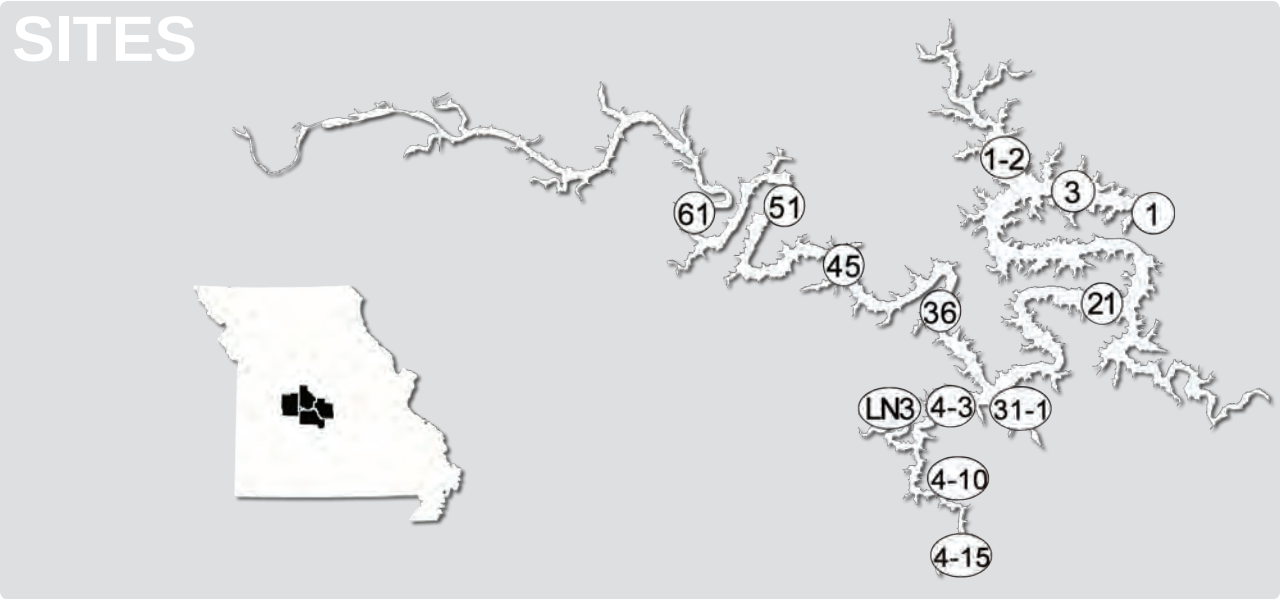
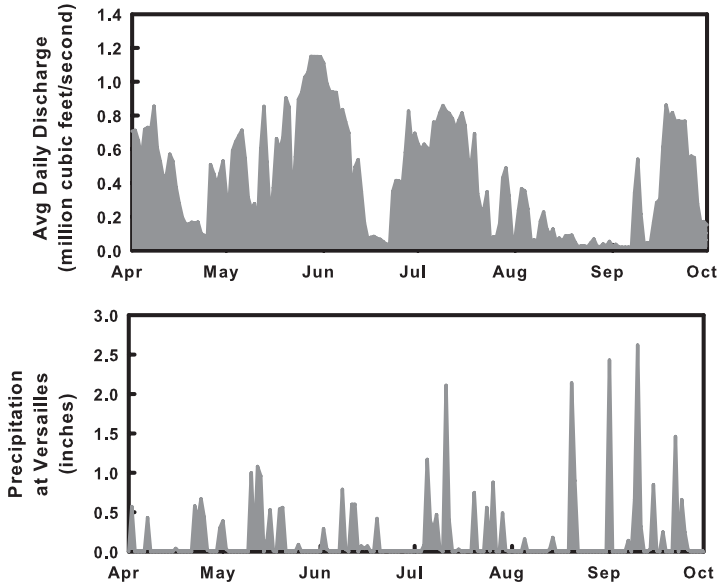
Lake of the Ozarks

Benton, Camden, Miller and Morgan Counties



In the lower lake near Bagnell Dam, nutrients were low and clarity was high (about 9 feet) early in the 2010 season. Turbidity was high during the early season in the upper Osage portion of the lake, causing reduced water clarity relative the remainder of the season.

At all but a few sites there was an increase in nutrients and sediments at the end of September. If the suspended sediments remained below approximately 7, there was an increase in algal chlorophyll on the same day. For those sites where the suspended sediment values exceeded 7 mg/L there was a decrease in algal chlorophyll due to shading. In the main lake, this happened at the sites between Truman Dam and the 21 mile marker (Site 21).



The two graphs above reflect the influence of rainfall and runoff. The first graph is the the average daily discharge from Bagnell Dam into the Osage River. The second (bottom) graph shows total daily precipitation at Versailles.

On August 31 samples were collected at both Site 1.2 and Site 3 by different volunteers. This duplication of effort allows for a cursory quality control examination. Secchi was similar among the 2 samples, differing by about 20% at each site. The variation between samplers could be explained by differences in time of observation. Because of the influence of the angle of the sun, we ask volunteers to sample at approximately the same time each visit. All other measurements were essentially identical. For the purposes of this report, the two samples were averaged to produce a single daily value.

LOWA
our lake - one voice

Many of the LMVP volunteers at the Lake of the Ozarks are also active in the Lake of the Ozarks Watershed Alliance (LOWA). Visit the LOWA website at www.soslowa.org.

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2010 SUMMARY DATA TABLE

Site	# of samples		Secchi (inches)	TP (µg/L)	TN (µg/L)	CHL (µg/L)	ISS (mg/L)	Site Description
1	**6**	**Mean**	**59**	**29**	**534**	**14.8**	**1.2**	Bagnell Dam
		Minimum	45	19	430	1.6	0.7	
		Maximum	83	48	690	32.1	2.3	
3	**8**	**Mean**	**64**	**28**	**564**	**15.3**	**1.6**	Main Lake, 3 mile marker
		Minimum	45	15	400	2.0	1.0	
		Maximum	110	52	970	43.5	3.3	
21	**7**	**Mean**	**53**	**36**	**603**	**13.5**	**1.3**	Main lake, 13 mile marker
		Minimum	32	23	480	6.1	0.1	
		Maximum	67	48	990	23.5	4.1	
45	**6**	**Mean**	**32**	**59**	**763**	**20.6**	**4.9**	Main lake, 45 mile marker
		Minimum	21	41	610	9.0	2.2	
		Maximum	44	77	1430	32.4	8.6	
51	**8**	**Mean**	**25**	**64**	**745**	**21.9**	**9.3**	Main lake, 51 mile marker
		Minimum	12	44	570	7.5	2.6	
		Maximum	40	92	1350	33.4	19.2	
61	**6**	**Mean**	**13**	**69**	**774**	**17.8**	**17.7**	Main lake, 61 mile marker
		Minimum	8	58	520	7.4	9.0	
		Maximum	21	100	1300	29.5	26.4	
1-2	**8**	**Mean**	**70**	**26**	**563**	**14.3**	**1.3**	Gravois Arm, 2 miles from main channel
		Minimum	57	15	480	2.3	0.7	
		Maximum	112	43	760	34.5	2.3	
31-1	**7**	**Mean**	**39**	**37**	**641**	**27.9**	**2.6**	Linn Creek Arm cove site, 1 mile from main channel
		Minimum	28	26	530	17.9	1.0	
		Maximum	48	52	970	41.2	5.9	
4-3	**6**	**Mean**	**52**	**26**	**718**	**13.1**	**1.2**	Niangua Arm, 3 miles from main channel
		Minimum	42	19	640	10.5	0.7	
		Maximum	63	29	870	16.0	2.0	
4-10	**7**	**Mean**	**38**	**45**	**502**	**19.5**	**2.6**	Niangua Arm, 10 miles from main channel
		Minimum	13	31	330	2.3	1.4	
		Maximum	58	64	710	47.6	17.1	
4-15	**6**	**Mean**	**24**	**54**	**649**	**18.4**	**11.1**	Niangua Arm, 15 miles from main channel
		Minimum	14	36	410	5.0	6.6	
		Maximum	34	136	1230	41.6	21.0	
		Mean	**35**	**40**	**493**	**17.4**	**2.8**	Little Niangua, 3 miles from the Niangua
LN3	5	Minimum	18	32	400	9.3	1.3	
		Maximum	51	68	620	26.5	12.4	

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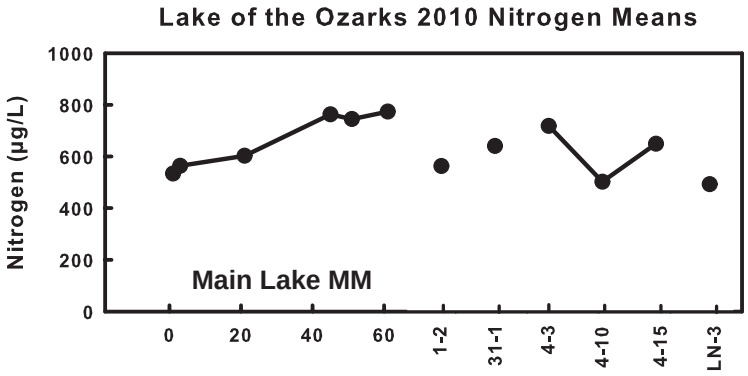
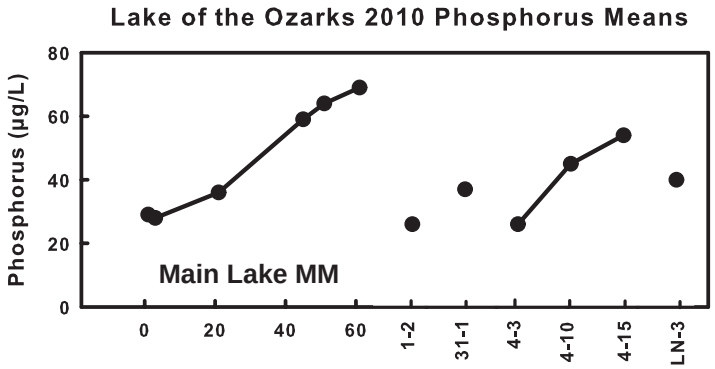
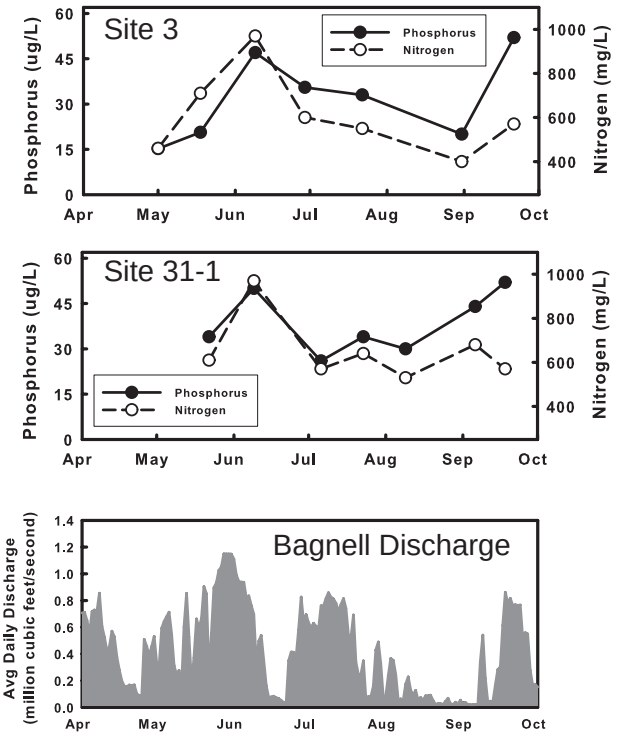
Nitrogen concentrations only varied by about 30% from the 61 mile marker (Site 61) to Bagnell Dam. Sites within the Niangua Arm showed approximately the same variability as the main lake. The lowest mean 2010 nitrogen value was measured in the Little Niangua, though lake-wide nitrogen values varied little.

As is typical of reservoirs, the up-lake sites had higher concentrations of phosphorus than the lower lake sites. Phosphorus values at Bagnell Dam averaged just over a third of the phosphorus values measured up-lake at Site 61. This phenomenon was also observable in the Niangua Arm, as Site 4-3 had about half the phosphorus measured 12 miles up the arm near Ha Ha Tonka (Site 4-15).







Across the 2010 sampling season, nutrient concentrations varied roughly with discharge from Bagnell Dam (bottom left). The discharge reflects the accumulated rain and runoff from the surrounding landscape and the Osage River. At many sites (e.g. Site 3, top left), there were two nutrient peaks in 2010, one in late May or early June and another in early or mid September. At other sites (e.g. Site 31-1, middle left) there was a smaller mid season bump in nutrient concentrations that more or less coincides with the Bagnell discharge data from July.

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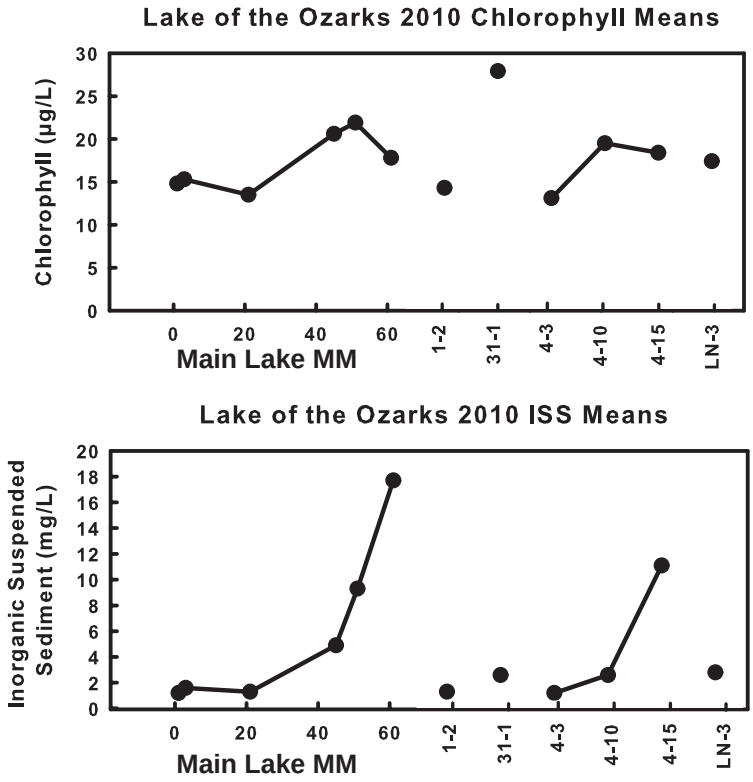
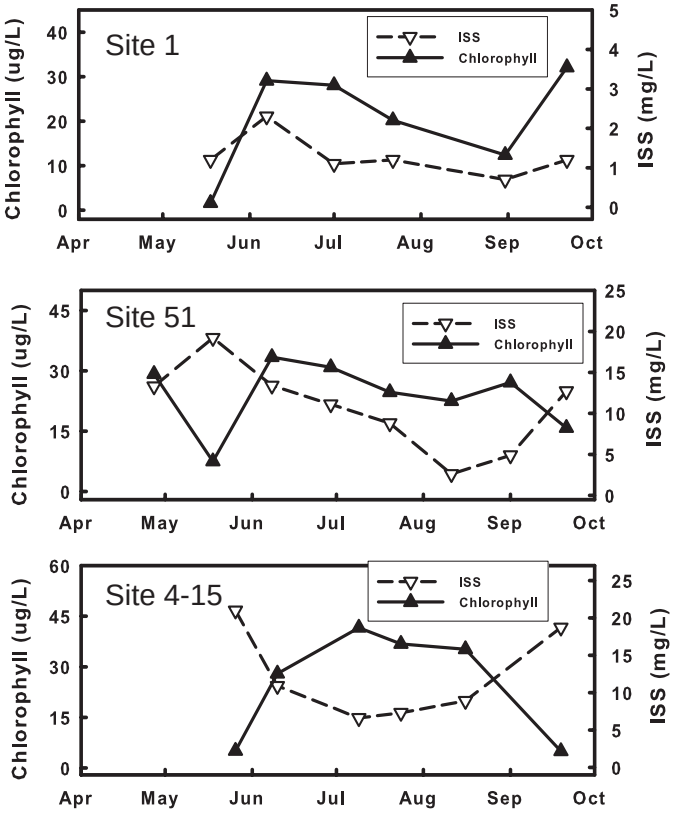


The abundance of algae, as measured by chlorophyll concentration, in the main lake was highest mid-lake at the 45 and 51 mile marker sites. Sites in the Niangua showed a similar pattern, with higher values mid-arm. This pattern reflects the abundance of inorganic suspended sediment materials present at the uppermost sites. Inflowing water carries sediment that shades the water column, inhibiting algal growth. As the water flows through the lake (or lake arm) the velocity slows and the particles settle to the bottom, allowing sunlight to penetrate deeper into the water column. The additional sunlight promotes algae growth and higher measured chlorophyll concentrations. Site 31-1 had the highest measured chlorophyll value in 2010. This site is located at the mouth of a cove on the Linn Creek arm.

At Bagnell Dam (Site 1, top) inorganic suspended sediment (ISS) concentrations were low, with the maximum measured ISS value less than 2 mg/L. At Site 51 (51 mile marker, center) and Site 4-15 (upper Niangua arm, near Ha Ha Tonka, bottom) ISS values were an order of magnitude higher and showed roughly the same seasonal pattern. At Sites 51 and 4-15 the highest ISS values were associated with the lowest concentrations of chlorophyll, illustrating the inhibition of algal growth due to shading by sediment particles.



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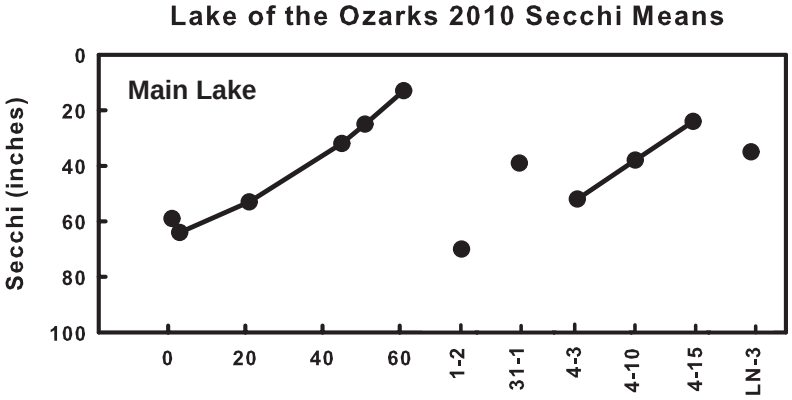
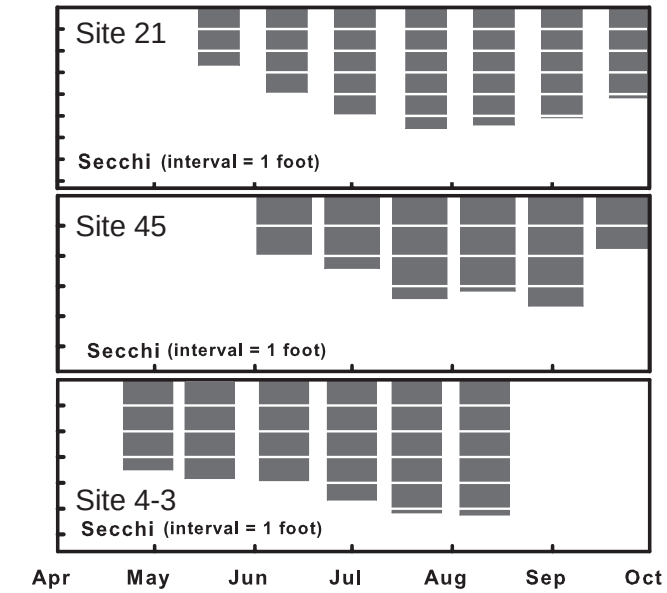
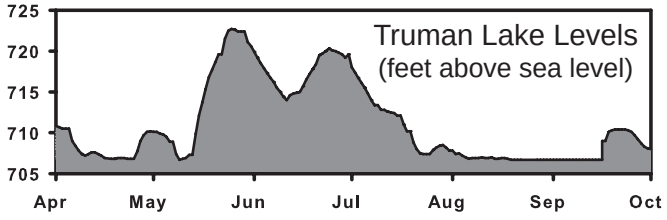


Water clarity is highest near the dam and decreases nearer to the source of inflowing water. In the main lake, Bagnell Dam (Site 1) and the 3 mile marker (Site 3) water clarity averaged about 5 feet, while clarity barely cleared one foot at mile marker 61 (Site 61). Within the Niangua Arm, the same spatial trend is clearly apparent, with clarity at the mouth of the arm similar to the main lake nearby. Water clarity at the head of the Niangua Arm (Site 4-15) averaged 2 feet in 2010. The Linn Creek and Little Niangua sites (31-1 and LN-3, respectively) each had about 3 feet of clarity on average. Water at the Gravois site (1-2) was somewhat clearer than at Bagnell Dam, with a 2010 average Secchi transparency of nearly 6 feet.

At all but a few down-lake sites (graphs not shown) water clarity was highest mid-season, during the latter part of July through August. The graphs to the right show water clarity, as measured via Secchi disk, at mile markers 21 (site 21) and 45 (Site 45) and at the Highway 5 bridge over the Niangua (Site 4-3). The period of higher 2010 water clarity roughly coincides with a 6-week period of comparatively low flow in the Osage River channel, as indicated by Truman Lake levels (bottom right) and discharge data from Bagnell Dam (page 35). In most reservoirs, lower flow (or greater "residence time") results in lower concentrations of suspended sediment materials and particulate phosphorus, as these materials will settle to the lake bottom, given enough time.





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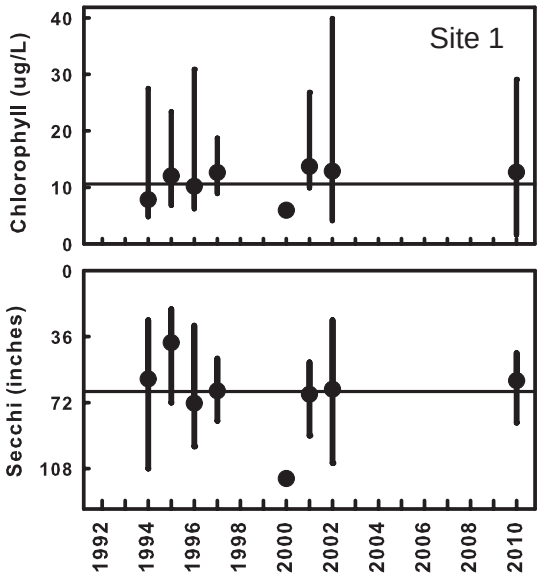
Lake of the Ozark Trends
Main Channel

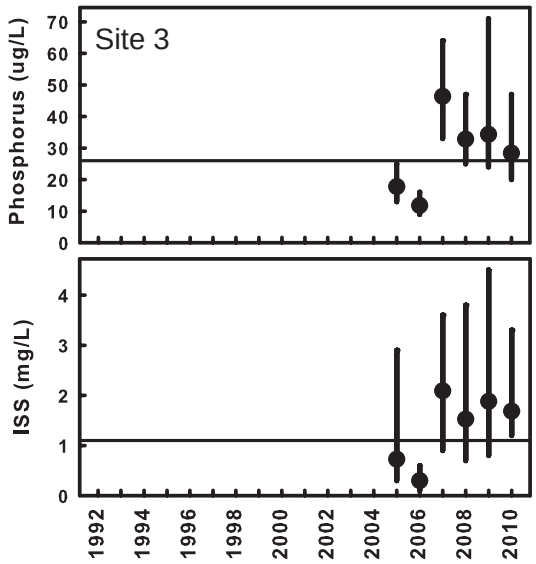
Nutrient, chlorophyll and sediment concentrations across the Lake of the Ozarks were typical, with very few exceptions. Water clarity, as measured by Secchi disk, was typical also, varying only slightly around the mean across the lake.

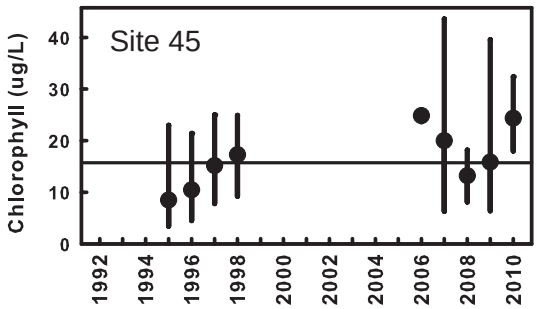
Data from Site 1 (Bagnell Dam) show chlorophyll concentrations in 2010 were very similar to the values measured before 2002, when this site was last sampled. This was the case for all water quality measurements at Site 1.

Site 3 has been monitored more consistently in recent years, but has no sampling history prior to 2005. These data are interesting in that they imply a trend in the past 4 years of higher nutrient concentrations, greater algal biomass, increased suspended sediments and reduced water clarity. However, 2005 and 2006 were dry years and the data from other sites show unusually low concentrations of nutrients, chlorophyll and sediment, resulting in higher than average water clarity lake-wide.

Chlorophyll concentrations were roughly 50% higher than the long-term average at the 45 mile marker (Site 45) in the summer of 2010. Lower than average suspended sediment concentrations during the summer of 2010 (graph not shown) likely encouraged algal growth by allowing sunlight deeper into the water column. Despite the greater algal biomass, the net effect was that the water clarity was higher than average in 2010.







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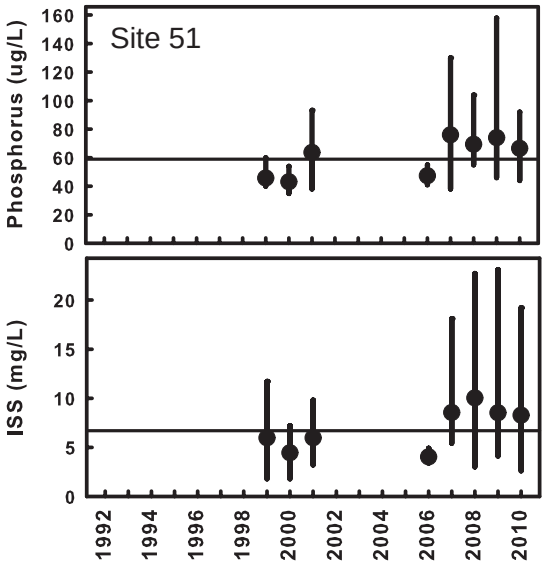
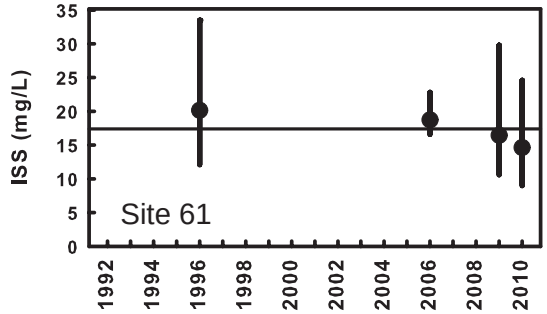
Conditions at the 51 mile marker (Site 51) are dependent upon the water released from Truman, reflecting the inorganic suspended sediment (ISS) and nutrients passed through Truman Dam and scoured from the bottom and the shoreline below Truman Dam. Phosphorus and ISS data from this site show slightly higher than average concentrations in the past 4 years.



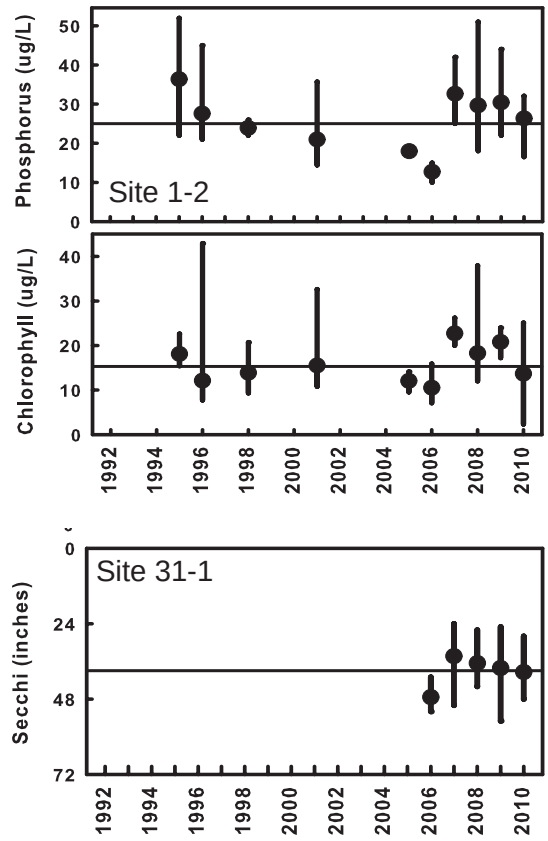
Site 61 (at the 61mile marker) was monitored for the second consecutive year in 2010, following a lengthy period of sporadic sampling. The mean 2009 and 2010 inorganic suspended sediment concentrations were lower, on average, than in either of the previous years.



In both the Gravois Arm and the Linn Creek Arm phosphorus concentrations were lower during 2010 than the previous 3 years. At Site 1-2 in the Gravois Arm, reduced algal biomass in the lake was the result.

Algal biomass was slightly higher at Site 31-1 in the Linn Creek Arm, possibly due to increased light penetration through the water column. Linn Creek's suspended sediment values were lower during 2010 than measured in the previous two years.

Water clarity was marginally improved at both sites.



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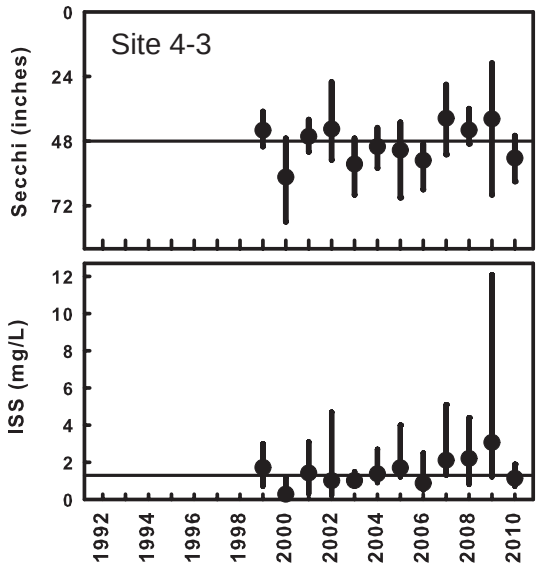
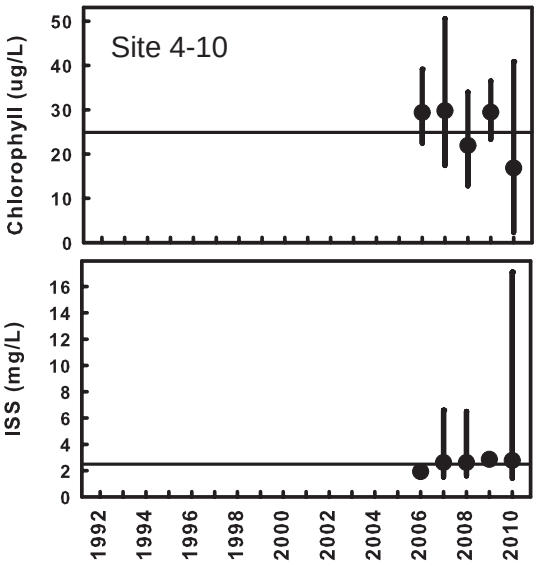
The water at Site 4-3 was clearer than average in 2010. The mean 2010 Secchi value was 14 inches greater than measured in 2009, largely due to the presence of less suspended sediment in 2010. Long-term data show 2010 ISS concentrations were very near the overall mean but just a third of the 2009 values.



The 2010 data show that there was less algae at Site 4-10, near Bridal Cave, than in recent years. The mean 2010 chlorophyll value was the lowest recorded to data, though the range of values observed was quite high. While the 2010 mean inorganic suspended sediment value was near the long-term mean, the range of values measured was quite high. The maximum ISS value measured in 2010 was nearly 10 times higher than the mean and more than double the next highest value. The high ISS value was measured on the same day as the lowest chlorophyll value. This illustrates the effect of light limitation on algal biomass. When ISS concentrations are high (typically at or above 10 mg/L) the soil particles in the water scatter enough light to inhibit algae growth.



Summer ISS concentrations were higher in 2010 than measured previously at Site 4-15. The maximum 2010 ISS value was more than double the second highest value (measured in 2007).