

DRAFT REPORT
2000 Scope of Work by
Iowa State University Limnology Laboratory
For
Rathbun Land and Water Alliance
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A. Tributaries

Personnel of the Iowa State University (ISU) Limnology Laboratory (LL) collected water samples from streams at 14 stations in the Rathbun Lake watershed during calendar year 2000: 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 (Fig. 1). The data collected was funded by a cooperative agreement between the Rathbun Land and Water Alliance 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.

Nine 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 mainstem 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 mainstem 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 was 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 0 to 14.1 m³/s (cubic meters per second, 1 m³/s ~ 16,000 gpm). Many of the smaller streams had low- to no-flow during the summer and fall of 2000. Flows at the mainstem stations RA-12 and RA-15 were less than 0.05 m³/s (~ 13 gpm) on these summer sampling dates. The largest discharges during sampling typically occurred during summer of 2000. The largest flow at all stations but RA-41 occurred during in June 2000 following a storm event. The largest flow at station RA-41 occurred in March 2000. The timing and volume of maximum discharges occurring at the 12 stations where there is no continuous recording information is unknown. Continuous records for the Chariton River indicate that 2000 was a relatively low-flow year, punctuated by 3 high-flow events. These events occurred in late June, early July, and mid-August (Fig. 2). Continuous records for the South Fork Chariton River were more variable in 2000 with numerous high-flow events

occurring in the spring and early summer (Fig. 3). The highest flow for both of these locations occurred on June 27, 2000

Dissolved-oxygen concentrations ranged from 1.5 to 18.6 mg/L (milligrams per liter). The annual range of dissolved-oxygen concentration at the mainstem sampling stations was narrower, 1.8 to 16.1 mg/L. The dissolved-oxygen data followed expected seasonal trends; highest during cold water temperatures and lowest during warm water temperatures.

Sediment concentrations in samples collected at the 14 sampling stations ranged from 3.4 to 534 mg/L. Two sampling stations had maximum sediment concentrations of greater than 500 mg/L, RA-40 (June) and RA-43 (March). Maximum sediment concentrations were observed at the same time as maximum discharge was observed for stations RA-12, RA-15, RA-33, RA-35, RA-36, RA-38, and RA-39.

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 is needed to determine continuous or annual sediment fluxes. 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. Also, sediment transport is highly dependent on but not limited to landuse, timing and intensity of rainfall, and season. Still, annual sediment fluxes can be estimated. For this exercise, we estimated daily discharge for each sampling site from the daily discharge at nearby continuous monitoring station, using subbasin area to determine relative water contribution. We then estimated daily suspended sediment concentrations using the data from sampling events before and after that date. This resulted in estimates of annual sediment flux from each subbasin. Comparisons of sediment data can be made by looking at annual sediment yield which is total annual flux divided by drainage area to derive a per unit land area yield. RA-40 had the largest annual sediment yield of 56.8 kg/ha (Fig. 4). RA-34 had no sediment yield, because no water was observed flowing in this channel in 2000. Stations RA-12 and RA-15 had annual sediment yields of 26.1 and 38.7 kg/ha/year, respectively. These two stations have the largest drainage areas, and in 2000 they had the largest total fluxes of sediment to Rathbun Lake. RA-12 and RA-15 had total annual sediment fluxes of 1.12 and 1.03 metric tons, respectively (Fig. 4). (1 metric ton = 1.1 US tons)

Phosphorus, nitrogen, and silica 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 is 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. Also, nutrient transport is highly dependent on but not limited to

landuse, 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 subbasin 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 subbasin. Comparisons of nutrient data can be made by looking at annual nutrient yield which is total annual flux divided by drainage area to derive a per unit land area yield. Stations RA-36 and RA-40 had the largest annual phosphorus yields of 0.13 kg/ha. RA-34 had no phosphorus, nitrogen, or silica yield, because no water was observed flowing in this channel in 2000. Station RA-37 had the largest annual nitrogen yield of 1.1 kg/ha. Station RA-40 had the largest annual silica yield of 15.8 kg/ha. Station RA-15 had annual phosphorus, nitrogen, and silica yields of 0.09, 0.5, and 15.5 kg/ha, respectively, while station RA-12 had annual phosphorus, nitrogen, and silica yields of 0.09, 0.7, and 13.2 kg/ha. Station RA-12, the South Fork Chariton River Drainage, dominated nutrient flux to Rathbun Lake during the period of study, contributed 28,000 kg of nitrogen, 3,800 kg of phosphorus, and 566,000 kg of silica to the lake (Figs. 5-7).

Annual differences in water, sediment and nutrient flux are quite evident when comparing 1999 to 2000. In 1999, Chariton reported 35.20 inches of rain for the year, while 33.16 inches of rain fell in 2000. Normal annual precipitation for Chariton is 35.48 inches. The 2 inch difference in rainfall meant that nearly 19.5 billion more gallons of water were deposited on the watershed in 1999 than in 2000. Additionally, of the 33.16 inches that fell in 2000, 11.21 inches fell in June. March, April, and May were very dry, which resulted in little water, sediment, or nutrient movement to the lake. The wet period in June probably initially recharged groundwater supplies, so no significant runoff occurred until late June. Using data from the USGS gauging stations in the watershed, nearly 203 billion m³ (53.6 billion gallons) of water passed by these two gauges in 1999, while 20.4 billion m³ (5.4 billion gallons) of water passed by in 2000. This difference in water flux resulted in huge differences in sediment and nutrient fluxes. Using data from sampling sites RA-12, RA-15, and RA-41, sediment flux in 1999 was 154,000 metric tons (170,000 t), while sediment flux in 2000 was 2,305 metric tons (2,540 t). Similarly, phosphorus flux was 199 metric tons (219 t) in 1999, and 6.9 metric tons (7.6 t) in 2000. Nitrogen flux was 961 metric tons (1,059 t) in 1999, and 46.4 metric tons (51.1 t) in 2000. Silica flux was 107,900 metric tons (119,000 t) in 1999, and 1,084 metric tons (1,195 t) in 2000. These large annual differences could have many causes, but differences in timing and intensity of rainfall is probably a primary contributor.

Seasonal differences in chemical water quality are indicated by the water-quality data (see USACE report data). The largest ammonia-nitrogen, nitrate-nitrogen, alachlor, atrazine, cyanazine, and metolachlor concentrations generally occur in samples collected during June. High concentrations of ammonia-nitrogen also occurred in July, while high concentrations of nitrate-nitrogen also occurred in November. Samples collected June 27, 2000 coincided with a runoff event in the watershed and generally had the largest concentrations detected during the sampling period. 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 in November if fertilizer was 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 orthophosphorus 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 months might indicate changes in stream quality related to biological processes. Animal manure also is a source of organic nitrogen.

Notable differences between the watersheds are indicated by peak atrazine concentrations, all of which occurred during June sampling (regular sampling, 6/13/2000 or storm sampling, 6/27/2000). Atrazine concentrations ranged from 0.31 µg/L at RA-41 to 32.30 µg/L at RA-38 on June 13, and from 1.90 µg/L at RA-39 to 11.50 µg/L at RA-34 on June 27 (see USACE report data).

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. None of the samples collected from the 13 stations had nitrate nitrogen concentrations greater than the MCL. Alachlor concentrations did not exceed the MCL in any of the samples collected, and cyanazine concentrations did not exceed the MCLG in any of the samples collected. Atrazine concentration in at least one sample collected at each station exceeded the MCL. Atrazine concentrations generally exceeded the MCL in samples collected in June (for complete pesticide data listing, see USACE report data).

Investigation of bacterial contamination of tributaries to Rathbun Lake continued in 2000. 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. Table 1 shows caffeine concentrations found during sampling in 2000, and potential sources are indicated where caffeine was found.

The results from bacteria collections made from March 28 to November 14 are presented in Tables 2 and 3. The bacterial results are very reflective of numbers seen in collections from the Mississippi River, and are lower than results published from a study of the Lower Kansas River basin. In some cases bacterial concentration in the streams are higher than the benchmark set for swimming beach concentrations (235 colonies/100 ml). The following are benchmark numbers which may be of interest:

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

Iowa does not have a state standard for E. coli, or any other bacterial constituent, in swimming beach areas. Preliminary investigations are underway to determine an appropriate

number for Iowa. Iowa presently posts warning on beaches if the bacterial concentration in beach water is greater than 126 col./100ml. There presently is not a criteria for secondary body contact recreation (e.g. fishing) for E. coli.

EPA has also set criteria for enterococci bacteria. Beaches are considered unsafe if the 30 day-5 sample geometric mean is greater than 33 col./100 ml of enterococcus bacteria. There is no secondary body contact recreation criteria set for enterococci bacteria.

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. But, 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. Once the bacteria reach the lake, increased light penetration into the water column allows ultraviolet rays from the sun to kill these bacteria. Thus, bacterial concentrations in the swimming beaches at Rathbun Lake are regularly low and safe.

Densities of E. coli found in Rathbun Lake tributaries ranged from <10 to >24,000 col/100 ml in 2000 (Table 2). All sampling sites have had E. 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 2000 col/100 ml in 2000 (Table 3). 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 is dimictic, meaning that it mixes from top to bottom twice during the ice-free season. Summer stratification is relatively weak, however, and it deepens and erodes during the windy part of August. Stratification was lost in early September. The high degree of wind fetch across the lake, probably keeps the lake mixed during all but the summer period of stagnation. There was some indication that the lake set up ephemeral stratification in late, September, probably during a period of relative calm.

The lake is generally well-oxygenated throughout the year. Hypoxic waters (those in which fish would have trouble living; <2 mg/L) only occur briefly in the deepest water in mid- to late-summer. 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 lakewater pH also reflect these same patterns, with slightly lower pH at the bottom of the lake than at the top. 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.

It is rather difficult to say much about lake nutrients, but some conclusions can be drawn. Phosphorus concentrations are moderate to high in Rathbun Lake, yielding values that would normally indicate a mesotrophic to eutrophic reservoir. Phosphorus peaked in July, probably due to influx from the large rain events in the watershed in late June and early July. Corresponding to this July phosphorus peak was a peak in chlorophyll *a* concentration in the surface layer of Rathbun Lake. Additionally, nitrogen concentrations were moderate to low, peaking in June. This is probably a result of inflows from the watershed carrying spring-applied fertilizer runoff.

Table 1. Concentration of caffeine in water samples taken 9/12/2000.

Site	Caffeine Concentration (ng/L)	Source??
12	18 J	Septic systems, lagoons at Humeston, Millerton or Allerton?
15	<40	
32	<40	
33	Dry, no sample taken	
34	Dry, no sample taken	
35	Dry, no sample taken	
36	Dry, no sample taken	
37	Dry, no sample taken	
38	Dry, no sample taken	
39	<40	
40	Dry, no sample taken	
41	<40	
42	Dry, no sample taken	
43	Dry, no sample taken	

Table 2. E. coli concentrations in stream water samples, 2000. Units are MPN/100 ml.

Site	3/28	4/18	5/16	6/13	6/27*	7/19	8/15	9/12	10/17	11/14
12	41	10	<10	360	930	930	390	85	86	850
15	<10	10	110	190	2100	1300	63	930	86	20
32	230	41	<10	52	260	1300	170	30	--	--
33	41	10	10	41	500	320	460	--	--	63
34	--	1000	--	--	1300	--	--	--	--	--
35	<10	10	<10	10	1500	260	680	--	150	98
36	10	130	10	370	270	1000	--	--	150	200
37	<10	<10	190	280	730	910	120	--	31	750
38	10	95	31	330	380	>24000	160	--	41	200
39	41	140	1300	700	1100	3100	1500	400	150	300
40	20	<10	--	1200	790	200	180	170	610	1800
41	10	10	31	86	1100	380	86	--	290	97
42	20	260	430	<10	1100	120	--	--	--	270
43	1300	20	<10	61	550	4400	1200	--	10	<10

*stormwater, -- indicates no sample

Table 3. Enterococci concentrations in stream water samples, 2000. Units are MPN/100 ml.

Site	3/28	4/18	5/16	6/13	6/27*	7/19	8/15	9/12	10/17	11/14
12	10	<10	30	85	97	180	<10	<10	<10	31
15	<10	<10	10	20	170	710	<10	31	150	<10
32	10	<10	20	<10	30	640	120	10	--	--
33	10	10	<10	20	52	150	130	--	--	10
34	--	200	--	--	780	--	--	--	--	--
35	<10	<10	52	<10	110	190	84	--	31	20
36	20	97	85	160	31	460	--	--	74	10
37	<10	<10	<10	10	10	20	52	--	<10	63
38	10	30	<10	31	63	2000	20	--	<10	20
39	<10	72	570	170	140	1700	160	20	63	74
40	<10	61	--	320	200	200	52	--	160	10
41	10	31	20	31	110	160	63	10	130	10
42	<10	10	190	<10	51	31	--	--	--	<10
43	720	52	<10	590	220	1500	1600	--	10	<10

*stormwater, -- indicates no sample

Figure 1. Rathbun Lake watershed, with sampling sites.

Rathbun Lake Watershed

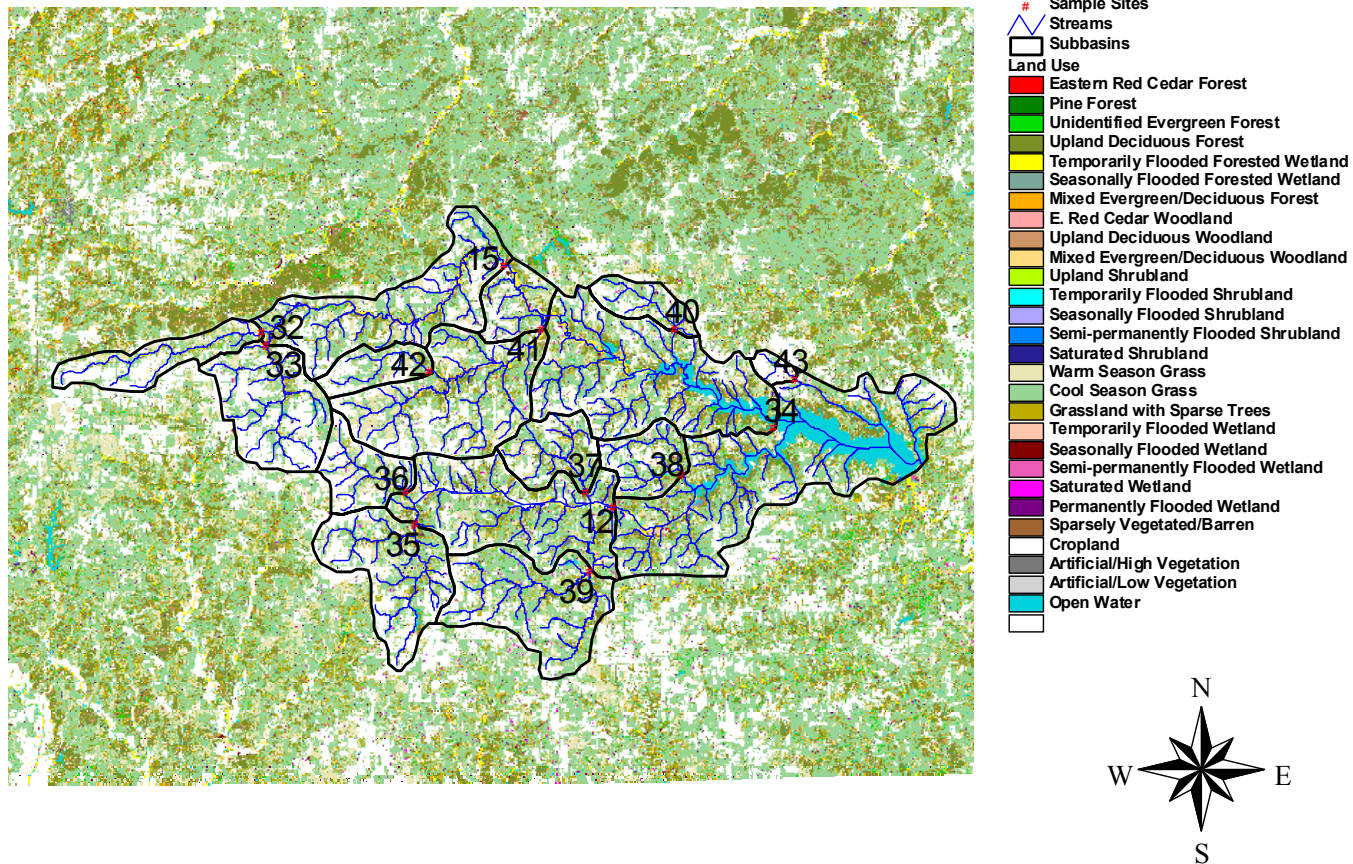


Figure 2. Chariton River Discharge.

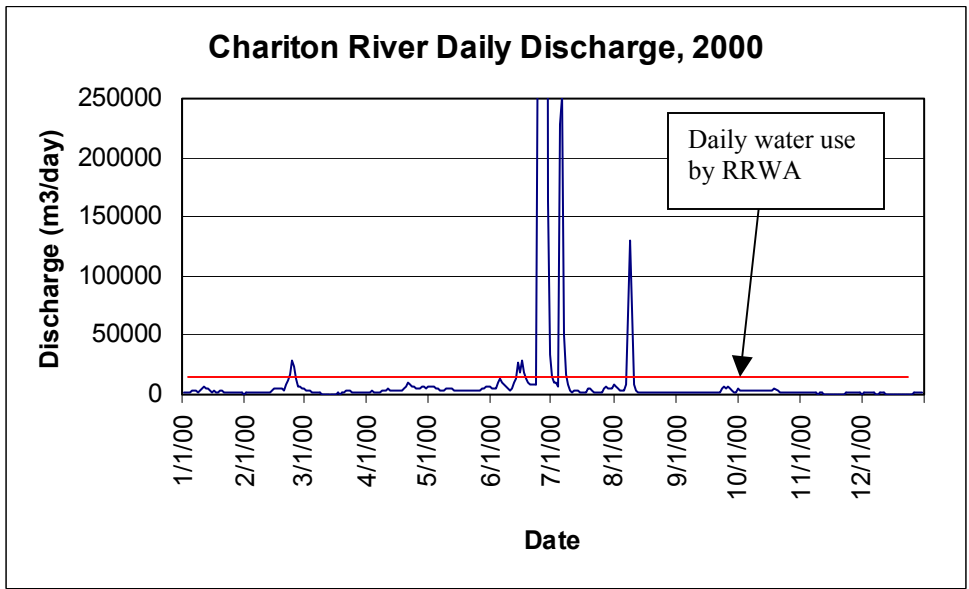
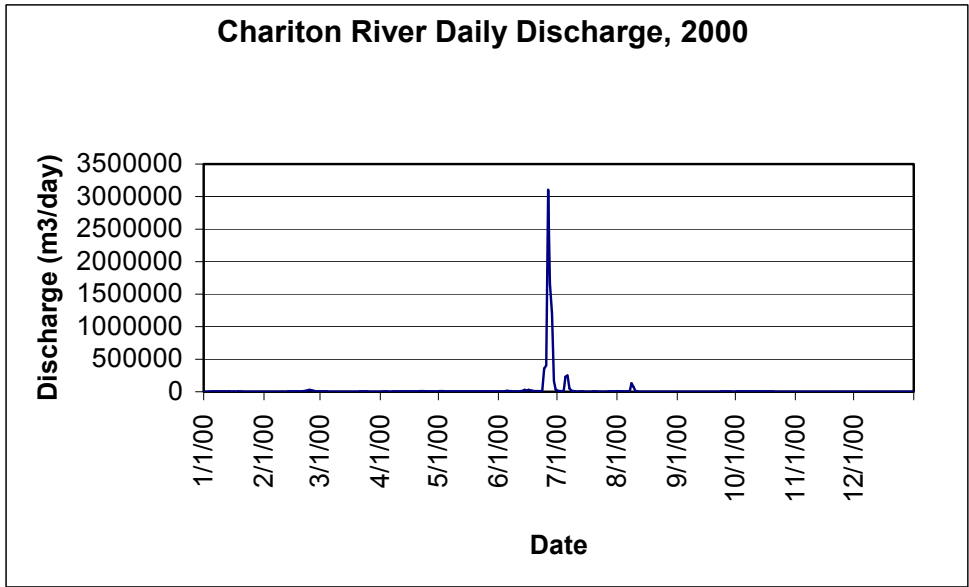


Figure 3. South Fork Chariton River Discharge.

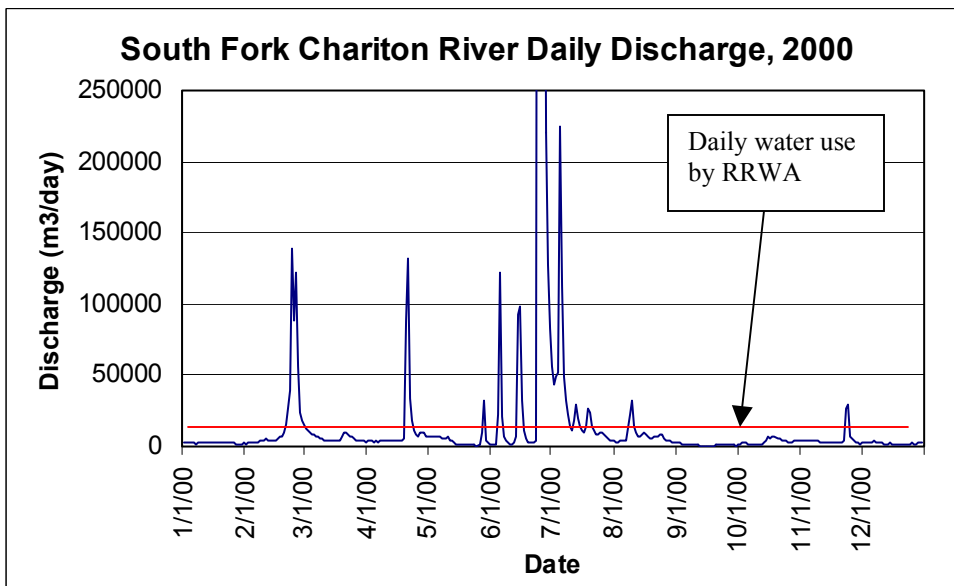
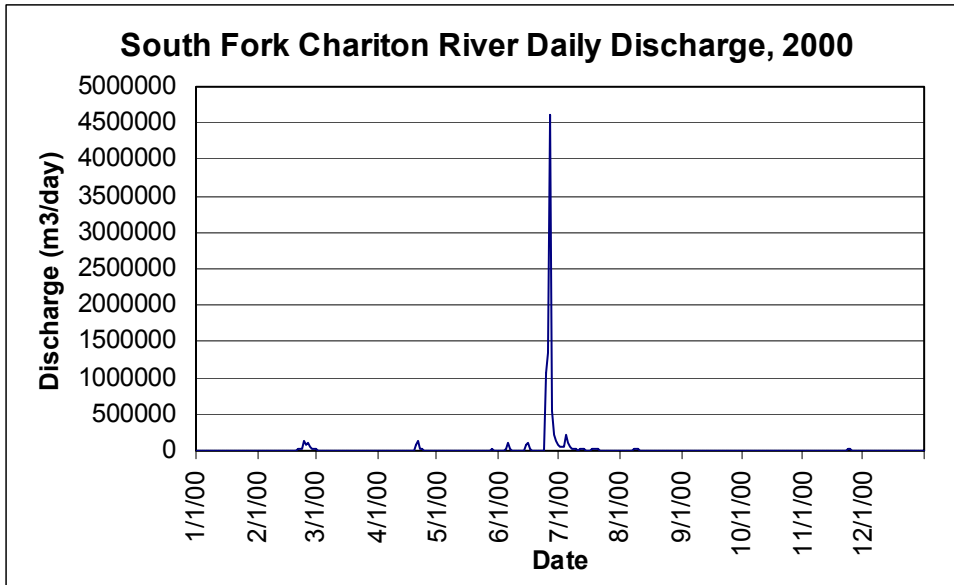


Figure 4. Sediment Flux and Loss, by subbasin.

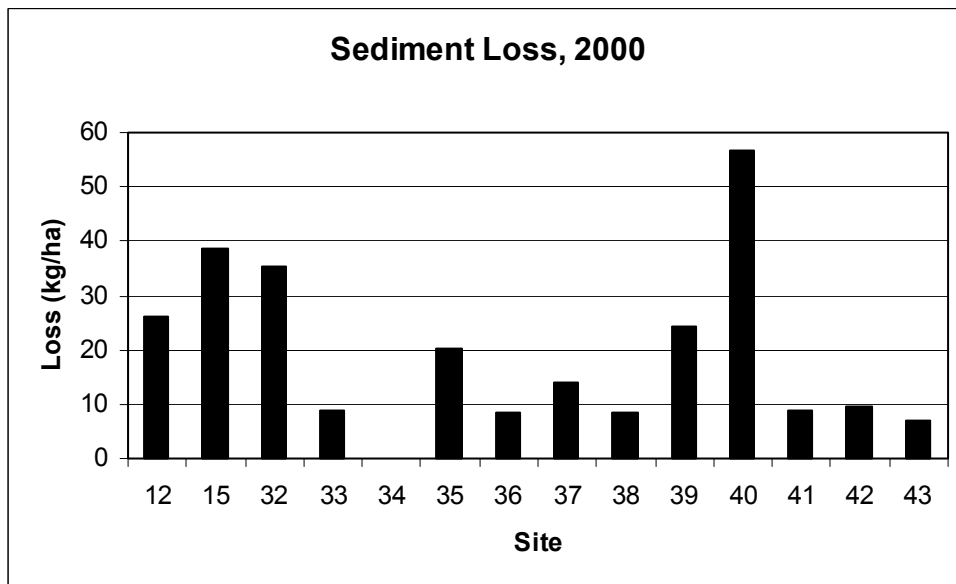
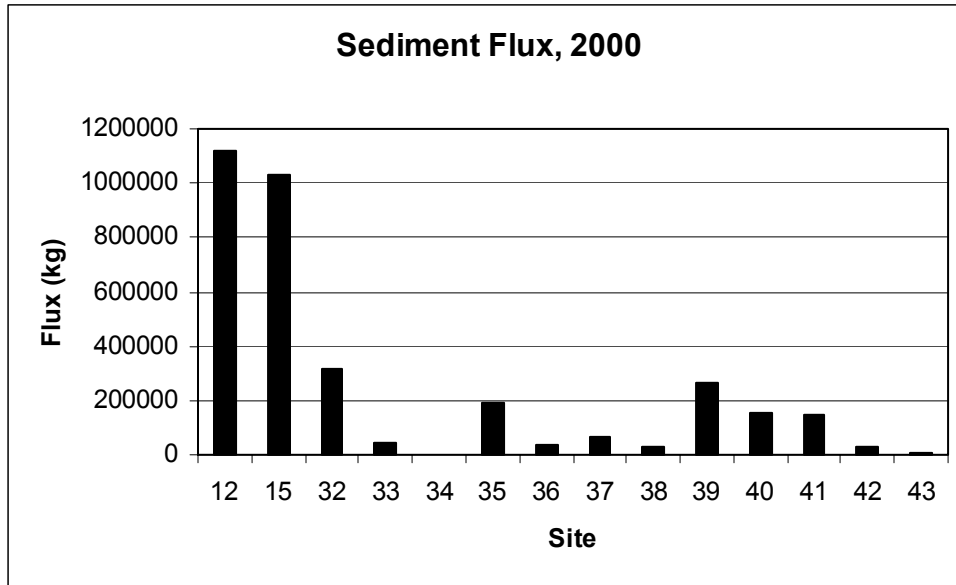


Figure 5. Phosphorus Flux and Loss, by subbasin.

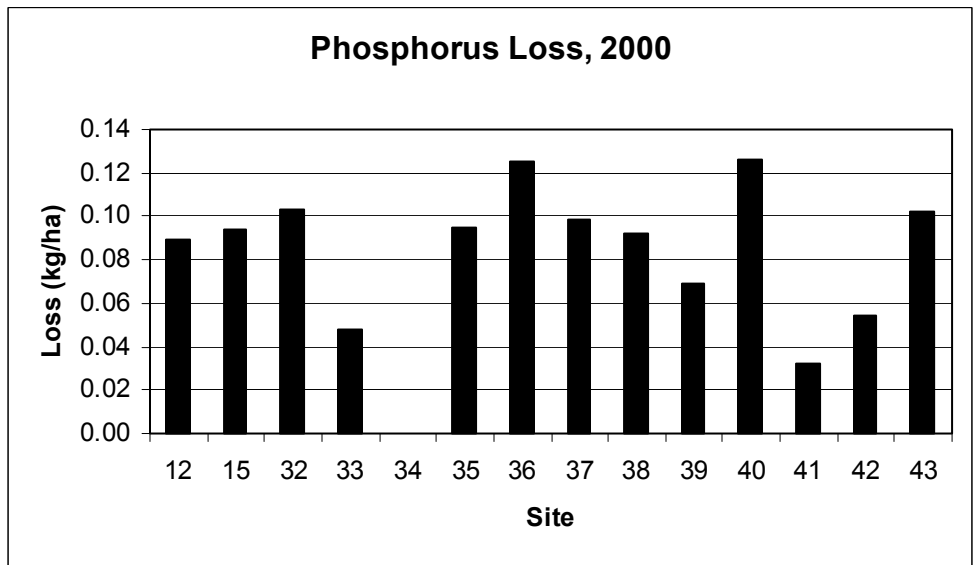
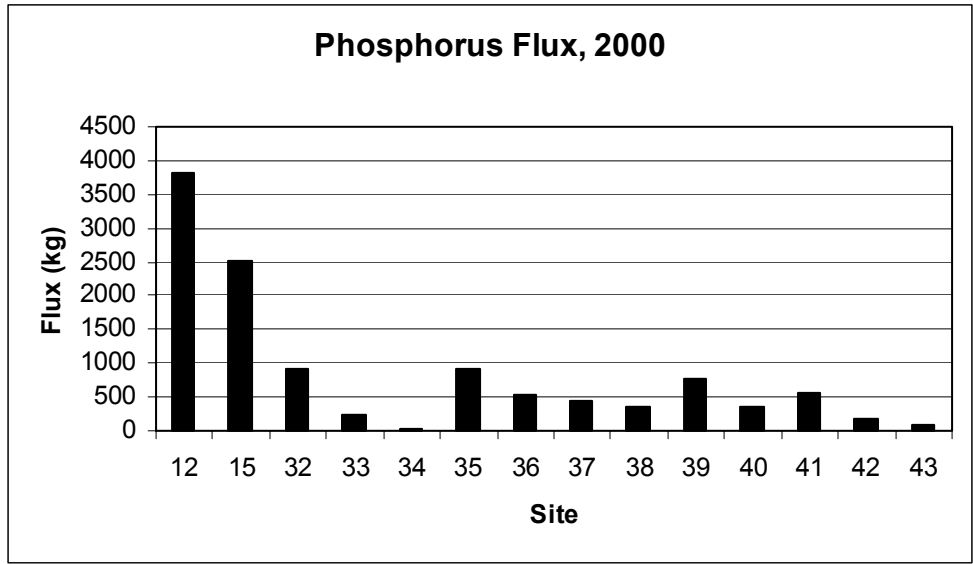


Figure 6. Nitrogen Flux and Loss, by subbasin.

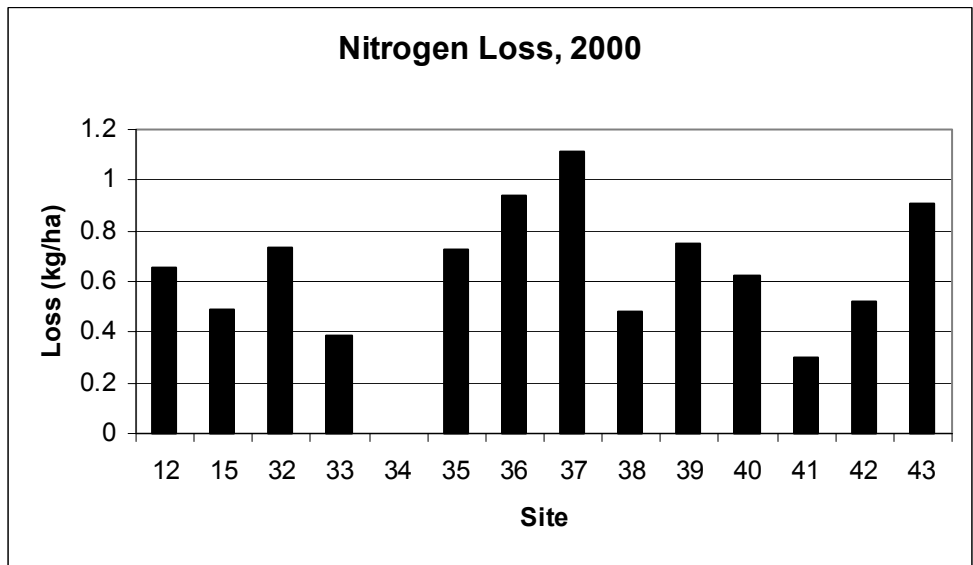
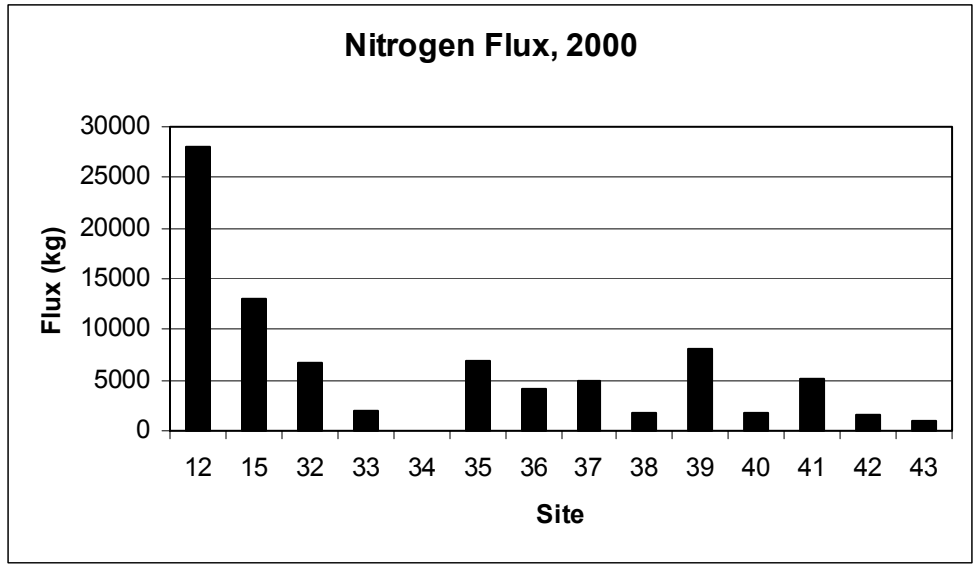


Figure 7. Silica Flux and Loss, by subbasin.

