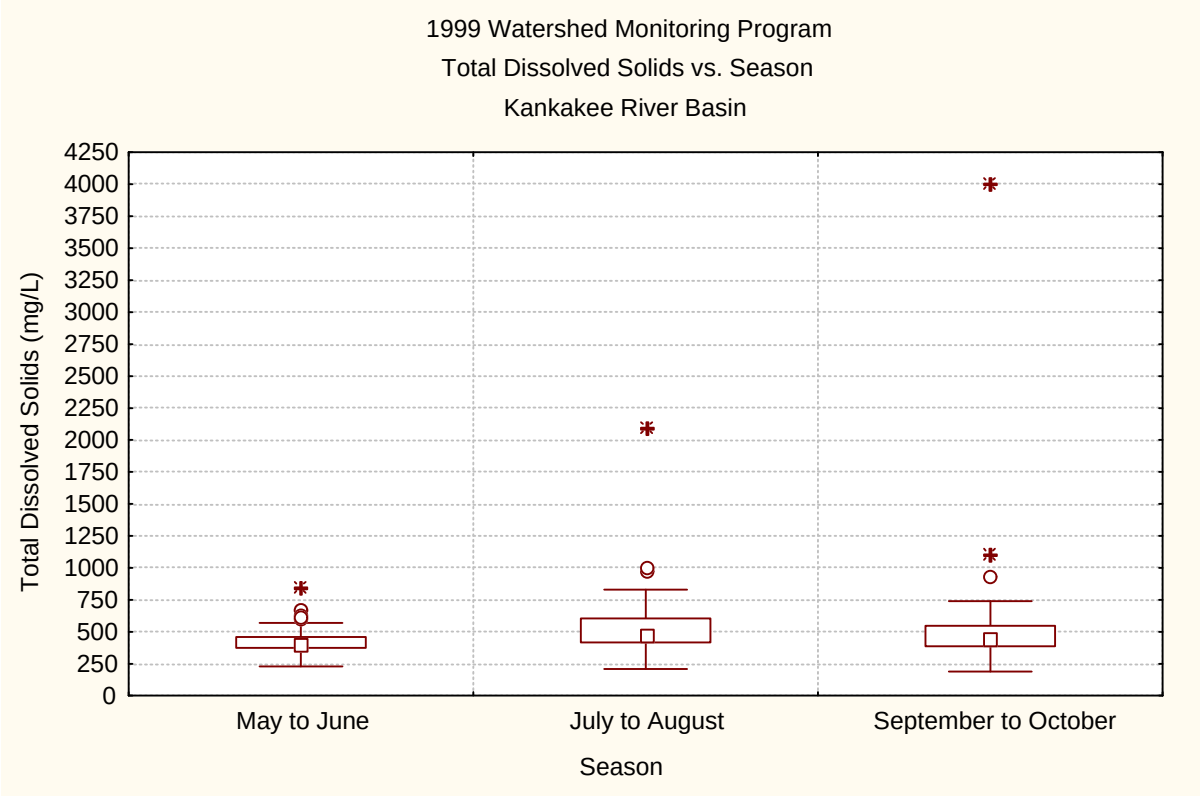

1999 Watershed Monitoring Program
COD vs. Season
Kankakee River Basin
COD (mg/L)
500
450
400
350
300
250
200
150
100
50
0
May to June
July to August
September to October
Season

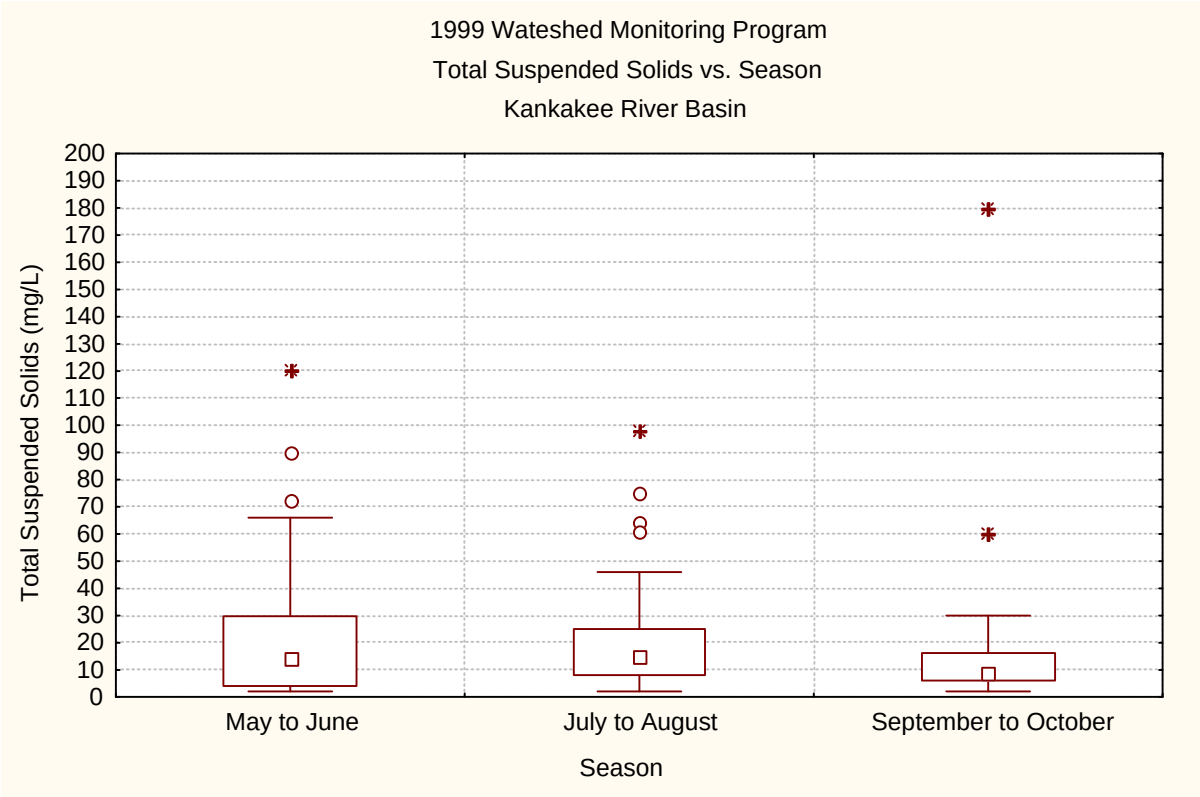

1999 Watershed Monitoring Program
Hardness vs. Season
Kankakee River Basin
Hardness (mg/L)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
May to June
July to August
September to October
Season

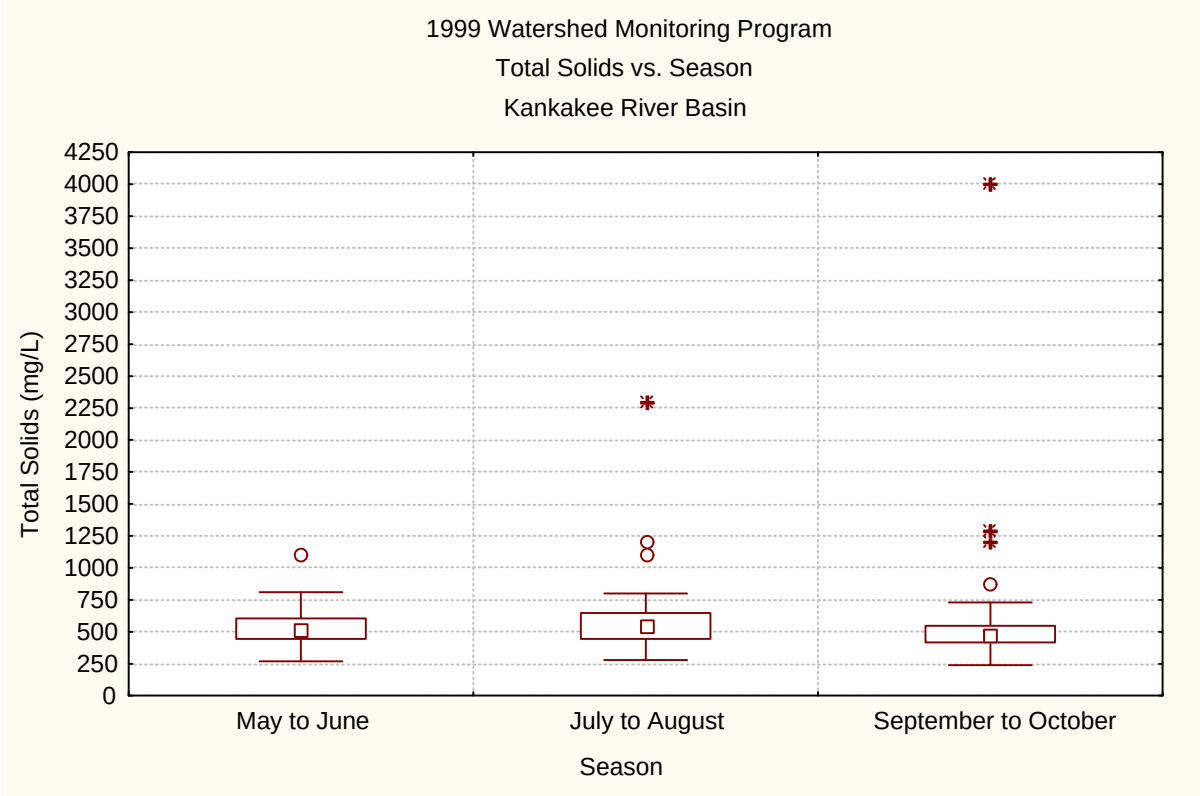

1999 Watershed Monitoring Program
Nitrate + Nitrite vs. Season
Kankakee River Basin
Nitrate + Nitrite (mg/L as N)
240
220
200
180
160
140
120
100
80
60
40
20
0
May to June
July to August
September to October
Season

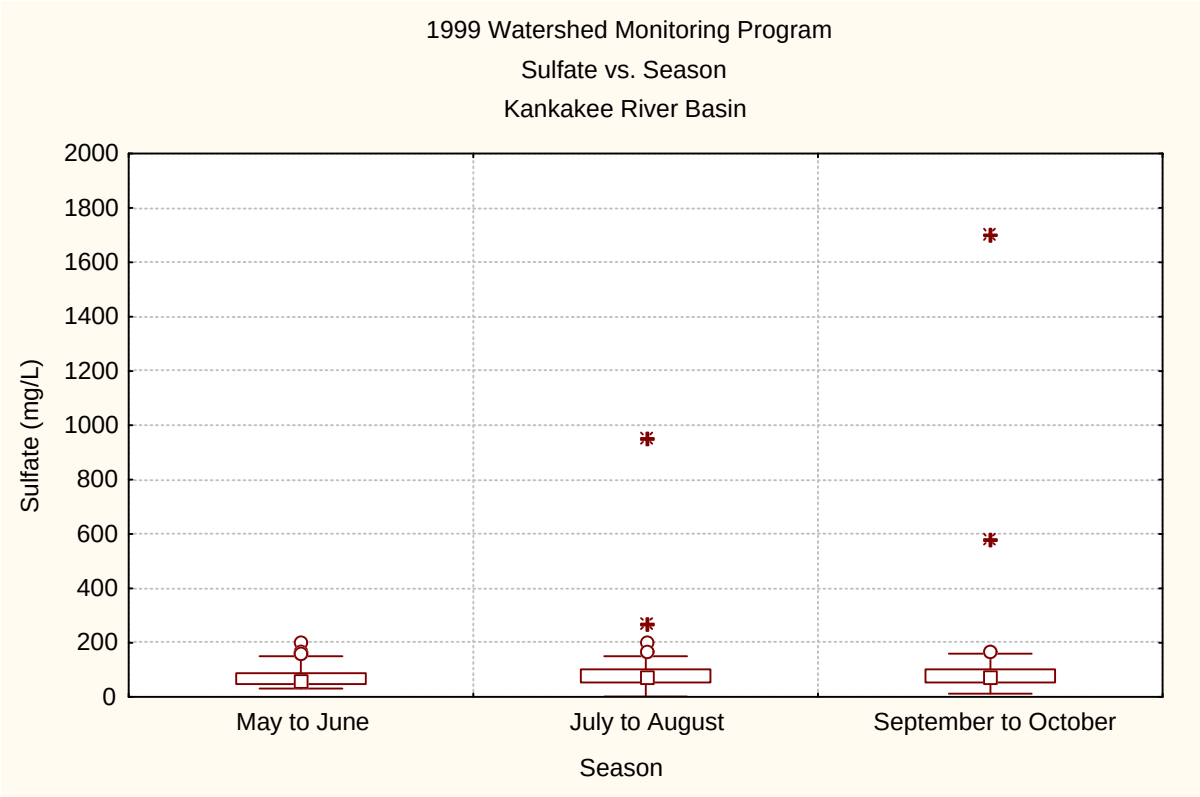

1999 Watershed Monitoring Program
TKN vs. Season
Kankakee River Basin
TKN (mg/L as N)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
May to June
July to August
September to October
Season

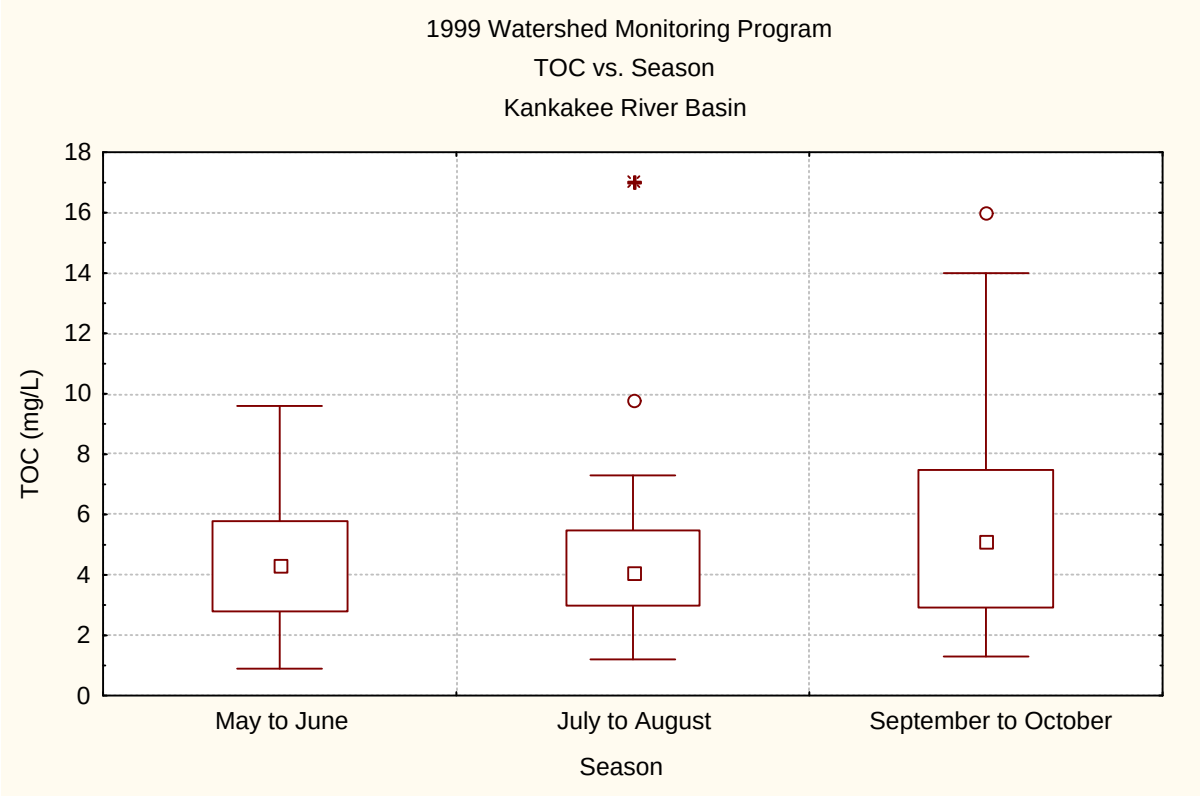

1999 Watershed Monitoring Program
Total Phosphrous vs. Season
Kankakee River Basin
Total Phosphorus (mg/L as P)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
May to June
July to August
September to October
Season

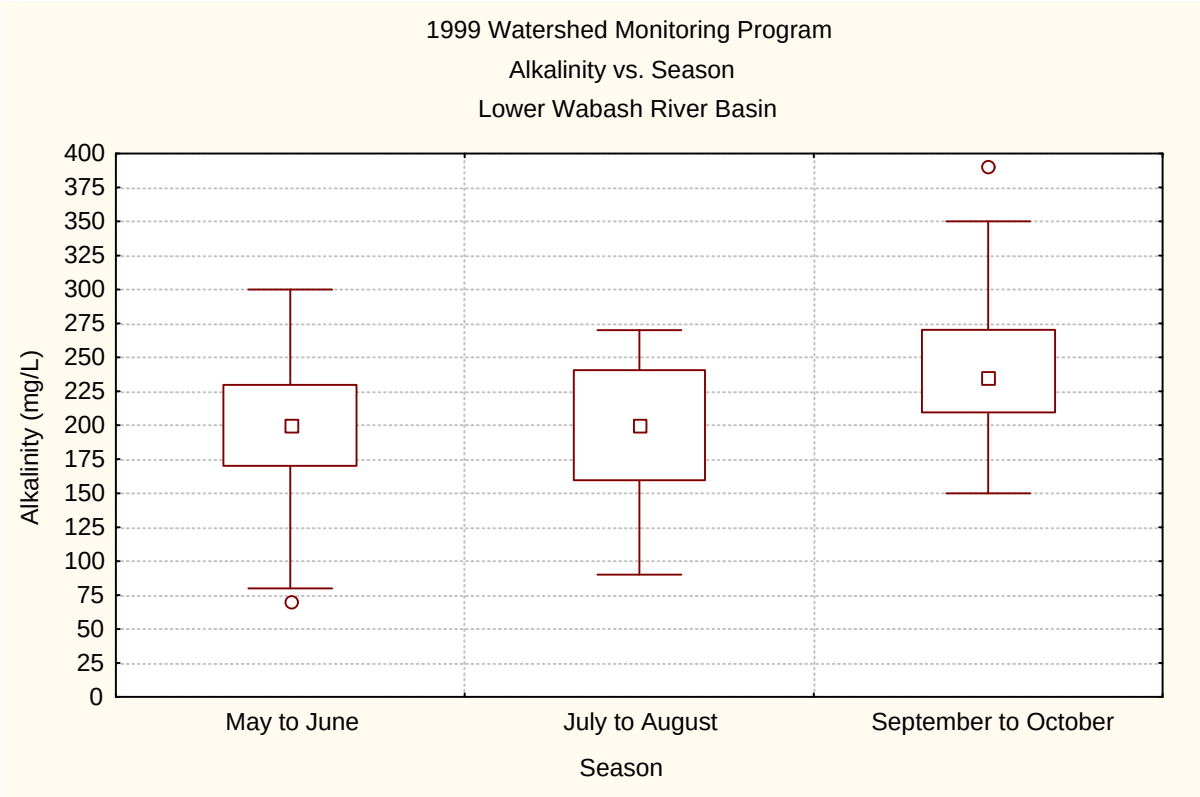

1999 Watershed Monitoring Program
Total Dissolved Solids vs. Season
Kankakee River Basin
Total Dissolved Solids (mg/L)
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
May to June
July to August
September to October
Season

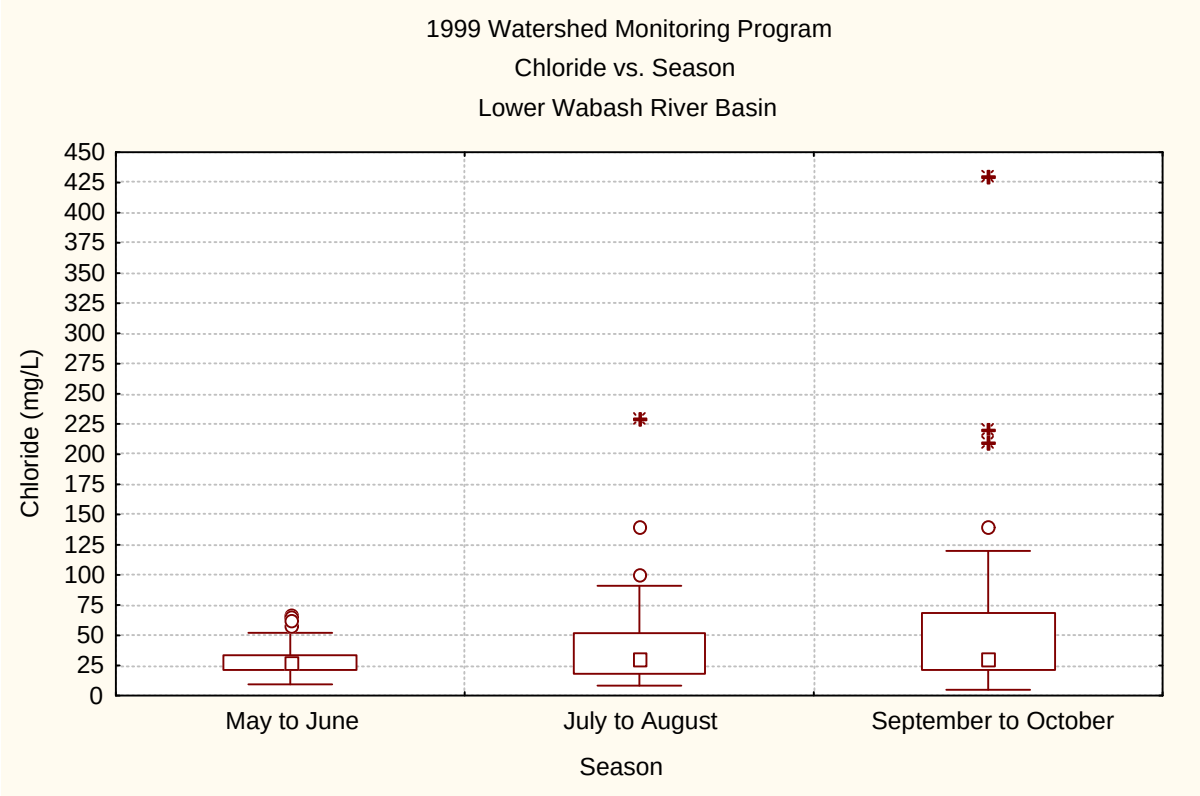

1999 Wateshed Monitoring Program
Total Suspended Solids vs. Season
Kankakee River Basin
Total Suspended Solids (mg/L)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
May to June
July to August
September to October
Season

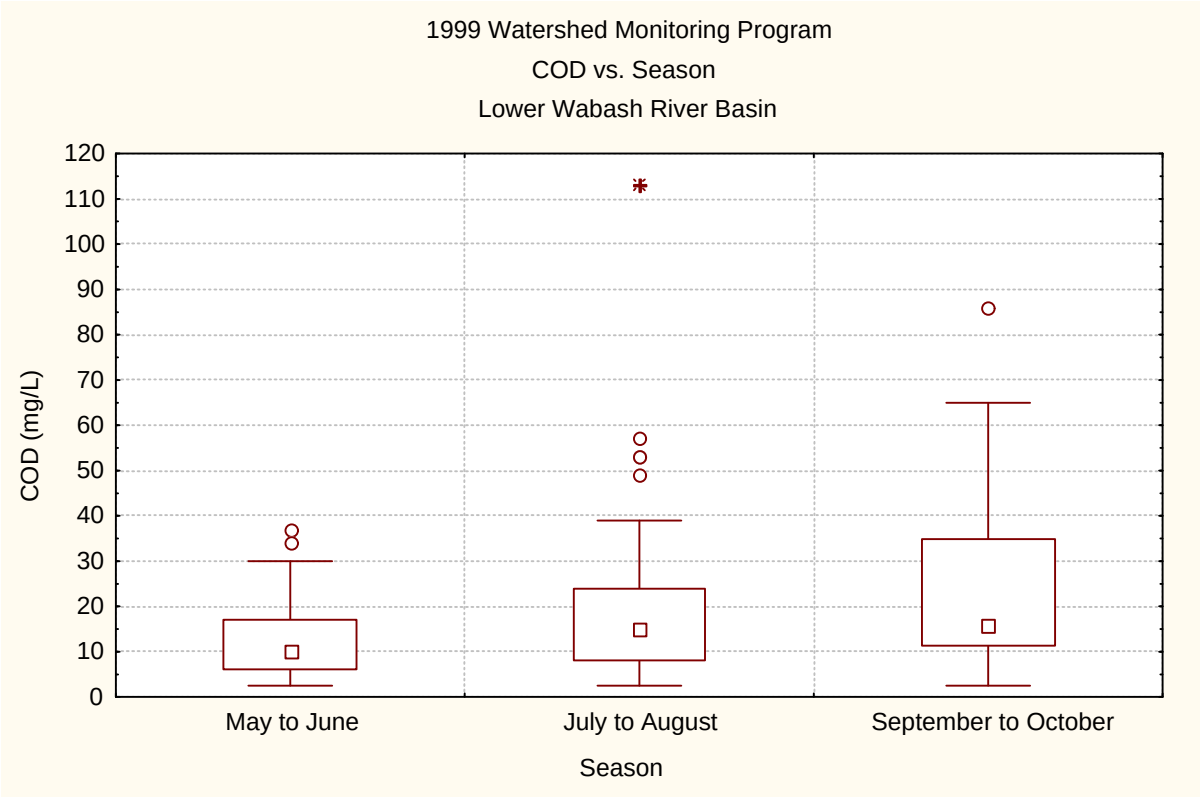

1999 Watershed Monitoring Program
Total Solids vs. Season
Kankakee River Basin
Total Solids (mg/L)
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
May to June
July to August
September to October
Season

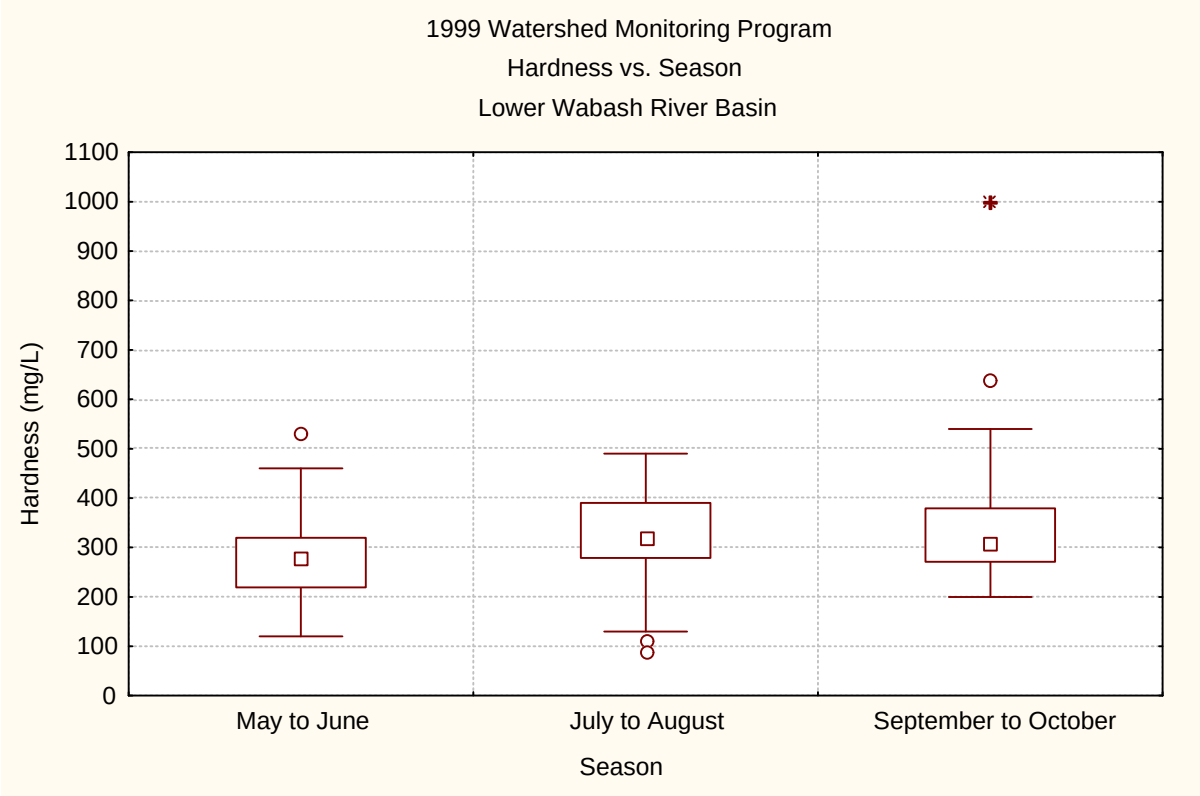

1999 Watershed Monitoring Program
Sulfate vs. Season
Kankakee River Basin
Sulfate (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
May to June
July to August
September to October
Season

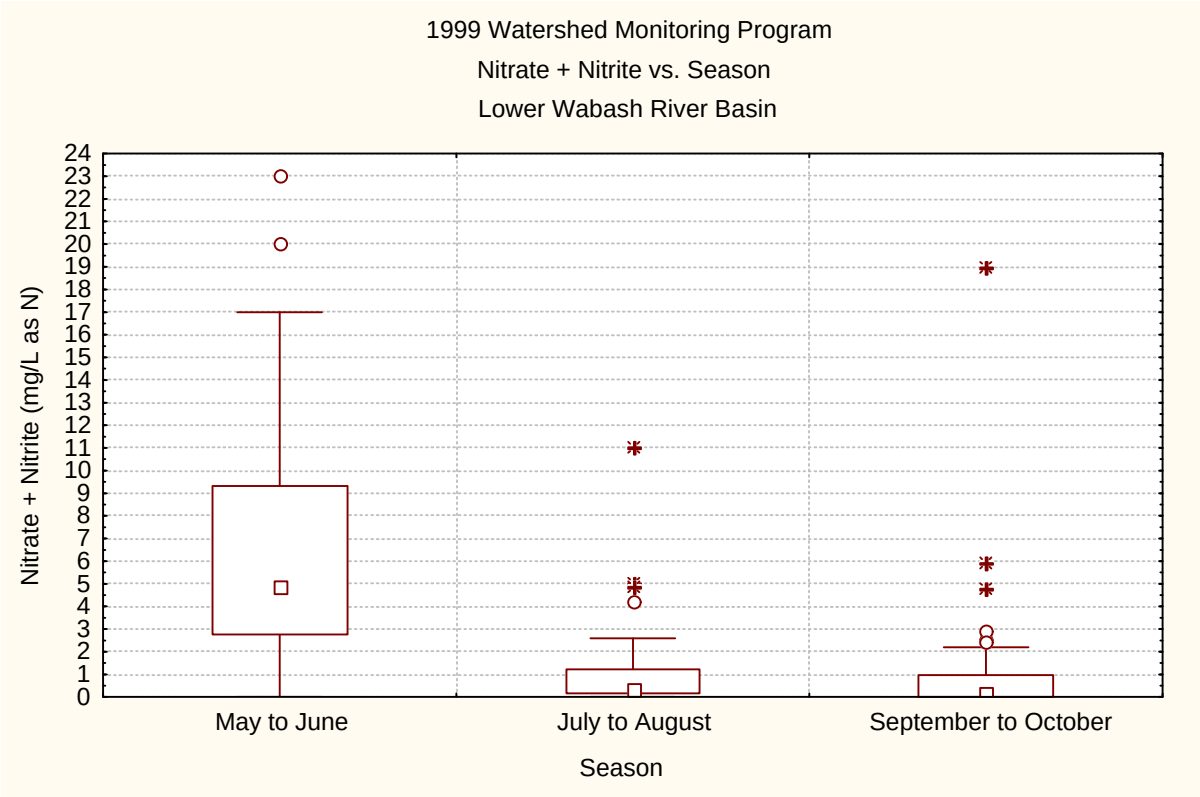

1999 Watershed Monitoring Program
TOC vs. Season
Kankakee River Basin
TOC (mg/L)
18
16
14
12
10
8
6
4
2
0
May to June
July to August
September to October
Season

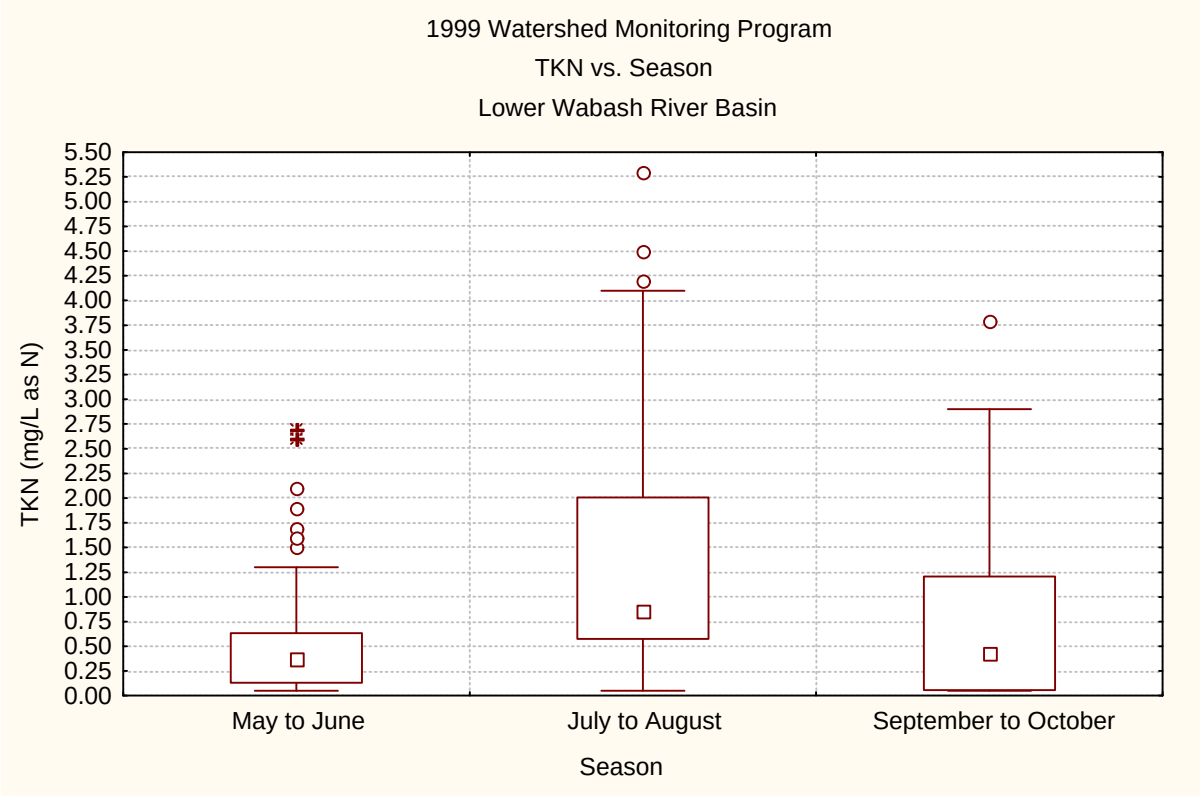

1999 Watershed Monitoring Program
Alkalinity vs. Season
Lower Wabash River Basin
Alkalinity (mg/L)
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
May to June
July to August
September to October
Season

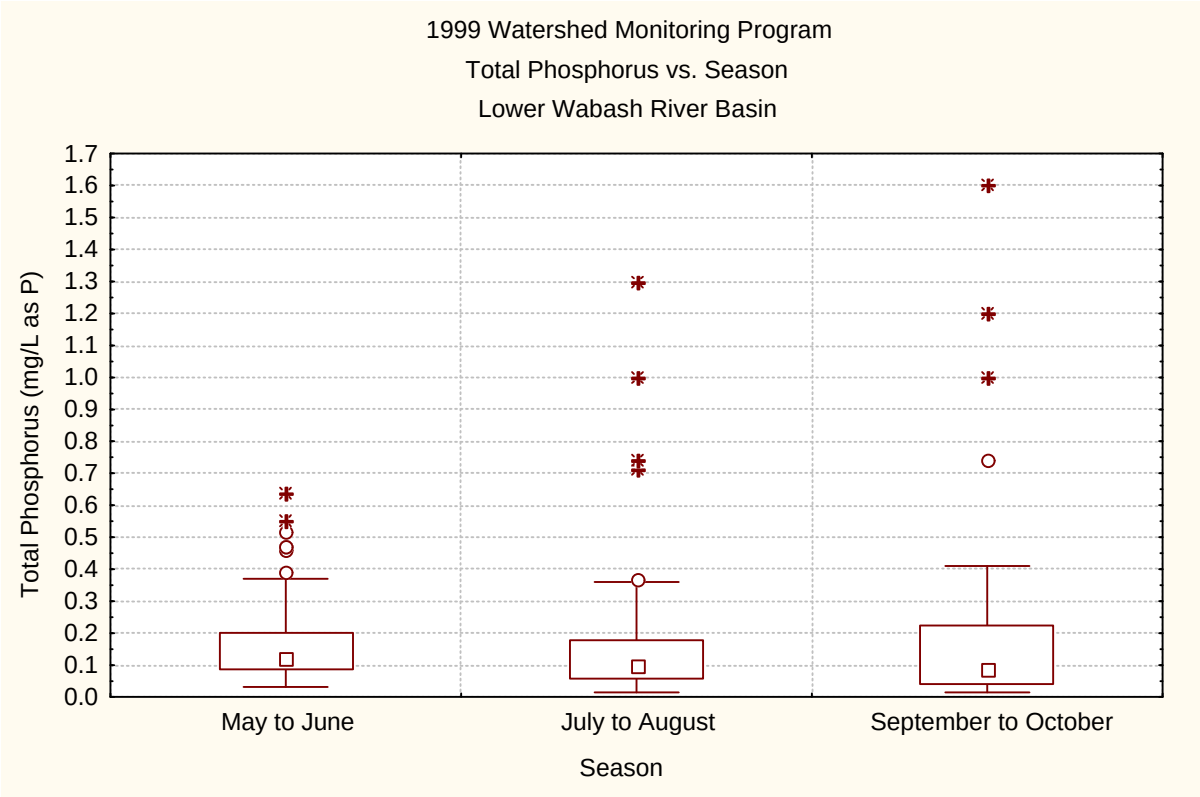

1999 Watershed Monitoring Program
Chloride vs. Season
Lower Wabash River Basin
Chloride (mg/L)
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
May to June
July to August
September to October
Season

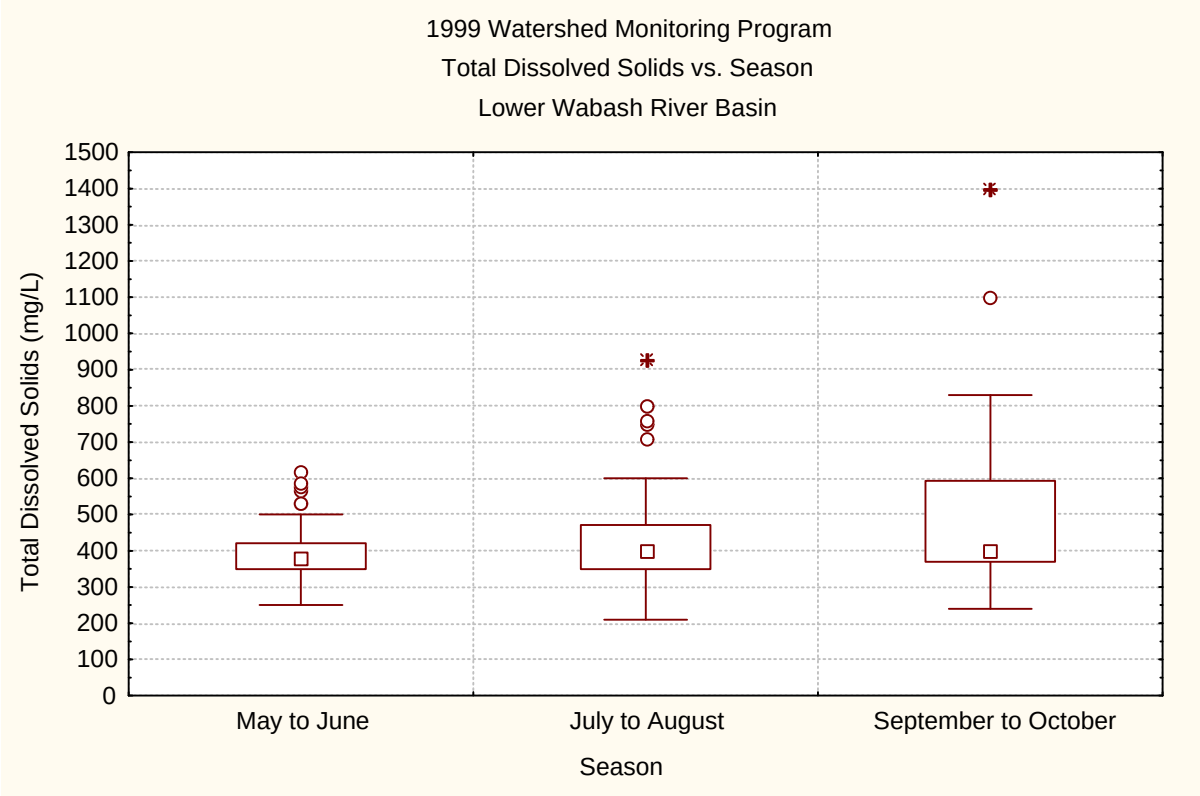

1999 Watershed Monitoring Program
COD vs. Season
Lower Wabash River Basin
COD (mg/L)
120
110
100
90
80
70
60
50
40
30
20
10
0
May to June
July to August
September to October
Season

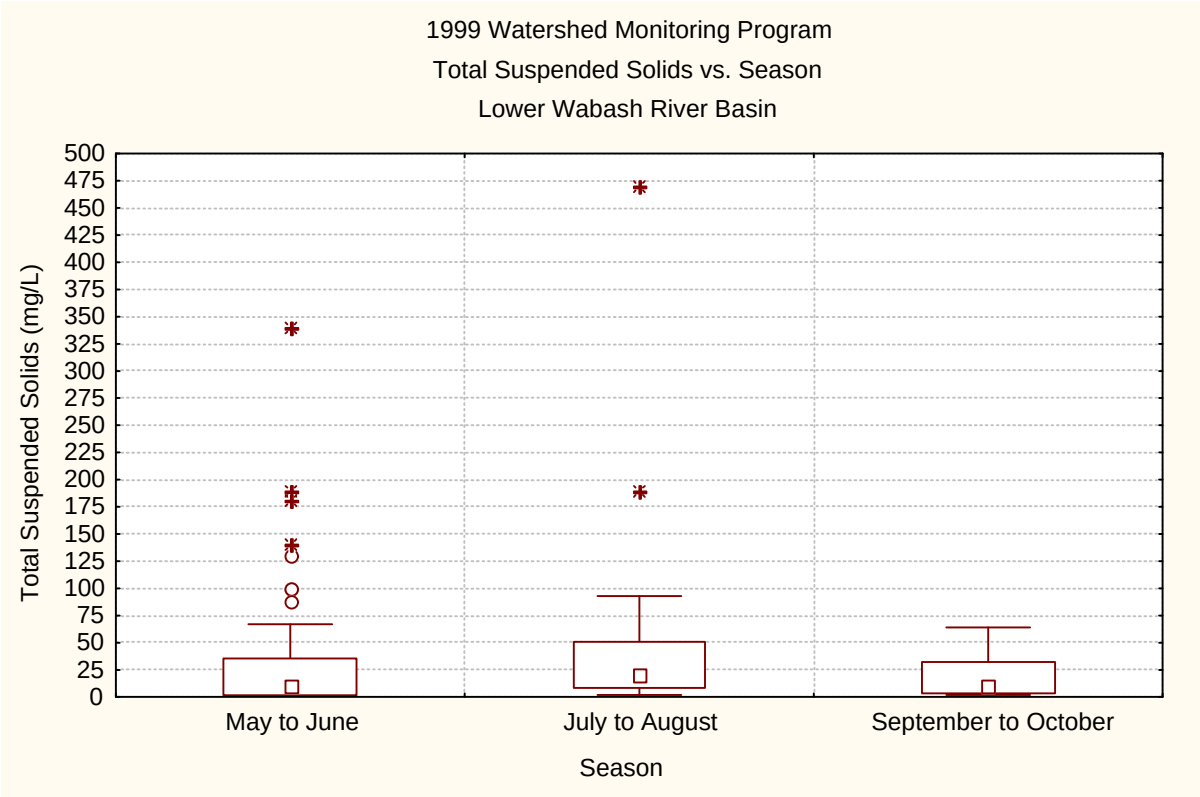

1999 Watershed Monitoring Program
Hardness vs. Season
Lower Wabash River Basin
Hardness (mg/L)
1100
1000
900
800
700
600
500
400
300
200
100
0
May to June
July to August
September to October
Season

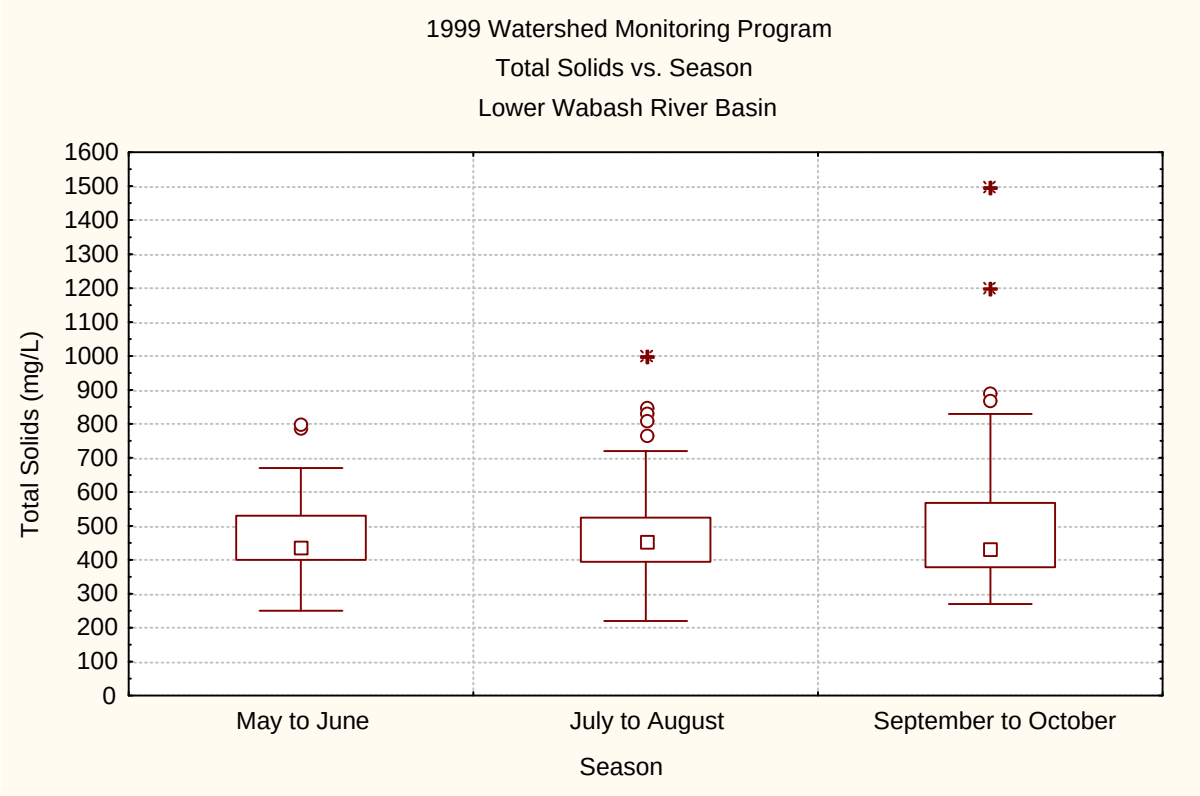

1999 Watershed Monitoring Program
Nitrate + Nitrite vs. Season
Lower Wabash River Basin
Nitrate + Nitrite (mg/L as N)
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
May to June
July to August
September to October
Season

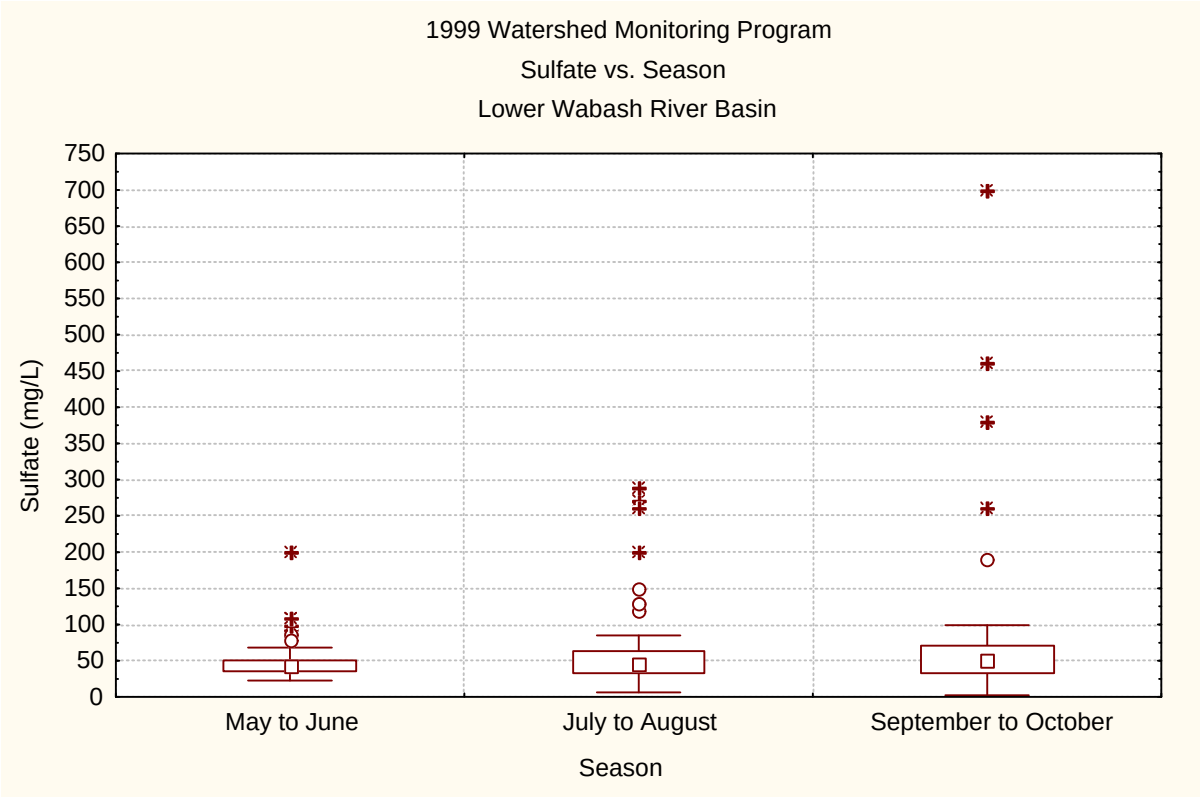

1999 Watershed Monitoring Program
TKN vs. Season
Lower Wabash River Basin
TKN (mg/L as N)
5.50
5.25
5.00
4.75
4.50
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
May to June
July to August
September to October
Season

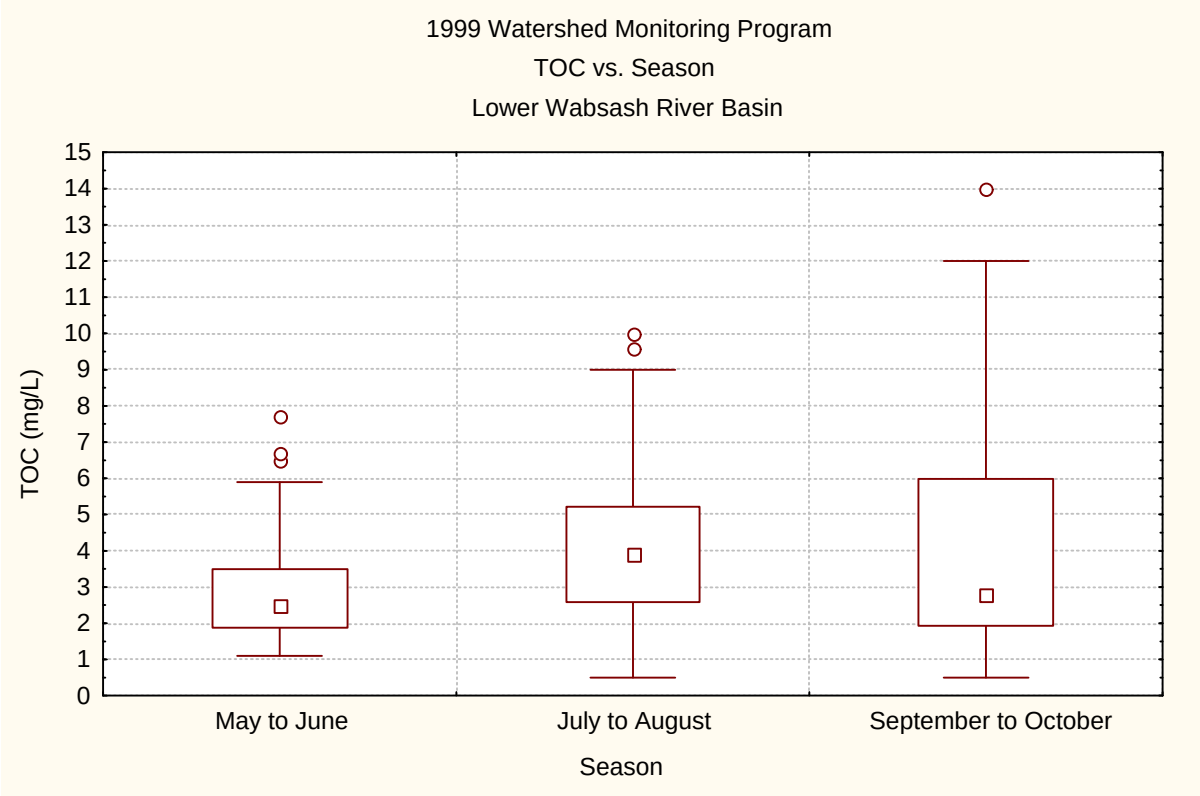

1999 Watershed Monitoring Program
Total Phosphorus vs. Season
Lower Wabash River Basin
Total Phosphorus (mg/L as P)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
May to June
July to August
September to October
Season


1999 Watershed Monitoring Program
Total Dissolved Solids vs. Season
Lower Wabash River Basin
Total Dissolved Solids (mg/L)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
May to June
July to August
September to October
Season

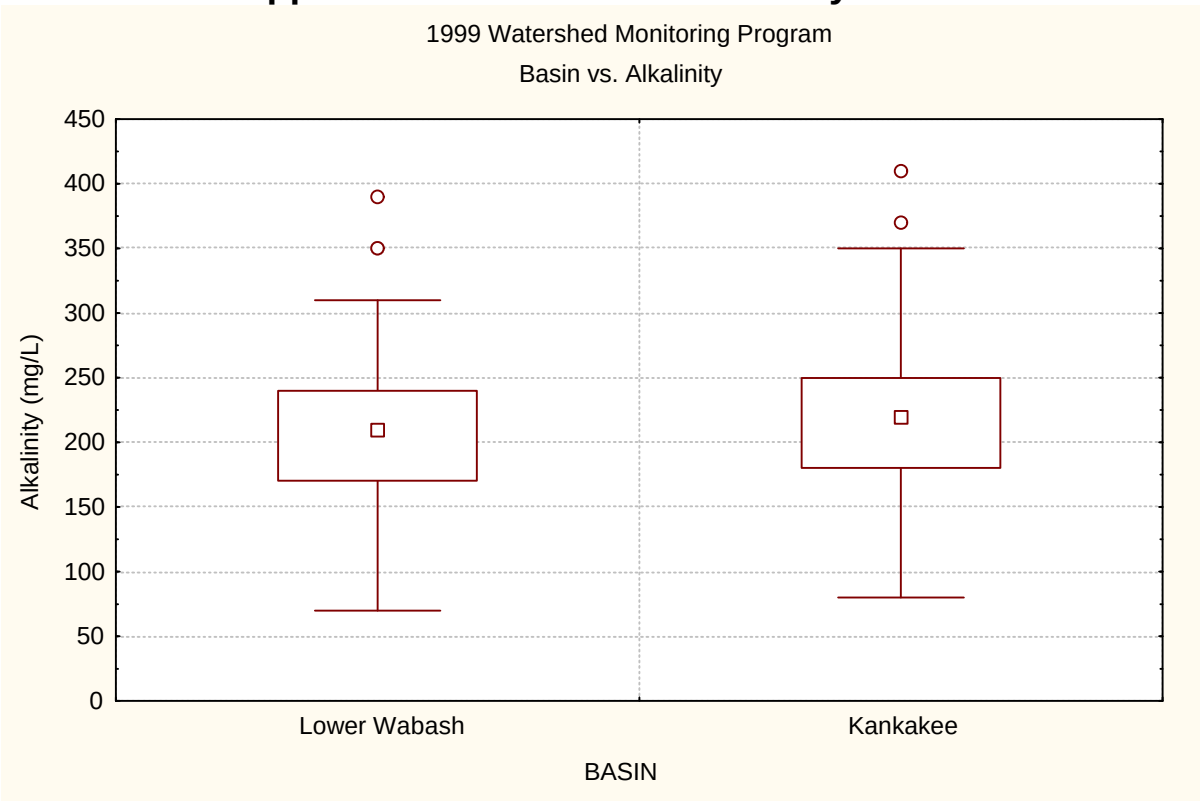

1999 Watershed Monitoring Program
Total Suspended Solids vs. Season
Lower Wabash River Basin
Total Suspended Solids (mg/L)
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
May to June
July to August
September to October
Season

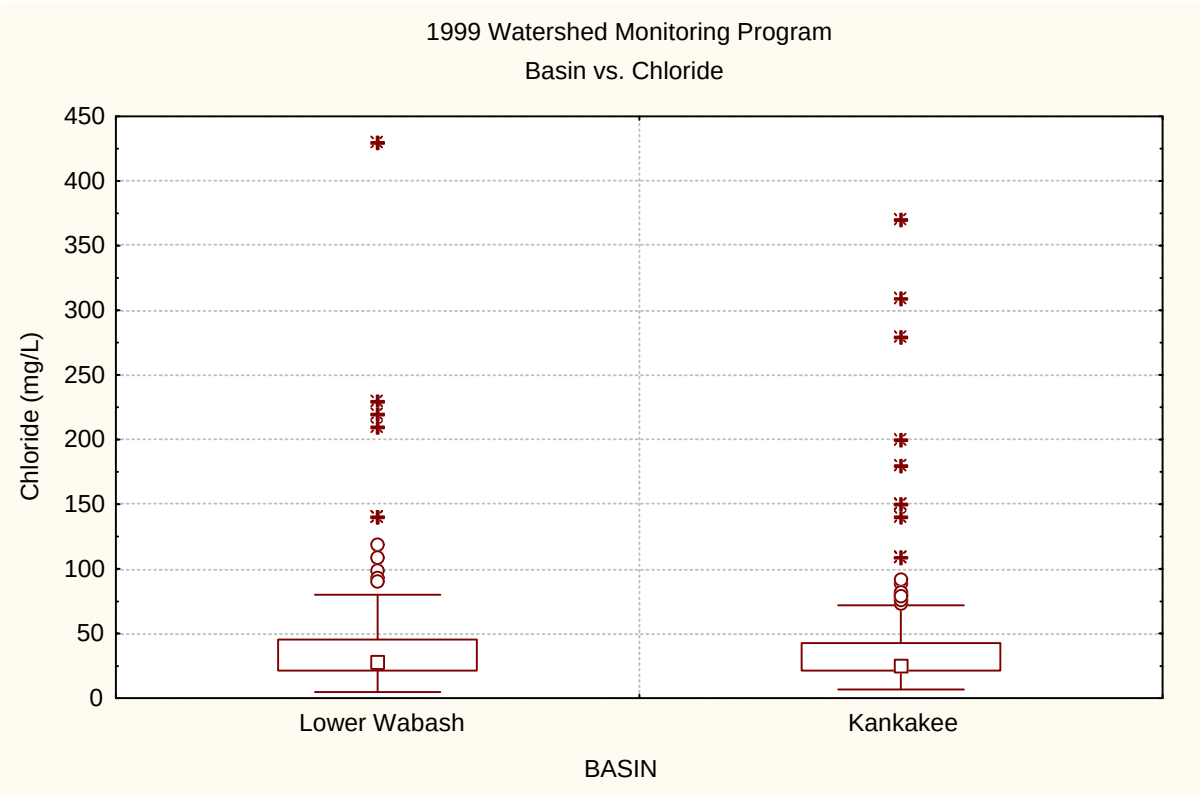

1999 Watershed Monitoring Program
Total Solids vs. Season
Lower Wabash River Basin
Total Solids (mg/L)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
May to June
July to August
September to October
Season

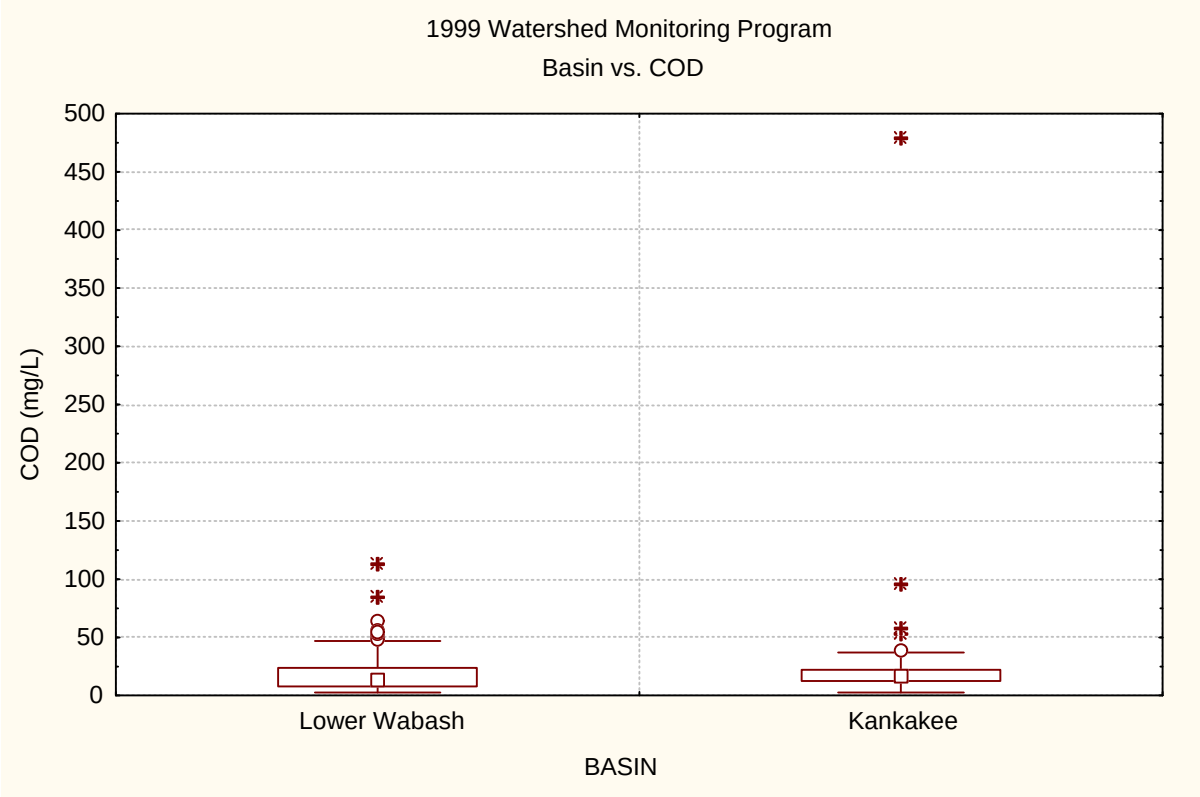

1999 Watershed Monitoring Program
Sulfate vs. Season
Lower Wabash River Basin
Sulfate (mg/L)
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
May to June
July to August
September to October
Season

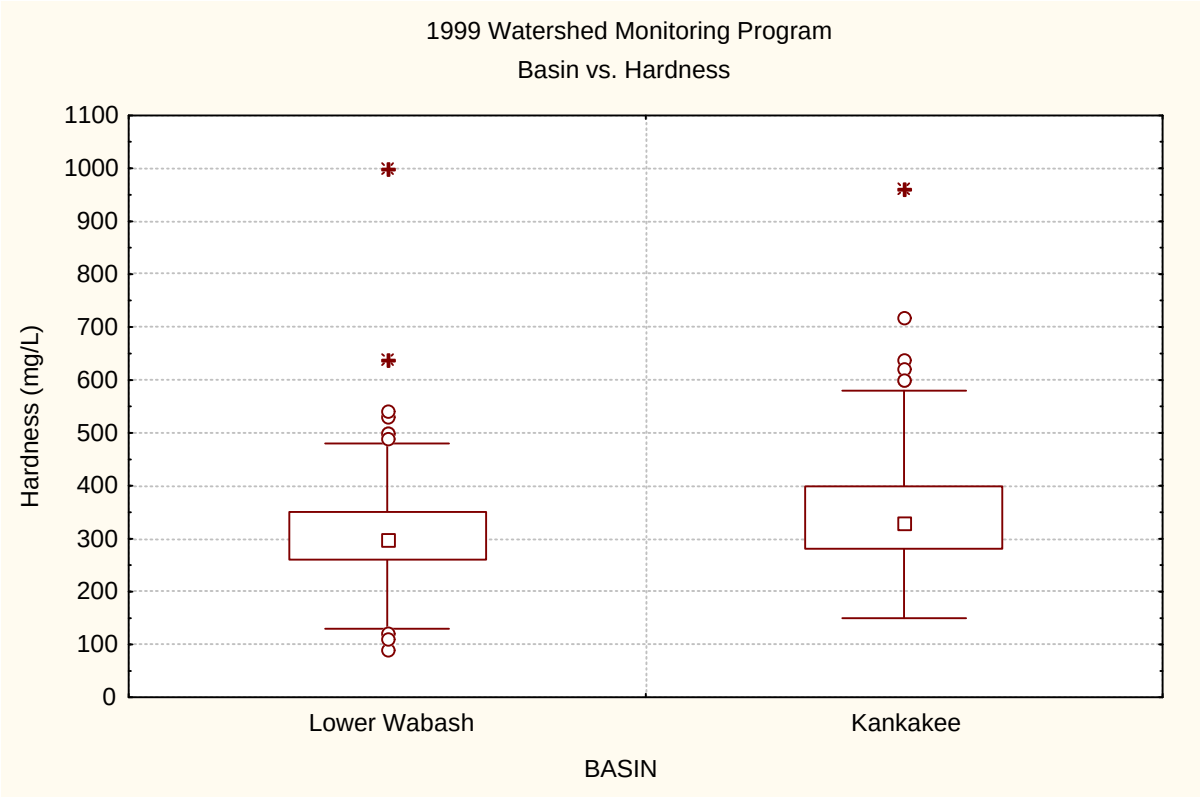

1999 Watershed Monitoring Program
TOC vs. Season
Lower Wabsash River Basin
TOC (mg/L)
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
May to June
July to August
September to October
Season

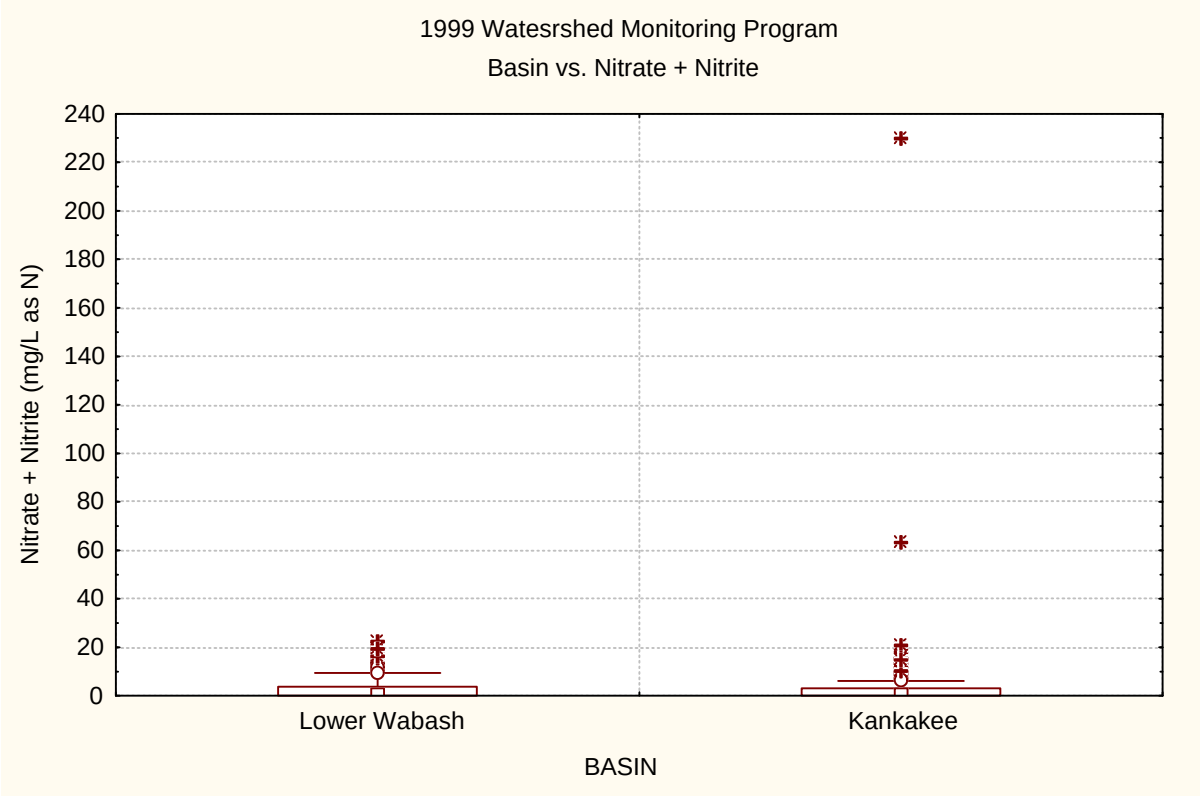
Appendix E Box-Whisker Plots by Basin

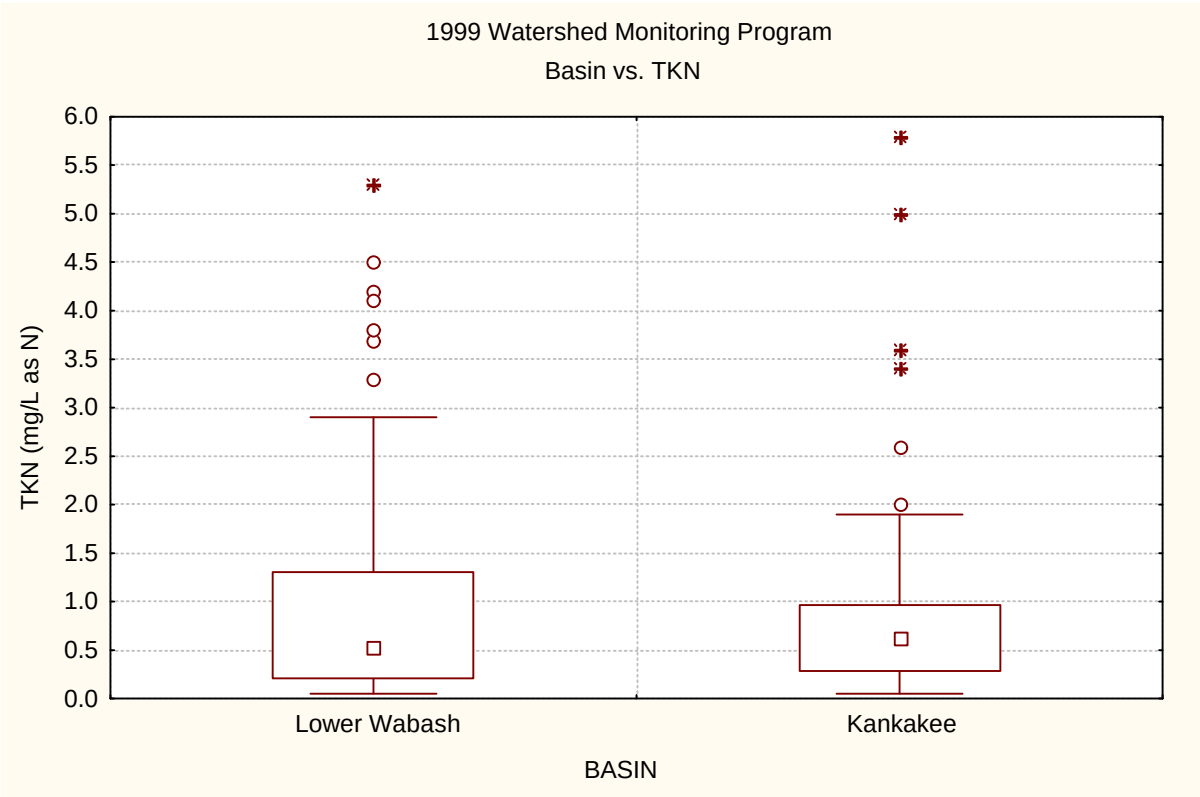


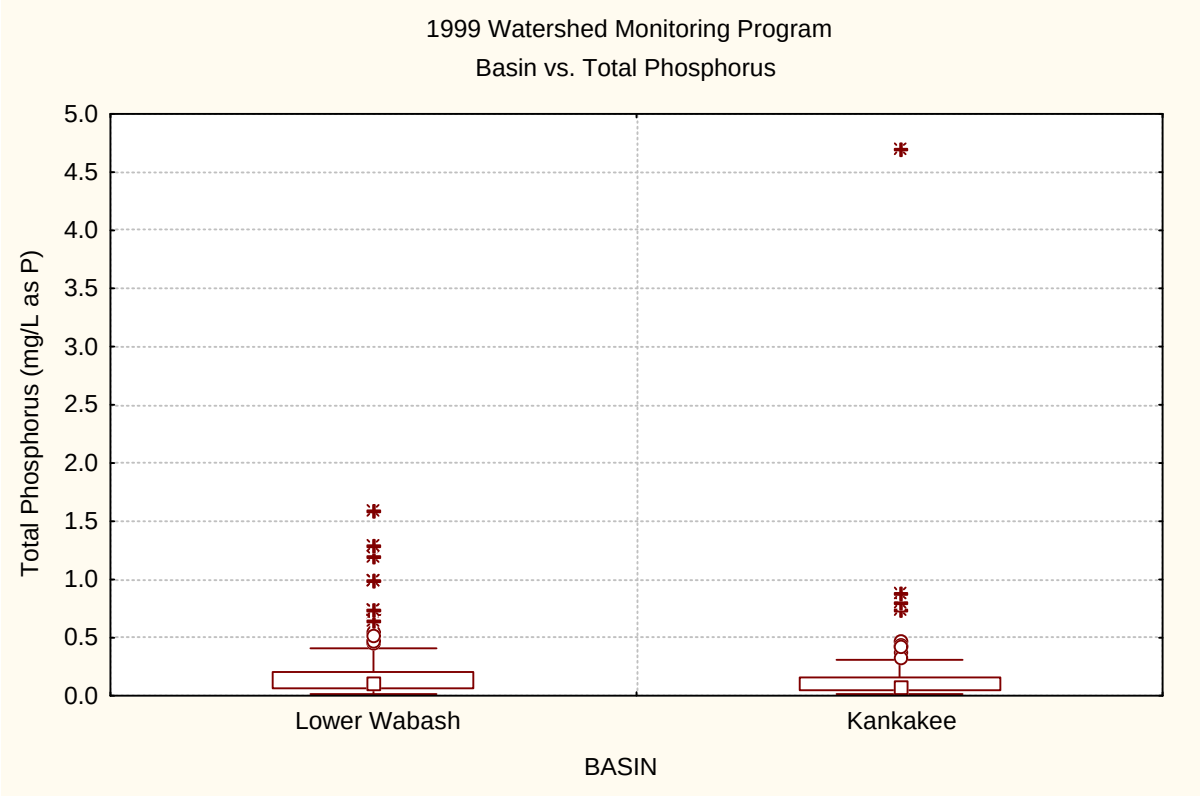


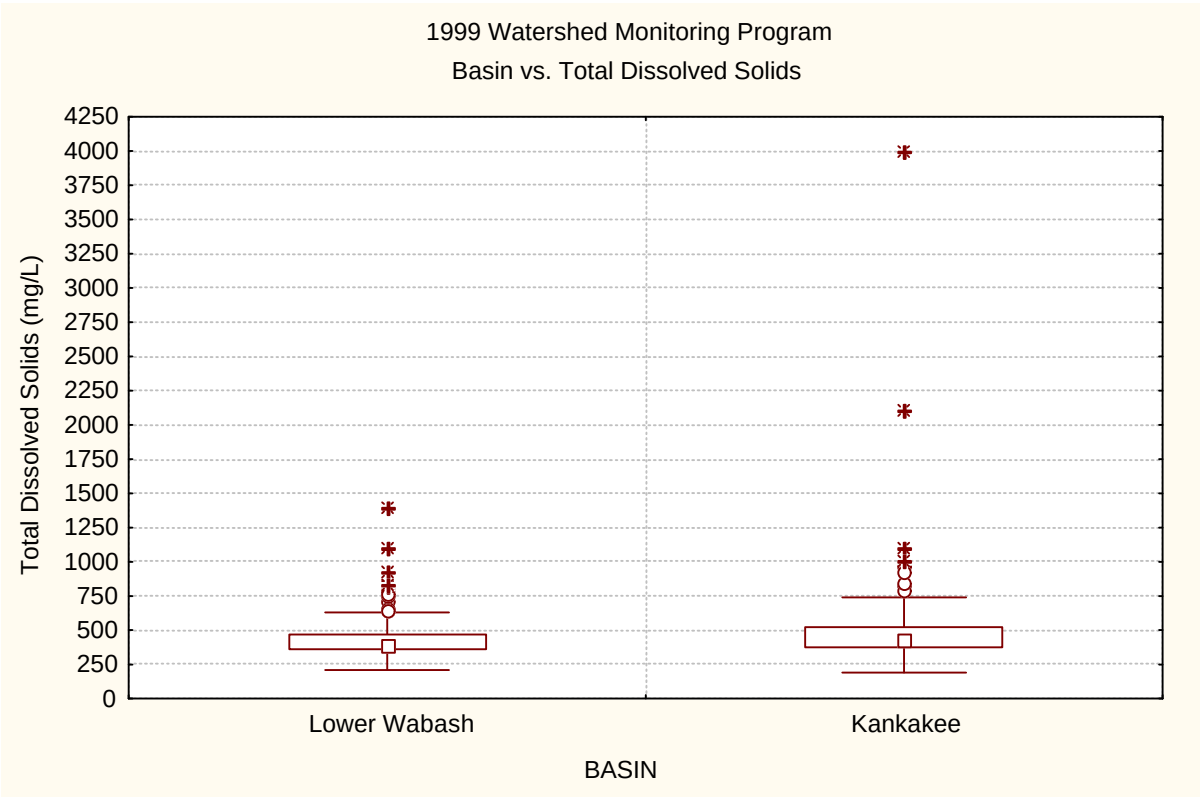

1999 Watershed Monitoring Program
Basin vs. COD
COD (mg/L)
500
450
400
350
300
250
200
150
100
50
0
Lower Wabash
Kankakee
BASIN

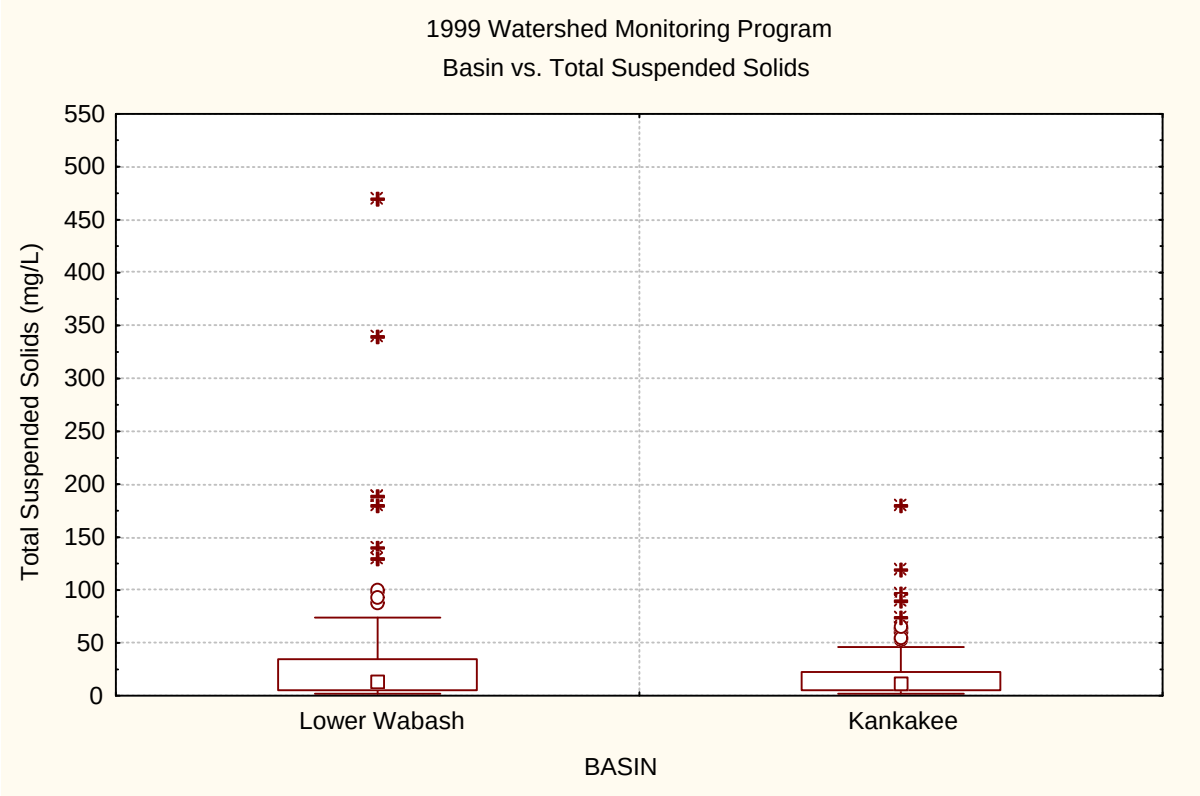

1999 Watershed Monitoring Program
Basin vs. Hardness
Hardness (mg/L)
1100
1000
900
800
700
600
500
400
300
200
100
0
Lower Wabash
Kankakee
BASIN

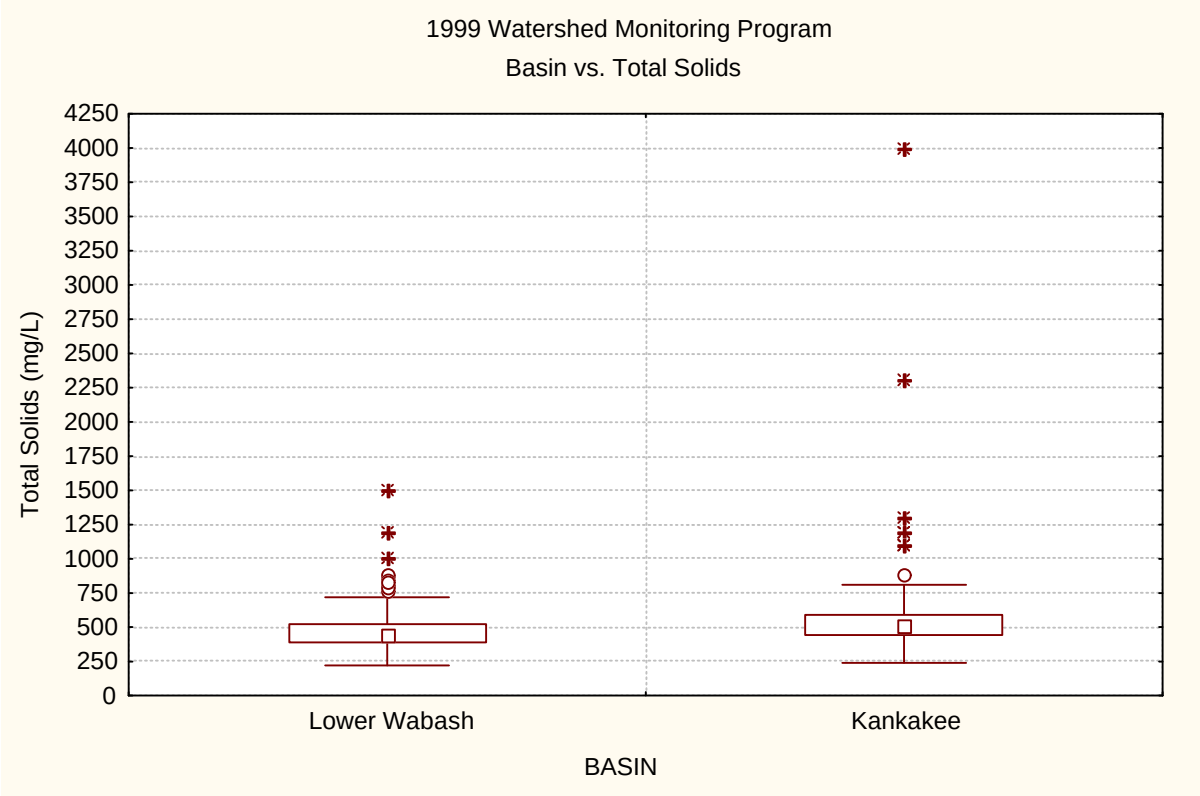

1999 Watesrshed Monitoring Program
Basin vs. Nitrate + Nitrite
Nitrate + Nitrite (mg/L as N)
240
220
200
180
160
140
120
100
80
60
40
20
0
Lower Wabash
Kankakee
BASIN

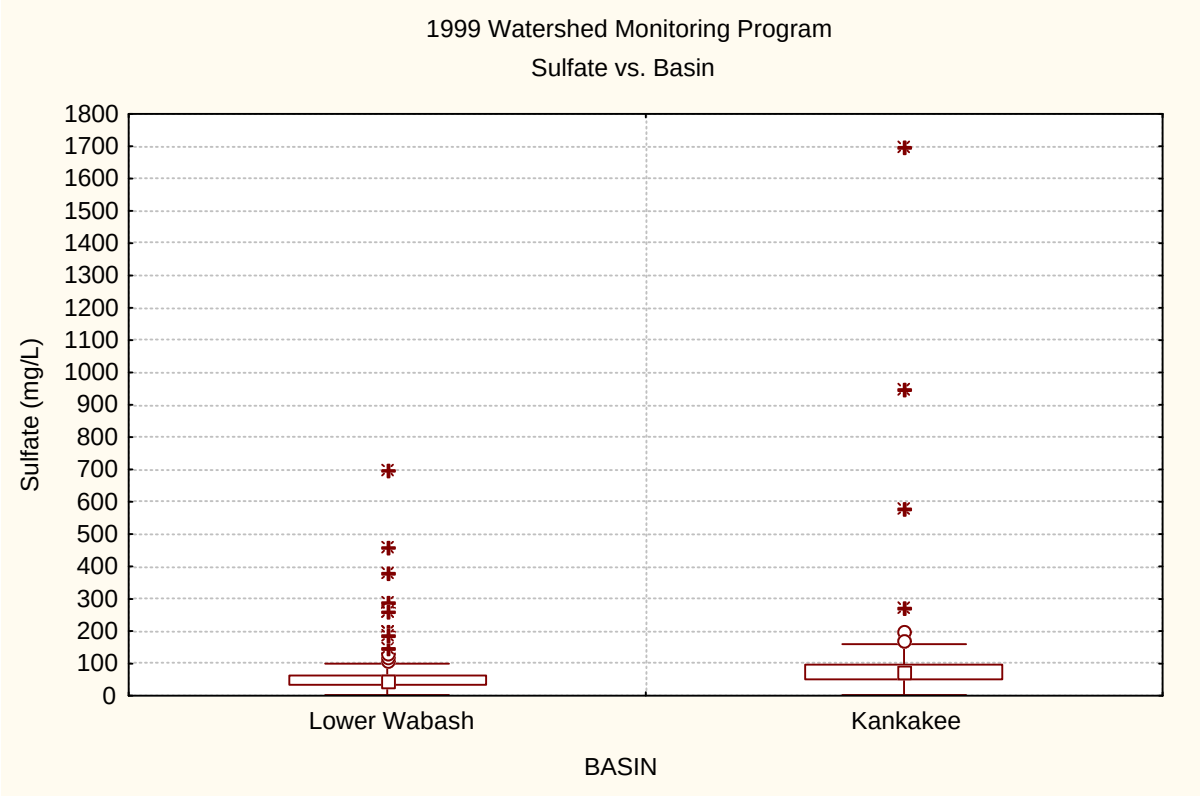

1999 Watershed Monitoring Program
Basin vs. TKN
TKN (mg/L as N)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Lower Wabash
Kankakee
BASIN

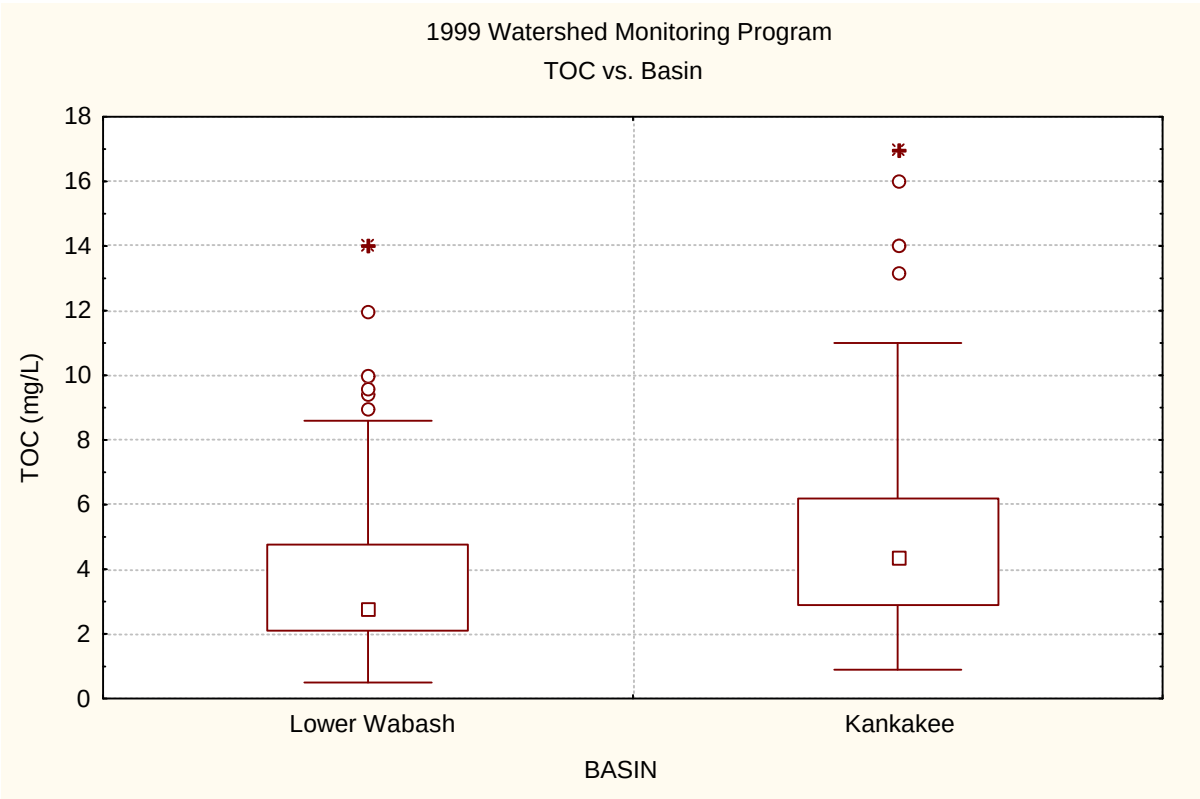

1999 Watershed Monitoring Program
Basin vs. Total Phosphorus
Total Phosphorus (mg/L as P)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Lower Wabash
Kankakee
BASIN


1999 Watershed Monitoring Program
Basin vs. Total Dissolved Solids
Total Dissolved Solids (mg/L)
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
Lower Wabash
Kankakee
BASIN


1999 Watershed Monitoring Program
Basin vs. Total Suspended Solids
Total Suspended Solids (mg/L)
550
500
450
400
350
300
250
200
150
100
50
0
Lower Wabash
Kankakee
BASIN


1999 Watershed Monitoring Program
Basin vs. Total Solids
Total Solids (mg/L)
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
Lower Wabash
Kankakee
BASIN


1999 Watershed Monitoring Program
Sulfate vs. Basin
Sulfate (mg/L)
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Lower Wabash
Kankakee
BASIN


1999 Watershed Monitoring Program
TOC vs. Basin
TOC (mg/L)
18
16
14
12
10
8
6
4
2
0
Lower Wabash
Kankakee
BASIN