2004 Rathbun Report

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A. Tributaries

Personnel of the Iowa State University (ISU) Limnology Laboratory (LL) collected water samples from streams at 15 stations in the Rathbun Lake watershed during calendar year 2004: RA-12, RA-15, RA-32, RA-33, RA-34, RA-35, RA-36, RA-37, RA-38, RA-39, RA-40, RA-41, RA-42, RA-43, and RA-44 (Fig. 1). The project was funded by a cooperative agreement between the Rathbun Land and Water Alliance, Iowa Geological Survey Bureau and ISU. The samples were analyzed for various water-quality constituents by the U.S. Army Corps of Engineers, Kansas City District (USACE-KC) and the ISU Limnology Laboratory.

Ten of the 14 stations sampled by the ISU-LL are located on small streams in the Rathbun Lake watershed. RA-15 and RA-32 are located on the Chariton River, and RA-12 and RA-35 are located on the South Fork Chariton River (Fig. 1). RA-34 and RA-43 are located on small drainages that lead directly to Rathbun Lake. RA-12 is located on the main stem of the South Fork Chariton River and has a continuous stage-discharge recorder present (USGS Gauging Station Number 06903700). There is another continuous stage-discharge recorder located on the main stem of the Chariton River just below the confluence of the Chariton River and Wolf Creek, or just below sites RA-15 and RA-41 (USGS Gauging Station Number 06903400). The purpose of the sampling is to continue to document seasonal differences in water quality in several small watersheds within the Rathbun Lake watershed and to document differences in water quality between the watersheds. Differences in water quality might be related to differences in drainage-basin characteristics, land use, the intensity and timing of rainfall, or chemical and biological processes in the streams.

Discharge at the time of sample collection ranged from zero to 180 m^3/s (one cubic meter per second ~ 15,852 gpm). Many of the smaller streams had low- to no-flow from January through mid-February, late April through early-May and October through December of 2004. Flows at the main stem stations RA-12 and RA-15 averaged 0.25 m^3/s (~ 3,960 gpm) during low flow conditions. The largest discharges during sampling occurred during spring, mid-summer, and early-fall. The largest flows measured at both the USGS gaging stations, Chariton River at Cty Hwy 14 (06903400) and South Fork Chariton River (06903700) occurred from August 27- 29,2004 (Figures 2 and 3) respectively. The timing and volume of maximum discharges occurring at the 13 other stations is unknown, since there is no continuous recording information for these sites.

Continuous records for the Chariton River indicate that 2004 was an average water year, with total flow approximately equal to the average annual total flow. Continuous records for the South Fork Chariton River also support that 2004 was an average water year (Figures 4 and 5).

Total Suspended Solid (Sediment) concentrations in samples collected at the 14 sampling stations ranged from 7 to 443 mg/L. Sediment concentrations do not always correlate with stream discharge. Greater variability in sediment values relative to stream discharge may be a result of the timing and intensity of rain events.

Sediment flux estimates are calculated by combining discharge information with sediment concentration in water at the time of sample collection. Instantaneous sediment flux can be calculated by multiplying instantaneous discharge by suspended sediment concentration, but this only reflects the amount of sediment transport at that time. Continuous discharge data and the development of a discharge-sediment transport relationship are needed to determine continuous or annual sediment flux. Typically, the majority of annual sediment transport can occur during a few brief events, thus the instantaneous sediment loads available for this sampling effort may provide only a glimpse of the actual sediment transport occurring in the watershed. In addition, sediment transport is highly dependent on but not limited to land use, timing and intensity of rainfall, and season. Still, annual sediment flux can be estimated. As has been done for past reports, we estimated daily discharge for each sampling site from the daily discharge at nearby continuous monitoring stations, using sub-basin area to determine relative water contribution. We then estimated daily-suspended sediment concentrations by averaging the data values from sampling events before and after sampling dates. This resulted in estimates of annual sediment flux from each sub-basin.

On average, and in 2004, Site 12 Site 15 and Site 41 have the highest annual sediment flux (loss) compared to the other sub-basins. In 2004 the South Fork Chariton River (RA-12) had a total annual sediment loss of 8,987 metric tons (1 metric ton = 1.1 US tons) compared to a six-year average of 13,832 metric tons, while the Chariton River (RA-15 + RA-41) had a total annual sediment loss 6,591 metric tons compared with an average of 22,074 metric tons (Fig. 6). The South Fork Chariton River (RA-12) and Chariton River (RA-15 + RA-41) reflect conditions found throughout the watershed, that even with average flow conditions annual export of sediment were lower for most sites in 2004 compared to their six-year average. The exceptions were sites RA-35 and RA-44, both of which had higher than average sediment loss.

Comparisons of sediment data can also be made by looking at annual sediment yield of a sub-basin, which is the total annual loss divided by drainage area. On average RA-15 and RA-41, two of the larger drainage areas on the Chariton River, have the highest annual sediment yield, 430 kg/ha and 621 kg/ha respectively (Fig.7). However, in 2004 sub-basins RA-42 (265 kg/ha), RA-33 (233 kg/ha) and RA-12 (209 kg/ha) had the largest annual sediment yields. Again, as with sediment loss, sites RA-35 and RA-44 were the only two drainage areas with higher than average sediment yield rates for 2004.

Phosphorus and nitrogen flux estimates are also calculated by combining discharge information with nutrient concentration in water at the time of sample collection. Instantaneous fluxes of these nutrients can be calculated by multiplying instantaneous discharge by nutrient concentration, but this only reflects the amount of nutrient transport at that time. Continuous discharge data and the development of a discharge-nutrient transport relationship are needed to determine continuous or annual nutrient fluxes. Typically, the majority of annual nutrient transport can occur during a few brief events, thus the instantaneous nutrient loads available for this sampling effort may provide only a glimpse of the actual nutrient transport occurring in the watershed. In addition, nutrient transport is highly dependent on but not limited to land use, timing and intensity of rainfall, and season. Still, annual nutrient fluxes can be estimated. For this exercise, we estimated daily discharge for each sampling site from the daily discharge at a nearby continuous monitoring station, using sub-basin area to determine relative water contribution. We then estimated daily nutrient concentrations using the data from sampling events before and after that date. This resulted in estimates of annual nutrient flux from each sub-basin.

On average, and in 2004, Site 12, Site 15, and Site 41 have the highest annual phosphorus export rates compared to the other sub-basins. In 2004, the South Fork Chariton River (RA-12) contributed 29 metric tons of phosphorus to the lake compared to a six-year average of 27 metric tons, while the Chariton River (RA-15 + RA-41) contributed 27 metric tons of phosphorus compared with an average of 37 metric tons (Fig. 8).

Comparisons of phosphorus data can also be made by looking at annual phosphorus yield (loss per unit land area) of a sub-basin. On average RA-15, RA-33 and RA-41, drainage areas on the Chariton River, have the highest annual phosphorus export rate per hectare, 0.83 kg/ha, 0.86 kg/ha and 0.84 kg/ha respectively. In 2004 sub-basins RA-33 (1.18 kg/ha) and RA-42 (0.86 kg/ha) had the largest annual phosphorus yields (Fig.9).

On average, and in 2004, Site 12, Site 15, and Site 41 have the highest annual nitrogen export rates compared to the other sub-basins. In 2004, the South Fork Chariton River (RA-12) contributed 127 metric tons of nitrogen to the lake compared to a six-year average of 165 metric tons, while the Chariton River (RA-15 + RA-41) contributed 146 metric tons of nitrogen compared with an average of 238 metric tons (Fig. 10).

Comparisons of nitrogen data can also be made by looking at annual nitrogen yield (loss per unit land area) of a sub-basin. On average RA-32, RA-33 and RA-43, have the highest annual nitrogen export rate per hectare, 7.78 kg/ha, 7.55 kg/ha and 9.29 kg/ha respectively. In 2004 sub-basins RA-32 (5.14 kg/ha), RA-33 (5.08 kg/ha) and RA-37 (4.77 kg/ha) had the largest annual nitrogen yields (Fig.11).

Annual differences in water, sediment, and nutrient flux are quite evident when comparing 1999-2004. The driving force of sediment and nutrient flux is most likely due to the annual differences in timing and intensity of rainfall, which is reflected in the overall amount of water moving through the watershed. Chariton reported 35.20 inches of rain in 1999, 33.16 inches in 2000, 40.77

inches in 2001, 30.48 inches in 2002, 31.64 inches in 2003, and 34.97 inches in 2004. Normal annual precipitation for Chariton is 34.76 inches, which again supports 2004 as an average year for precipitation and therefore runoff within the watershed.

Using data from the USGS gauging stations in the watershed, nearly 204 million m^3 (53.9 billion gallons) of water passed by these two gauges in 1999, 25.9 million m^3 (6.8 billion gallons) in 2000, 317 million m^3 (83.8 billion gallons) in 2001, 75 million m^3 (19.8 billion gallons) in 2002, 31.3 million m^3 (8.3 billion gallons) in 2003 and 213 million m^3 (56.4 billion gallons) in 2004. Rathbun Lake at normal pool holds approximately 25.3 million m^3 (6.7 billion gallons) of water, so the lake flushed completely approximately 8.4 times in 2004. These differences in water flux result in huge differences in sediment and nutrient fluxes and lake flushing rate.

Data from sampling sites RA-12, RA-15, and RA-41 suggest a possible trend to lower annual export of sediments, phosphorus, and nitrogen for a given amount of annual water export. Comparing 1999 and 2004, both average water years, sediment flux was 154,000 metric tons in 1999 and 15,578 metric tons in 2004. Phosphorus flux was 199 metric tons in 1999 and 57 metric tons in 2004. Nitrogen flux was 961 metric tons in 1999 and 273 metric tons in 2004. Comparing 2000 and 2003, both low water years, sediment flux was 2,305 metric tons in 2000 and 969 metric tons in 2003. Phosphorus flux was 7metric tons in 2000 and 7 metric tons in 2003. Nitrogen flux was 46 metric tons in 2000 and 16 metric tons in 2003 (Fig. 12).

There are many methods available to estimate nutrient and sediment fluxes from watersheds. The methods described above have been found to provide the most accurate estimate of nitrogen and phosphorus transport, and be the most cost-effective (Kronvang and Bruhn, 1996).

The U.S. Environmental Protection Agency's (USEPA) maximum contaminant levels (MCL) for nitrate-nitrogen, alachlor, and atrazine are 10 mg/L, 2 µg/L, and 3 µg/L, respectively. The USEPA maximum contaminant level goal (MCLG) for cyanazine is 1 µg/L.

In 2004 nitrate concentrations exceeded USEPA guidelines for MCL seven times and atrazine concentrations exceeded the MCL on twenty-three occasions. The largest nitrate concentrations occurred during the month of May in sub-basin RA-32 (15mg/L) and RA-33 (17mg/L). The largest atrazine concentrations occurred during the month of May in sub-basins RA-32 and RA-33 with monthly averages of 16.5(µg/L) and 29.5(µg/L). High metolachlor concentrations also occurred during the month of May in sub-basins RA-32 and RA-33 with monthly averages of 5.9(µg/L) and 5.1(µg/L). Alachlor and cyanazine concentrations did not exceed USEPA guidelines for MCL's in 2004. However, elevated levels of alachlor did occur from April through July in sub-basins RA-33 (0.43µg/L) and RA-34 (0.54µg/L) and high cyanazine concentrations were present from May through July in RA-32 (0.35µg/L) and RA-34 (0.85µg/L).

Some studies in agricultural areas have related large nutrient and pesticide concentrations collected during spring and early summer to timing of runoff after applications of agricultural chemicals. This scenario would also apply to high nitrate-nitrogen concentrations early in the year if fertilizer were fall-applied. Increased organic nitrogen and phosphorus concentrations sometimes are related to runoff, because these constituents tend to bind to soil particles, which can be transported with runoff. Large ammonia plus organic nitrogen, phosphorus, and ortho-phosphorus concentrations in samples collected for this study do not always coincide with spring runoff. Increased concentrations of these constituents detected in samples collected during the fall and early spring months might indicate changes in stream quality related to biological processes. Animal manure also is a source of organic nitrogen.

Investigation of bacterial contamination of tributaries to Rathbun Lake continued in 2004. Bacterial counts in lakes and rivers in Iowa have led to public concern about the safety and quality of these natural resources. To address this issue ISU undertook monthly and event-based bacteria sample collections in the Rathbun Lake watershed. These bacteria samples are used to assess temporal trends in bacterial concentrations. Further, potential human sources of fecal contamination were investigated by also testing for caffeine in surface water samples. Caffeine is a non-naturally occurring substance in Iowa, thus finding it in surface water is indicative a fecal contamination. Caffeine was only present above the detection limit once during late-summer sampling at RA-40 (45 ng/L) Table 1.

The results from bacteria collections made from February to November 2004 are presented in Tables 2. The following are benchmark numbers, which may be of interest:

126 col. /100 ml – USEPA *Escherichia coli* limit for swimming beaches (geometric mean from at least 5 samples taken in 30 days)
235 col. /100 ml – USEPA *Escherichia coli* limit for swimming beaches (one-time event)
576 col. /100 ml – USEPA *Escherichia coli* criterion for infrequently used full-body contact recreation
33 col. /100 ml – USEPA *Enterococci* limit for swimming beaches (geometric mean from at least 5 samples taken in 30 days)
61 col. /100 ml – USEPA *Enterococci* limit for swimming beaches (one-time event)
151 col. /100 ml – USEPA *Enterococci* criterion for infrequently used full-body contact recreation

Iowa does not have a state standard for *Escherichia coli*, or any other bacterial constituent, in swimming beach areas. Preliminary investigations are underway to determine an appropriate number for Iowa, and the IDNR has proposed geometric mean water quality standard for bacteria (the geometric mean of 5 samples in a 30-day period exceeds 126 colony forming units of *Escherichia coli* bacteria per 100 ml of water). IDNR has also proposed a one-time maximum value for bacterial contamination (235 colony forming units of *Escherichia coli* bacteria per 100 ml of water). IDNR presently posts a warning on beaches if the bacterial concentration in beach water is exceeds the aforementioned criteria. There presently are not criteria for secondary body contact recreation (e.g. fishing) for any bacterial constituent.

There are no standards set for surface waters other than swimming beaches. Thus, there is no appropriate standard against which to compare the data presented below. However, high numbers do indicate pollution of these waters by fecal material, be it human-, livestock-, or wildlife-derived. Water-borne bacteria from these tributaries may reach Rathbun Lake. However, once the bacteria reach the lake, increased light penetration into the water column allows ultraviolet rays from sun to kill these bacteria. Thus, bacterial concentrations in the swimming beaches at Rathbun Lake are regularly low and safe.

Densities of *Escherichia coli* found in Rathbun Lake tributaries ranged from <10 to 46,000 col/100 ml in 2004. All sampling sites have had *Escherichia coli* concentrations that would be considered unsafe for swimming, but swimming does not occur at these locations. Densities of *Enterococci* found in Rathbun Lake tributaries ranged from <10 to 51,000 col/100 ml in 2004. All sampling sites have had *Enterococci* concentrations that would be considered unsafe for swimming, but swimming does not occur at these locations.

B. Lake Limnology

Rathbun Lake mixing is intermittent, meaning that it mixes from top to bottom during the ice-free season. On average (2000-2004) the lake has been stratified approximately 50% of the observed samplings during June through August. In 2004, Rathbun Lake was mixed during early and late June samplings and stratified during August. The high degree of wind fetch across the lake most likely allows the lake to mix during the summer period.

Intermittent mixing results in Rathbun Lake being well oxygenated throughout the year. There are times during summer stratification that hypoxic waters (those in which fish would have trouble living; <2 mg/L) are present in the lower region of the lake. Lake profiles collected by ISU staff for the statewide lake survey indicate that oxygen levels were high (8.0 mg/L) throughout the water column in early to late June, but that stratification and hypolimnetic hypoxia had set in below 12m during August. Low oxygen values in the deep waters occur due to the decomposition of plant material and other organic matter in the deepest part of the basin. Patterns in the lake water pH also reflect these same patterns, with slightly lower pH at the bottom of the lake than at the top in August. These lowered pH values occur because the hypolimnion is somewhat of a reducing environment (i.e., low dissolved oxygen). Conductivity mirrors these patterns because high conductivity values arise due to the generation of ions in the bottom waters where sediments are decomposing.

As part of Iowa’s statewide water quality monitoring, Rathbun Lake was sampled three times during the summers of 2000-2004. The summary data for these different monitoring efforts are shown in Table 3. Phosphorus concentrations are moderate to high in Rathbun Lake, yielding values that would normally indicate a mesotrophic to eutrophic reservoir. Values for phosphorus, chlorophyll *a,* and Secchi depth support a Trophic State Index indicative of mesotrophic to eutrophic conditions. In general, lakes in this category have decreased transparency, anoxic hypolimnion during summer stratification, macrophyte problems, and warm water fisheries. On average, Rathbun Lake has lower nutrient and chlorophyll *a* concentrations compared to many other Iowa Lakes. Values support that Rathbun Lake has superior water quality concerning nutrients and chlorophyll a concentrations to other lakes in Iowa. However, Secchi depth (water clarity) is generally worse or the same in Rathbun Lake relative to Iowa lakes. This is probably due to turbidity or high levels of suspended solids in the water column, because chlorophyll *a* levels in the water are generally quite low.

Surface and bottom phosphorus concentrations were similar in value until late June consistent with what is typical for a well-mixed system (Table 4). In July, during stratified conditions, bottom samples (0.06 mg/L) had slightly elevated phosphorus values compared to surface water (0.04 mg/L average). Nitrogen concentrations peaked in July. Even with mixed lake conditions, bottom nitrogen concentrations were higher than surface water samples until late June. In July and September, after stratification, bottom nitrogen concentrations were lower than values found near the surface.

Figure 1. Rathbun Lake watershed, with sampling sites.

Figure 2. Discharge (USGS 06903400) Chariton River at County Highway 14.

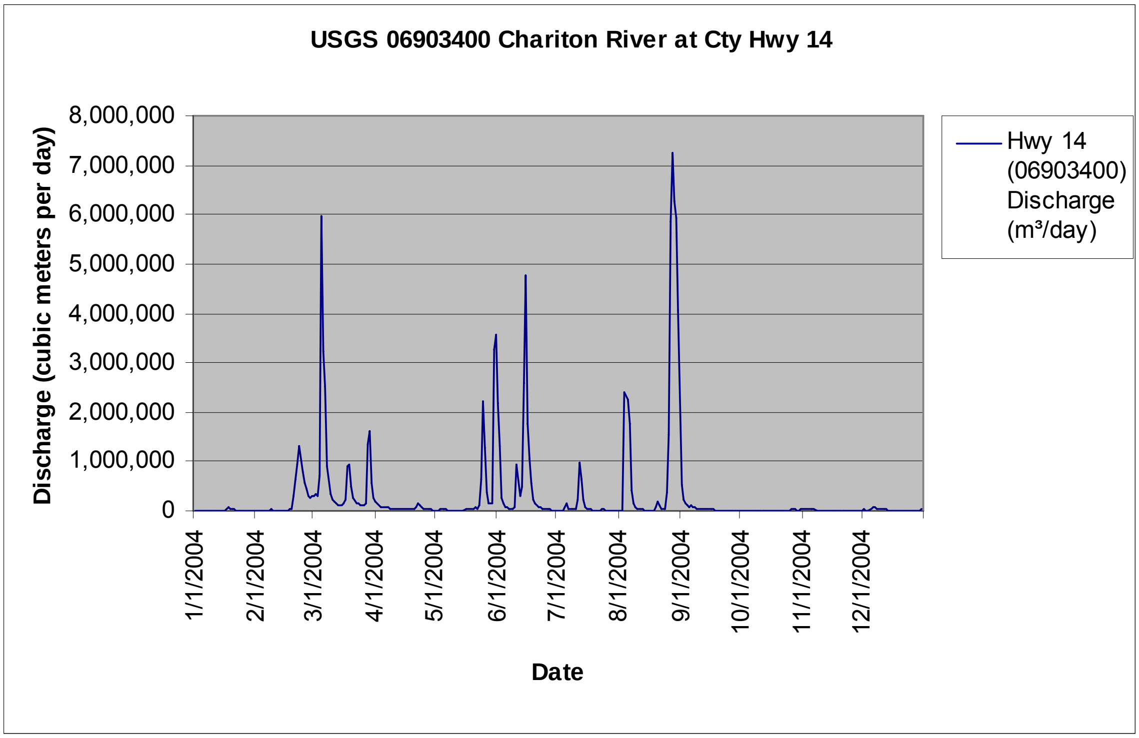

Figure 3. Discharge (USGS 06903700) South Fork Chariton River.

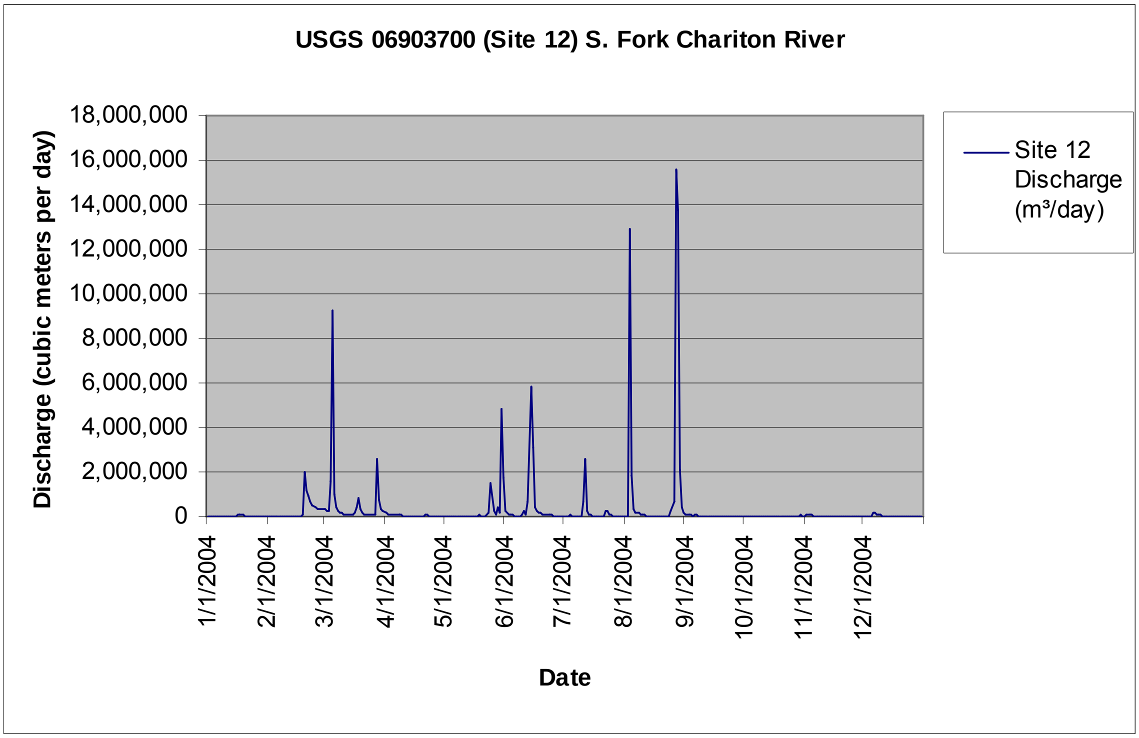

Figure 4. Annual Water Load (USGS 06903400) Chariton River at County Highway 14.

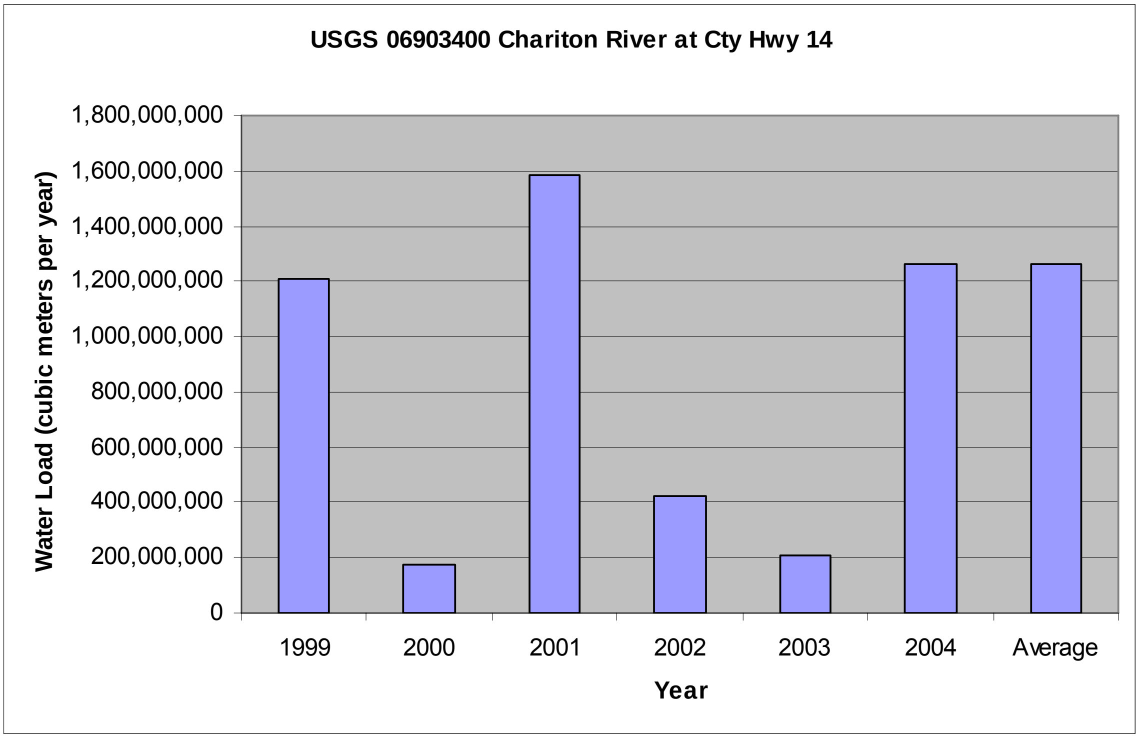

Figure 5. Annual Water Load (USGS 06903700) South Fork Chariton River.

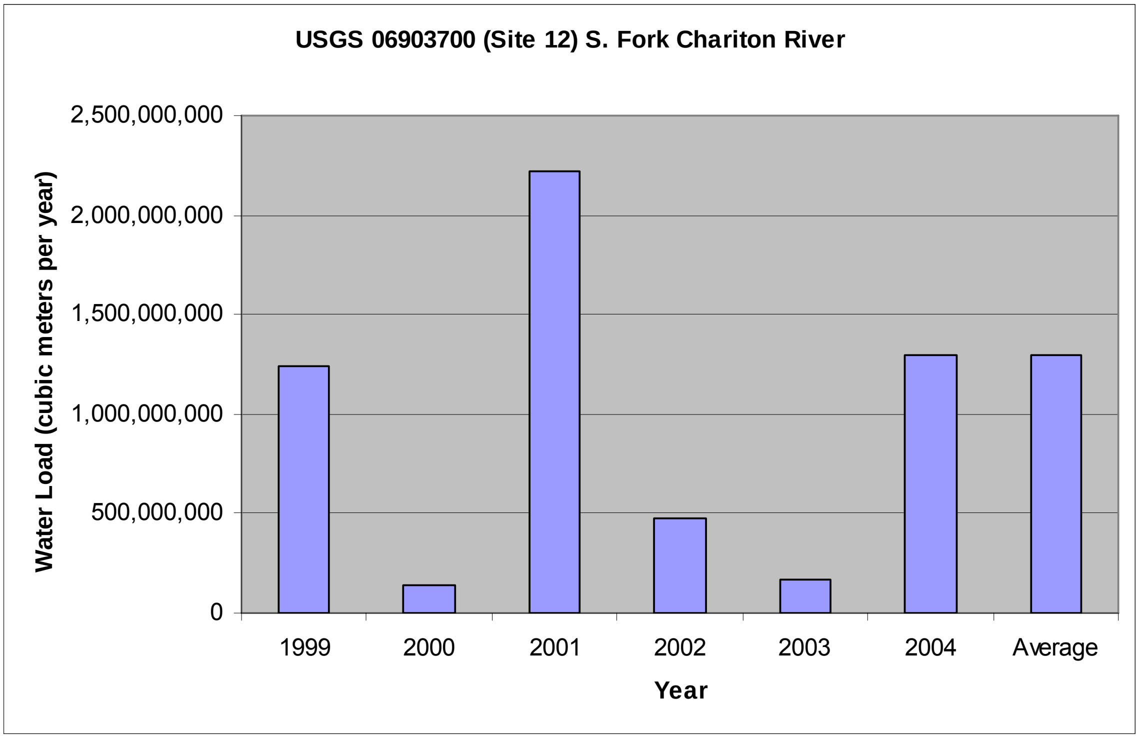

Figure 6. Sediment Flux, by sub-basin.

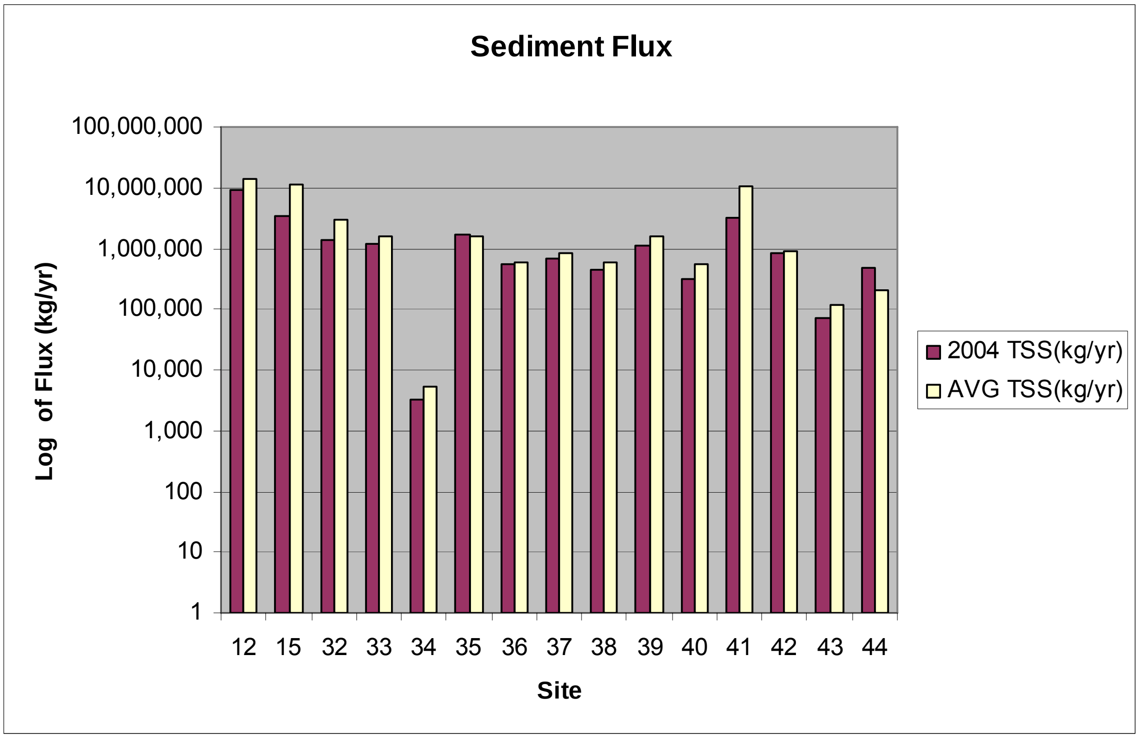

Figure 7. Sediment Yield, by sub-basin.

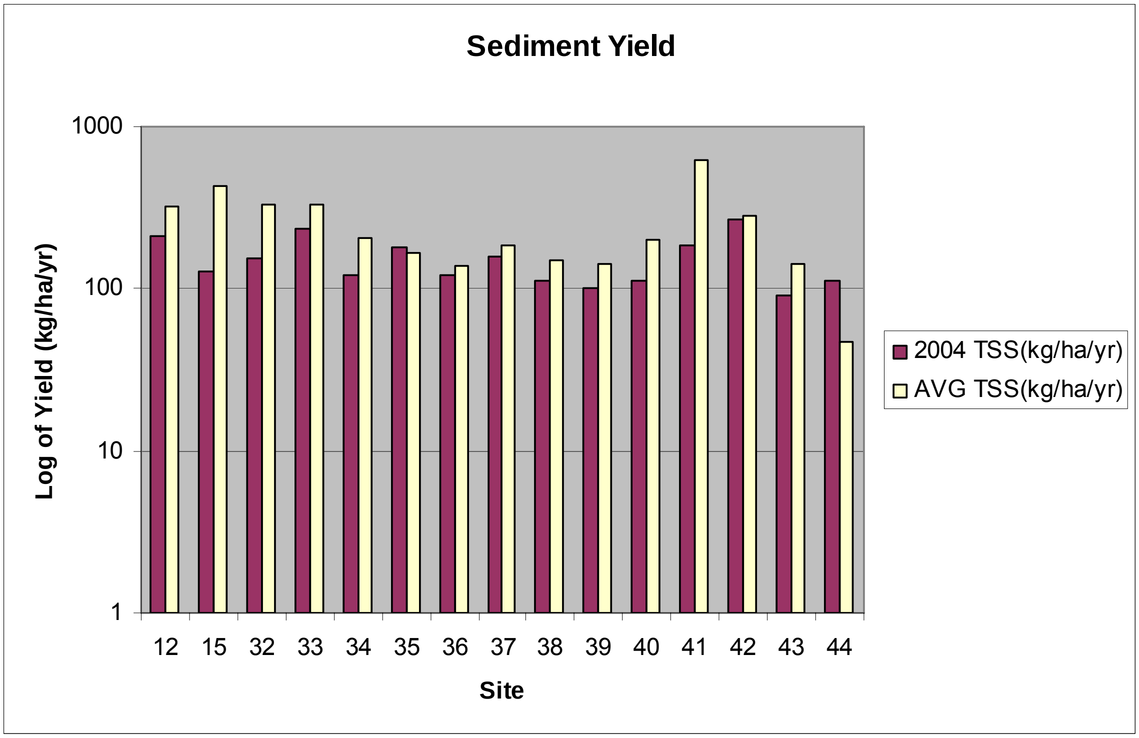

Figure 8. Phosphorus Flux, by sub-basin.

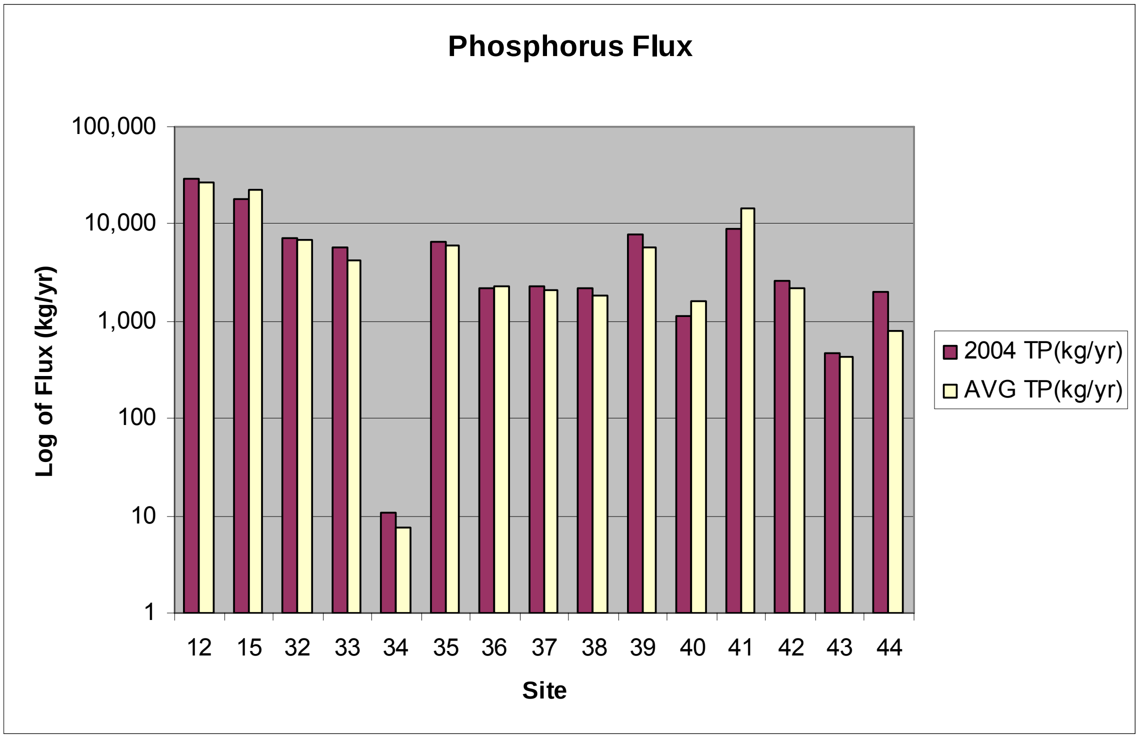

Figure 9. Phosphorus Yield, by sub-basin.

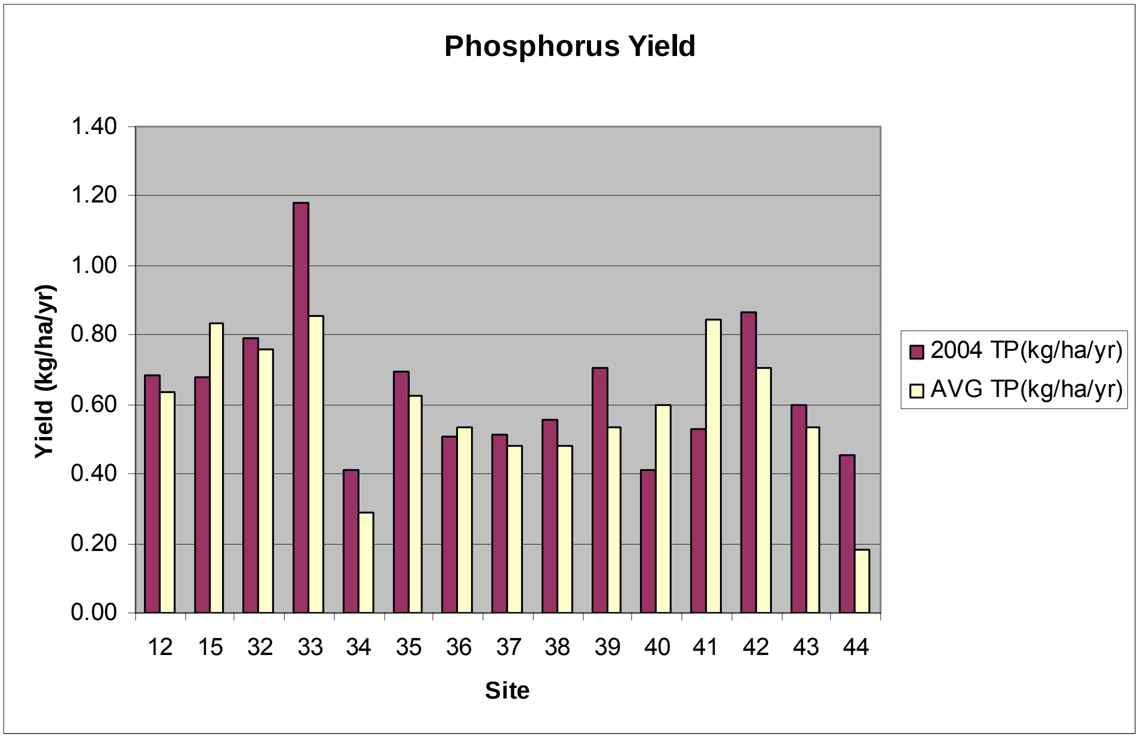

Figure 10. Nitrogen Flux, by sub-basin.

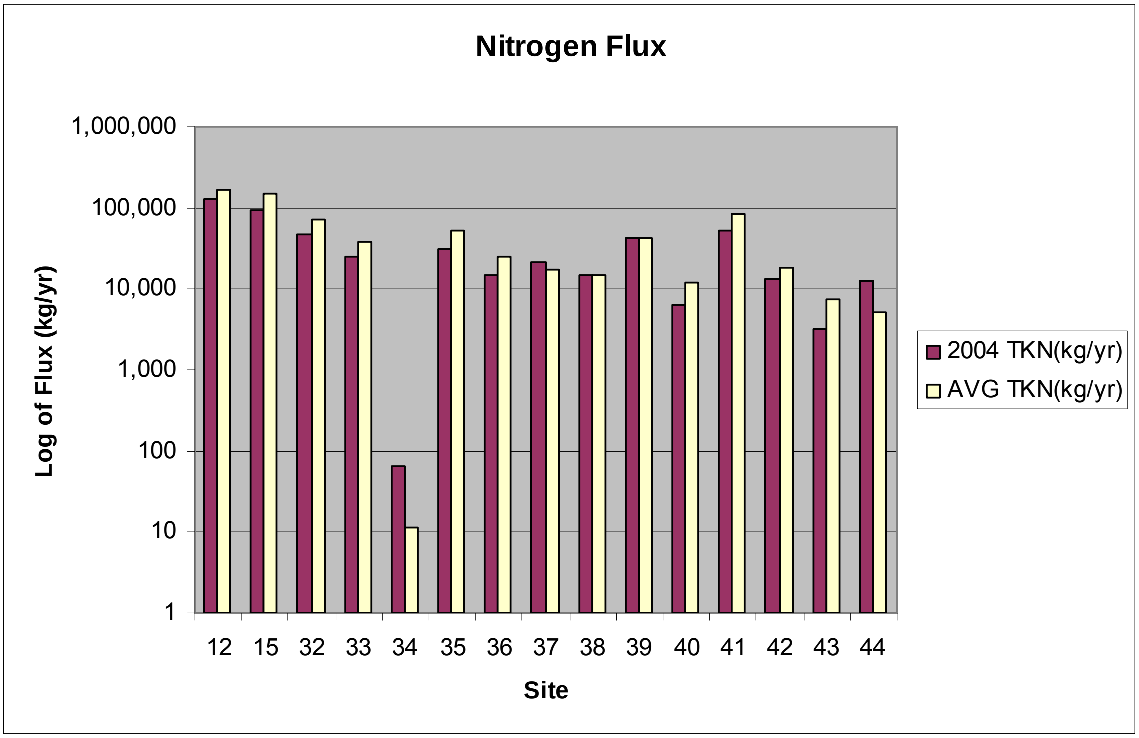

Figure 11. Nitrogen Yield, by sub-basin.

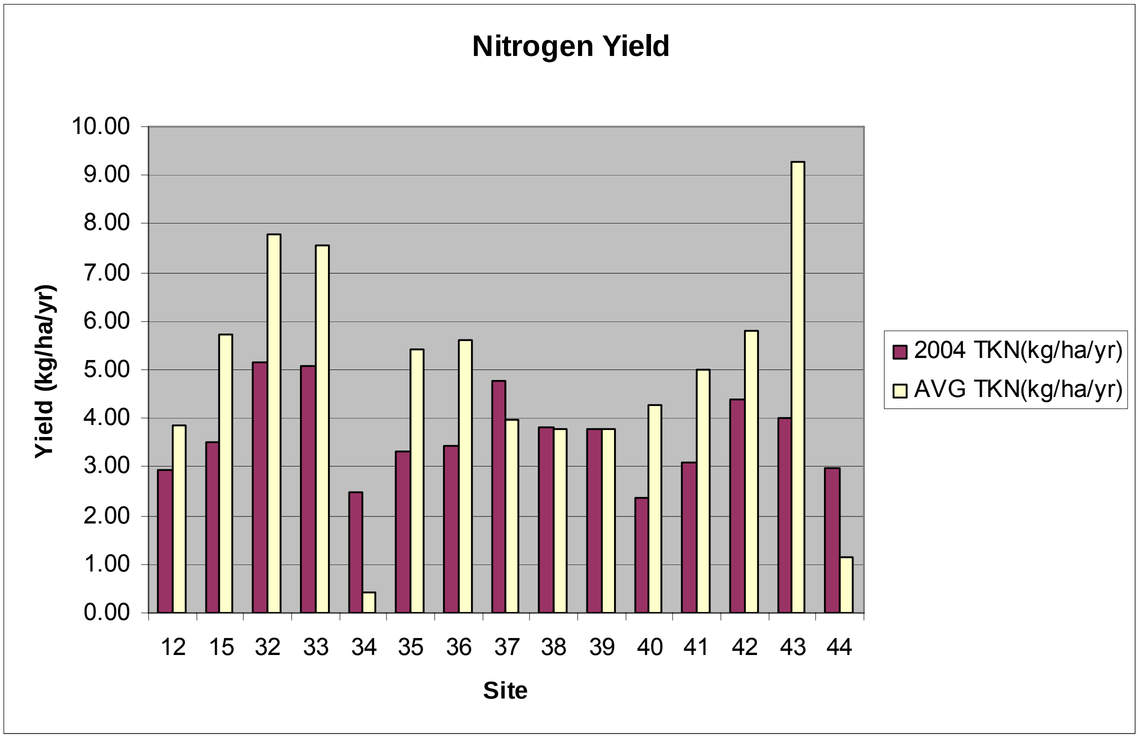

Figure 12. Cumulative annual export of sediment, nitrogen, and phosphorus from watershed sampling locations RA-12, RA-15, and RA-41.

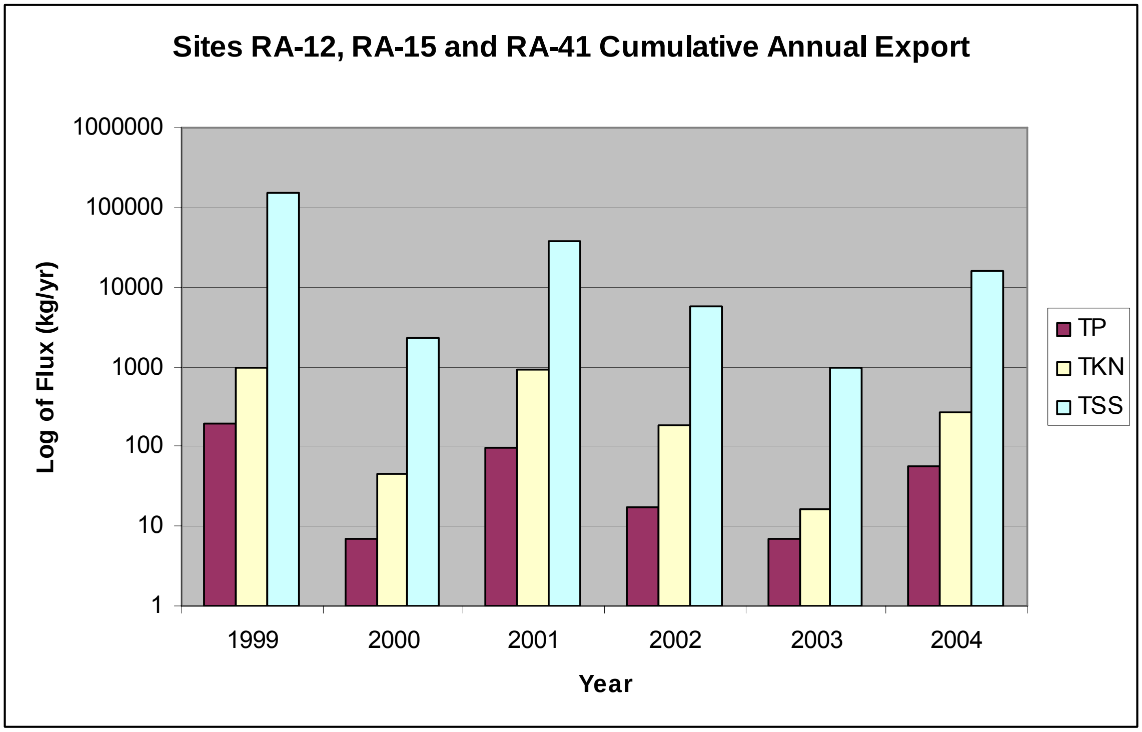

Table 1. Concentration of Caffeine in stream water samples, 2004. Units are in nanograms per liter.

Site	Sampling Date	Caffeine (ng/L)
12	8/17/2004	<40
15	8/17/2004	<40
32	8/17/2004	<40
33	8/17/2004	<40
34	8/17/2004	-
35	8/17/2004	<40
36	8/17/2004	-
37	8/17/2004	<40
38	8/17/2004	<40
39	8/17/2004	<40
40	8/17/2004	45
41	8/17/2004	<40
42	8/17/2004	-
43	8/17/2004	-
44	8/17/2004	<40

Note: “<” denotes that caffeine was present at concentrations below the detection limit.

Table 2. *Enterococci, Escherichia coli,* and *Fecal coliform* concentrations in stream water samples, 2004. Units are number of colony formers per 100 ml.

Site	**Sampling Date**	***Enterococci* (conc. /100mL)**	***Escherichia coli* (conc. /100mL)**	***Fecal Coliform* (conc. /100mL)**
RA-12	2/25/2004	70	120	70
RA-12	3/31/2004	410	370	480
RA-12	4/21/2004	420	45	500
RA-12	5/19/2004	51000	4700	68000
RA-12	5/26/2004	3200	11000	3300
RA-12	6/22/2004	300	780	300
RA-12	7/13/2004	4600	4500	4600
RA-12	7/20/2004	350	230	480
RA-12	8/17/2004	430	340	430
RA-12	9/21/2004	300	180	330
RA-12	10/19/2004	120	100	130
RA-12	11/16/2004	54	230	54
RA-15	2/25/2004	80	600	90
RA-15	3/31/2004	750	820	980
RA-15	4/21/2004	760	150	940
RA-15	5/19/2004	270	560	270
RA-15	6/22/2004	200	320	370
RA-15	7/13/2004	7000	9700	7100
RA-15	7/20/2004	360	230	410
RA-15	8/17/2004	180	150	180
RA-15	9/21/2004	320	250	380
RA-15	10/19/2004	10	45	10
RA-15	11/16/2004	18	160	18
RA-32	2/25/2004	70	180	70
RA-32	3/31/2004	570	320	640
RA-32	4/21/2004	4400	2800	6000
RA-32	5/19/2004	44000	46000	61000
RA-32	5/26/2004	2400	7700	2700
RA-32	6/22/2004	280	440	390
RA-32	7/13/2004	2800	2000	13000
RA-32	7/20/2004	910	680	1000
RA-32	8/17/2004	170	860	170
RA-32	9/21/2004	340	310	390
RA-32	11/16/2004	360	81	410
RA-33	2/25/2004	30	120	30
RA-33	4/21/2004	23000	3800	26000
RA-33	5/19/2004	4100	36000	5800
RA-33	5/26/2004	2000	7500	7500
RA-33	7/13/2004	3100	6900	3100
RA-33	8/17/2004	450	840	490
RA-33	9/21/2004	210	110	210

Table 2 (continued). *Enterococci, Escherichia coli,* and *Fecal coliform* concentrations in stream water samples, 2004. Units are number of colony formers per 100 ml.

Site	**Sampling Date**	***Enterococci*** **(conc. /100mL)**	***Escherichia coli*** **(conc. /100mL)**	***Fecal Coliform*** **(conc. /100mL)**
RA-33	10/19/2004	10	20	10
RA-33	11/16/2004	20	10	20
RA-34	2/25/2004	45	54	63
RA-34	5/19/2004	300	930	440
RA-34	6/22/2004	11000	2000	12000
RA-34	7/13/2004	2000	2300	2300
RA-34	7/20/2004	4600	4000	5200
RA-35	2/25/2004	40	120	40
RA-35	5/19/2004	2500	6600	2500
RA-35	5/26/2004	910	5800	1300
RA-35	6/15/2004	2600	13000	4400
RA-35	7/13/2004	4000	5800	4500
RA-35	7/20/2004	45000	7600	65000
RA-35	8/17/2004	81	230	81
RA-35	9/21/2004	50	80	50
RA-35	10/19/2004	80	63	80
RA-35	11/16/2004	27	72	27
RA-36	2/25/2004	10	110	10
RA-36	3/31/2004	310	410	370
RA-36	4/21/2004	2500	3000	2500
RA-36	5/19/2004	2600	2400	2600
RA-36	5/26/2004	2600	6400	2800
RA-36	6/15/2004	2200	12000	3600
RA-36	6/22/2004	190	300	200
RA-36	7/13/2004	2100	3100	2400
RA-36	7/20/2004	530	280	710
RA-36	9/21/2004	80	160	80
RA-36	11/16/2004	160	600	150
RA-37	2/25/2004	210	150	210
RA-37	3/31/2004	420	230	600
RA-37	4/21/2004	580	200	740
RA-37	5/19/2004	4000	1100	4900
RA-37	5/26/2004	3600	8300	4400
RA-37	6/15/2004	4000	10000	5700
RA-37	6/22/2004	2700	1900	2700
RA-37	7/13/2004	3900	1500	4800
RA-37	7/20/2004	580	230	820
RA-37	8/17/2004	680	130	690
RA-37	9/21/2004	2100	130	2400
RA-37	10/19/2004	460	530	490
RA-37	11/16/2004	72	50	81
RA-38	2/25/2004	10	45	10
RA-38	3/31/2004	340	330	390

Table 2 (continued). *Enterococci, Escherichia coli,* and *Fecal coliform* concentrations in stream water samples, 2004. Units are number of colony formers per 100 ml.

Site	**Sampling Date**	***Enterococci* (conc. /100mL)**	***Escherichia coli* (conc. /100mL)**	***Fecal Coliform* (conc. /100mL)**
RA-38	4/21/2004	480	570	600
RA-38	5/19/2004	6400	2800	6800
RA-38	6/22/2004	670	700	820
RA-38	7/13/2004	2600	2300	13000
RA-38	7/20/2004	1200	670	1500
RA-38	8/17/2004	680	2200	680
RA-38	10/19/2004	240	170	260
RA-38	11/16/2004	90	420	100
RA-39	2/25/2004	30	110	30
RA-39	3/31/2004	270	360	300
RA-39	4/21/2004	200	340	200
RA-39	5/19/2004	5100	4900	5500
RA-39	5/26/2004	2000	6000	2600
RA-39	6/22/2004	270	540	580
RA-39	7/13/2004	4300	4300	5000
RA-39	7/20/2004	740	740	970
RA-39	8/17/2004	450	780	450
RA-39	9/21/2004	2000	330	2000
RA-39	10/19/2004	200	110	210
RA-39	11/16/2004	70	90	100
RA-40	2/25/2004	520	2100	540
RA-40	3/31/2004	40	63	60
RA-40	4/21/2004	690	480	770
RA-40	5/19/2004	950	6000	1000
RA-40	5/26/2004	3400	4500	4000
RA-40	6/22/2004	590	680	730
RA-40	7/13/2004	12000	4200	25000
RA-40	7/20/2004	800	260	1000
RA-40	8/17/2004	490	390	490
RA-40	9/21/2004	330	200	400
RA-40	10/19/2004	330	520	350
RA-40	11/16/2004	380	740	470
RA-41	2/25/2004	10	10	10
RA-41	3/31/2004	210	540	210
RA-41	4/21/2004	600	200	780
RA-41	5/19/2004	230	410	270
RA-41	5/26/2004	4000	14000	4000
RA-41	6/22/2004	460	300	570
RA-41	7/13/2004	5700	4200	7800
RA-41	7/20/2004	830	340	1100
RA-41	8/17/2004	650	760	660
RA-41	9/21/2004	210	160	260
RA-41	10/19/2004	10	210	10

Table 2 (continued). *Enterococci, Escherichia coli,* and *Fecal coliform* concentrations in stream water samples, 2004. Units are number of colony formers per 100 ml.

Site	**Sampling Date**	***Enterococci* (conc. /100mL)**	***Escherichia coli* (conc. /100mL)**	***Fecal Coliform* (conc. /100mL)**
RA-41	11/16/2004	20	110	20
RA-42	2/25/2004	18	150	27
RA-42	4/21/2004	670	40	840
RA-42	5/19/2004	2300	3700	2500
RA-42	5/26/2004	4100	9000	4700
RA-42	6/15/2004	4500	22000	7100
RA-42	6/22/2004	600	750	700
RA-42	7/13/2004	5600	2600	9300
RA-43	2/25/2004	100	140	100
RA-43	3/31/2004	130	230	160
RA-43	5/26/2004	950	9400	1200
RA-43	6/15/2004	2100	10000	2900
RA-43	6/22/2004	880	940	1300
RA-43	7/13/2004	930	1200	940
RA-43	7/20/2004	1400	880	4500
RA-43	9/21/2004	80	740	80
RA-43	11/16/2004	90	180	90
RA-44	2/25/2004	30	40	30
RA-44	3/31/2004	210	540	210
RA-44	4/21/2004	920	1500	960
RA-44	5/19/2004	730	1200	740
RA-44	5/26/2004	2800	7900	6200
RA-44	6/15/2004	2000	14000	2200
RA-44	6/22/2004	200	260	250
RA-44	7/13/2004	550	2000	590
RA-44	7/20/2004	720	550	910
RA-44	8/17/2004	100	220	100
RA-44	9/21/2004	10	270	10
RA-44	10/19/2004	10	50	10
RA-44	11/16/2004	110	10	110

Table 3. Summary table of summer measurements made on Rathbun Lake and all Iowa Lakes during the 2000-2004 Iowa State University Lakes Survey.

	Total Phosphorus	Total Nitrogen-N	Chlorophyll *a*	Secchi Depth	Trophic State Index
Units	mg/L	mg/L	µg/L	m	
Rathbun 2004	0.04	1.25	17.3	0.8	60
Rathbun AVG	0.07	1.32	9.6	1.0	58
IA Lakes AVG	0.12	2.68	32.7	1.2	63

Table 4. Summary table of summer measurements made on Rathbun Lake (Site RA-3) during the 2004 USACE Monitoring Program.

	Total Phosphorus	Total Nitrogen-N	Location
Units	mg/L	mg/L	
4/19/04	0.07	0.86	Surface
4/19/04	0.08	0.96	Bottom
5/20/04	0.09	0.63	Surface
5/20/04	0.10	0.68	Bottom
6/22/04	0.06	0.70	Surface
6/22/04	0.05	0.82	Bottom
7/19/04	0.04	1.00	Surface
7/19/04	0.06	0.82	Bottom
9/21/04	0.10	0.84	Surface
9/21/04	0.10	0.77	Bottom