

Water Quality Monitoring Results
Of Beaver Creek and Bull Shoals Lake

Year 2
August 2004 through July 2005

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Introduction and Methods

Year 2 of the Bradleyville and Bull Shoals Lake Project was from August, 2004, through July, 2005. Samples were collected 33 times during the year: once during August, September, December, January, February, and July and sampled weekly during October, November, March, April, May, and June. Three sites on Beaver Creek were sampled: one above Bradleyville (BA), one at the bridge in Bradleyville (BB), and one downstream of Bradleyville (BD). Two sites were sampled on Bull Shoals Lake: near the mouth of Beaver Creek (BM) at Kissee Mills and near K-Dock Marina (BK). In 2003/2004, the second Bull Shoals site was Buck Creek near the Missouri-Arkansas border. The BM site replaced the Buck Creek site in Year 2. It was thought that the BM site would give a better indication on how Beaver Creek influences Bull Shoals Lake.

Total nitrogen (TN), total phosphorus (TP), and *E. coli* were examined for each site. Additional data collected included temperature, pH, and dissolved oxygen (DO). Statistical analyses, using a Repeated Measures Analysis of Variance (ANOVA), were completed for both years of data combined. Field procedures followed the Quality Assurance Project Plan submitted to the U.S. Environmental Protection Agency and accepted in December, 2004.

Results and Discussion

Rain events of 0.5 inches or more that preceded sampling dates by 1-3 days are found in Table 1. Rainfall amounts are from the BSFS weather station on the Drury Wildlife Conservation Area. Several rain events occurred which did not occur within three days prior to the sample date.

More detailed results are given with the graphs.

Table 1. Rain events with amount of precipitation and the following samples dates. Rain events are only listed if they occurred within three days prior to the sampling date.

Rain Dates	Precipitation (inches)	Sample Dates
October 12, 2004	1.77	October 13, 2004
November 2, 2004	1.13	November 3, 2004
March 22, 2005	0.55	March 23, 2005
April 12, 2005	0.70	April 13, 2005

Beaver Creek

Temperature and pH. In general, there were very small differences between the three creek sites for temperature and pH (pgs. 10-14). Mean temperatures were higher at the BD site compared to the two upstream sites (Table 2). The BD site, although shaded, is after a long stretch of stream with little or no shade. All pH values were in the basic range (7.3 to 8.7 with most values between 7.8 and 8.5). Site BD also had the lowest pH values in late Feb and early March (pgs. 15-19).

Dissolved Oxygen (DO). Mean values for DO were calculated for each site. Year 1 and Year 2 data for Beaver Creek are shown in Table 3(a) and on pages 20-24. The DO means decreased from upstream of Bradleyville to the downstream site. When the sites were compared using the repeated measures ANOVA, there was a significant difference between sites ($p < 0.001$) and between dates ($p < 0.001$; $R^2 = 94.43\%$). (The R^2 value tells how much of the variation of the data is explained by date and site e.g., 94% of the variation in DO values is related to date and site.)

Table 2. Mean temperatures for Beaver Creek and Bull Shoals Lake sites are given for Years 1/2 combined, Year 1, and Year 2. Locations are above Bradleyville (BA), at the Bradleyville bridge (BB), downstream of Bradleyville (BD), Kissee Mills (BM), K-Dock Marina (BK), and Buck Creek (BC).

Mean	BA (°C)	BB (°C)	BD (°C)	BM (°C)	BK (°C)	BC (°C)
Combined Years 1 and 2	16.6	16.5	17.1		18.7	19.5
Year 1	16.1	16.2	16.4		19.2	
Year 2	16.9	16.9	17.6	18.3	18.3	

E. coli. *E. coli* colony forming units (CFU) increased after the rainfall events (Table 1; pgs. 25-33). There was a significant difference between dates ($p < 0.001$), however, differences between sites approached significance ($p = 0.063$; $R^2 = 82.03\%$). The low p -value, although technically not significant, probably indicates a difference.

Total Nitrogen (TN). Mean values for TN were calculated for each site (Table 3b). Year 1, Year 2 and combined data for Beaver Creek are shown. TN values increased from upstream to downstream sites in combined years and in Year 1 and Year 2 (Table 3b). TN means show smaller changes in Year 2 (pgs. 34-38). There were significant differences between sites ($p < 0.001$) and dates ($p < 0.001$; $R^2 = 93.3\%$) for TN. The EPA recommended criteria for TN in the aggregate Ecoregion XI is 31 ppm (31.0 mg/L; <http://www.epa.gov/waterscience/criteria/nutrient/ecomap.html>).

Total Phosphorus (TP). Mean values for Year 1, Year 2, and combined data were calculated for each site (Table 3c). TP values increased from upstream to downstream sites in combined years and in Year 1 and Year 2 (Table 3c). However, TP means show

very small increases. TP values were significantly different for dates ($p < 0.001$) but not for sites ($p = 0.281$; $R^2 = 40.33\%$; pgs. 39-43). The EPA recommended criteria for TP in the aggregate Ecoregion XI is 10 ppb (0.010 mg/L;

<http://www.epa.gov/waterscience/criteria/nutrient/ecomap.html>).

Table 3. Mean dissolved oxygen (mg/L), total nitrogen (mg/L), and total phosphorus (mg/L) values with +/- standard deviations (SD) are given for Years 1/2 combined, Year 1, and Year 2. Locations are above Bradleyville (BA), at the Bradleyville bridge (BB) and downstream of Bradleyville (BD).

(a) Dissolved Oxygen (mg/L)

Mean	BA (+/- SD)	BB (+/- SD)	BD (+/- SD)
Combined Years	9.94 (1.50)	9.82 (1.39)	9.58 (1.52)
Mean Year 1	9.98 (1.34)	9.84 (1.13)	9.75 (1.18)
Mean Year 2	9.92 (1.64)	9.80 (1.61)	9.43 (1.77)

(b) Total Nitrogen (mg/L or ppm)

Mean	BA (+/- SD)	BB (+/- SD)	BD (+/- SD)
Combined Years	0.485 (0.274)	0.515 (0.303)	0.544 (0.300)
Mean Year 1	0.421 (0.252)	0.485 (0.329)	0.540 (0.309)
Mean Year 2	0.539 (0.285)	0.543 (0.277)	0.548 (0.297)

(c) Total Phosphorus (mg/L; 0.013 mg/L would be 13 ppb)

Mean	BA (+/- SD)	BB (+/- SD)	BD (+/- SD)
Combined Years	0.013 (0.011)	0.013 (0.012)	0.014 (0.011)
Year 1	0.014 (0.014)	0.015 (0.014)	0.015 (0.012)
Year 2	0.011 (0.007)	0.012 (0.010)	0.013 (0.010)

Lake Sites

Temperature and pH. Temperature showed seasonal differences with lowest temperatures in December through March and highest temperatures being in July. There

appear to be larger temperature fluctuations in Year 1 than in Year 2 (pgs. 10-14). pH values were near 8.0 and very steady at all lake sites (pgs. 15-19).

Dissolved Oxygen (DO). DO peaked in January and February while lowest values were in July and August (pgs. 20-24). Both Buck Creek (Year 1) and Kissee Mills (Year 2) had lower DO mean values than K-Dock (Table 4a).

E. coli. Values for *E. coli* were usually low, however, peaks usually occurred after a rain event (Table 1; pgs. 25-33).

Total Nitrogen (TN). Mean values for Year 1, Year 2, and combined years are found in Table 4b. Means were lower at Kissee Mills and Buck Creek than K-Dock (also see pgs. 34-38).

Total Phosphorus (TP). Mean values for Year 1, Year 2, and combined years are found in Table 4c. As with TN, TP means were lower at Kissee Mills and Buck Creek than at K-Dock (also see pgs. 39-43).

Table 4. Mean (a) dissolved oxygen, (b) total nitrogen, and (c) total phosphorus values with +/- standard deviations (SD) are given for Years 1 and 2 combined, Year 1, and Year 2. Locations are near K-Dock Marine (BK), Buck Creek (BC; Year 1 only), and Kissee Mills (BM; Year 2 only).

(a) Dissolved Oxygen (mg/L)

Mean	BK (+/- SD)	BC (+/- SD)	BM (+/- SD)
Combined Years	10.06 (1.25)	9.85 (1.88)	9.04 (1.56)
Mean Year 1	10.28 (1.25)	9.85 (1.88)	
Mean Year 2	9.89 (1.25)		9.04 (1.56)

(b) Total Nitrogen (mg/L or ppm)

Mean	BK (+/- SD)	BC (+/- SD)	BM (+/- SD)
Combined Years	0.531 (0.169)	0.330 (0.093)	0.443 (0.245)
Mean Year 1	0.473 (0.162)	0.330 (0.093)	
Mean Year 2	0.583 (0.160)		0.443 (0.245)

(c) Total Phosphorus (mg/L; 0.020 mg/L would be 20 ppb)

Mean	BK (+/- SD)	BC (+/- SD)	BM (+/- SD)
Combined Years	0.020 (0.014)	0.015 (0.011)	0.010 (0.007)
Mean Year 1	0.021 (0.018)	0.015 (0.011)	
Mean Year 2	0.019 (0.010)		0.010 (0.007)

Summary

DO can decrease with increased algal growth and decomposition or increased temperature. DO was lower at the BD site which correlates to higher temperatures.

Changes in DO in lake sites were also correlated to temperature changes.

Rain events appear to have a greater impact on values for all variables considering that there were statistically significant differences for dates for all variables. Seasonal differences also account for changes in some variables.

The Beaver Creek sites were statistically different only for DO and TN. The overall variability in data can decrease chances of getting statistical differences. However as we continue to collect data, we will be able to get a better picture of the differences between sites.

Graphs

Graphs are provided for each variable measured. There are four graphs for each variable: Year 1 for the three Bradleyville sites on Beaver Creek; Year 2 for the three Bradleyville sites on Beaver Creek; Year 1 for K-Dock Marina and Buck Creek; and Year 2 for K-Dock Marina and Kissee Mills, near the mouth of Beaver Creek. There are eight graphs for *E. coli*; each graph mentioned above also has an associated log graph.

Temperature

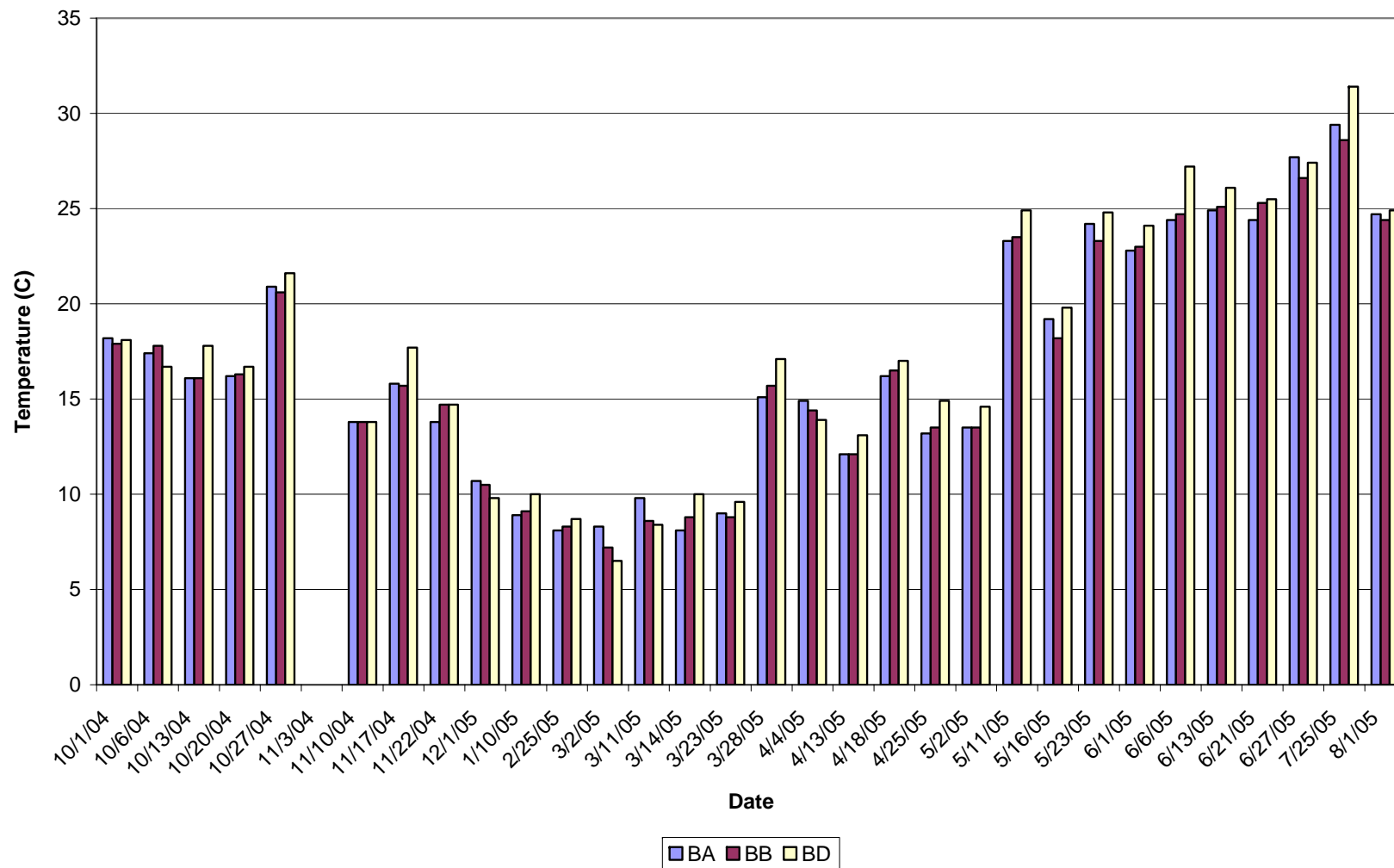
Temperature ranges followed seasonal changes in both Beaver Creek and the Bull Shoals Lake sites.

The highest temperatures, in both years, were in late July while the lowest temperatures were found between December and March.

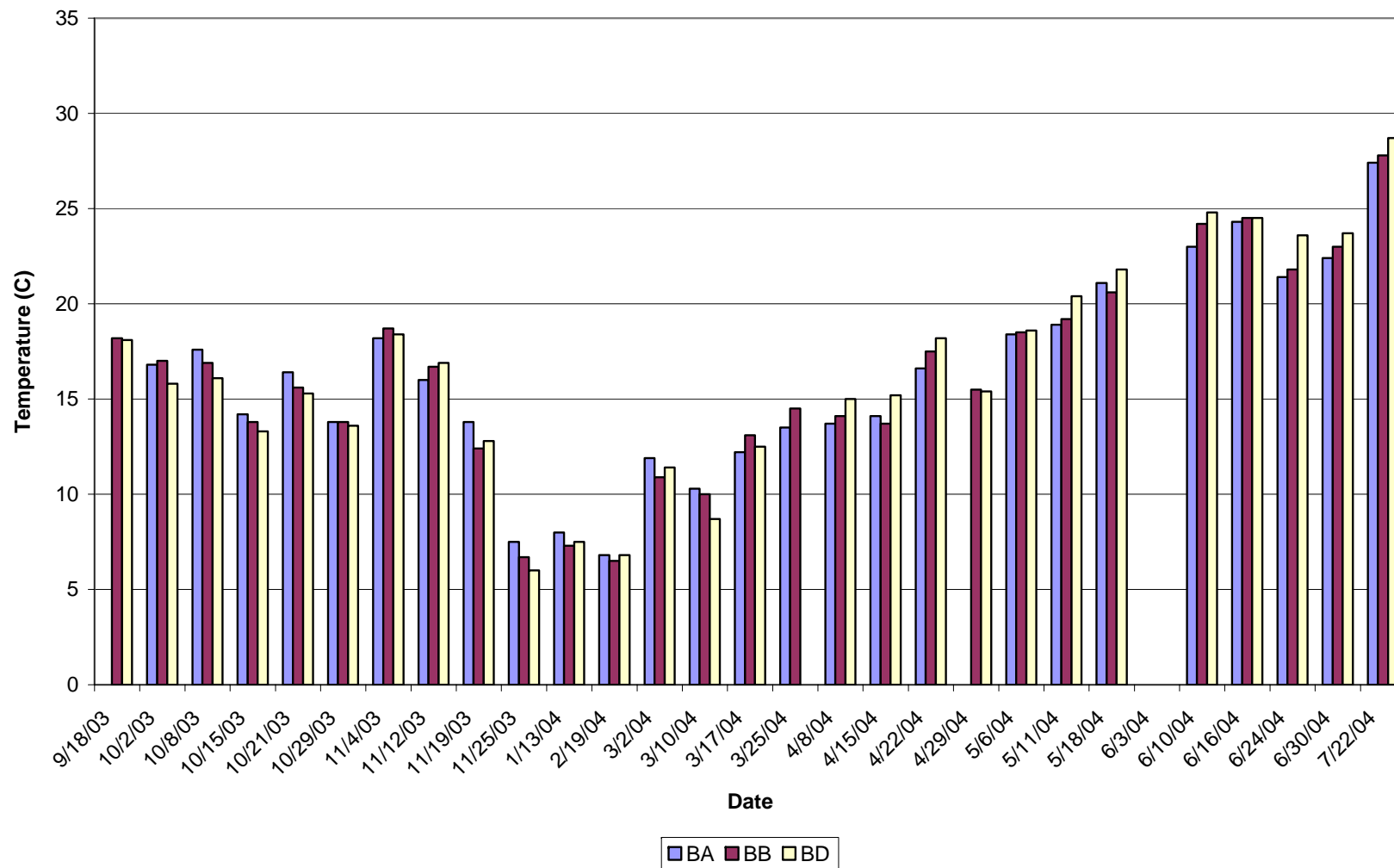
Temperatures at the downstream site on Beaver Creek (BD) were higher slightly over 50% of the dates in Year 2 while in Year 1 BD was higher approximately 30% of the time.

Mean temperatures were higher at lake sites than Beaver Creek sites.

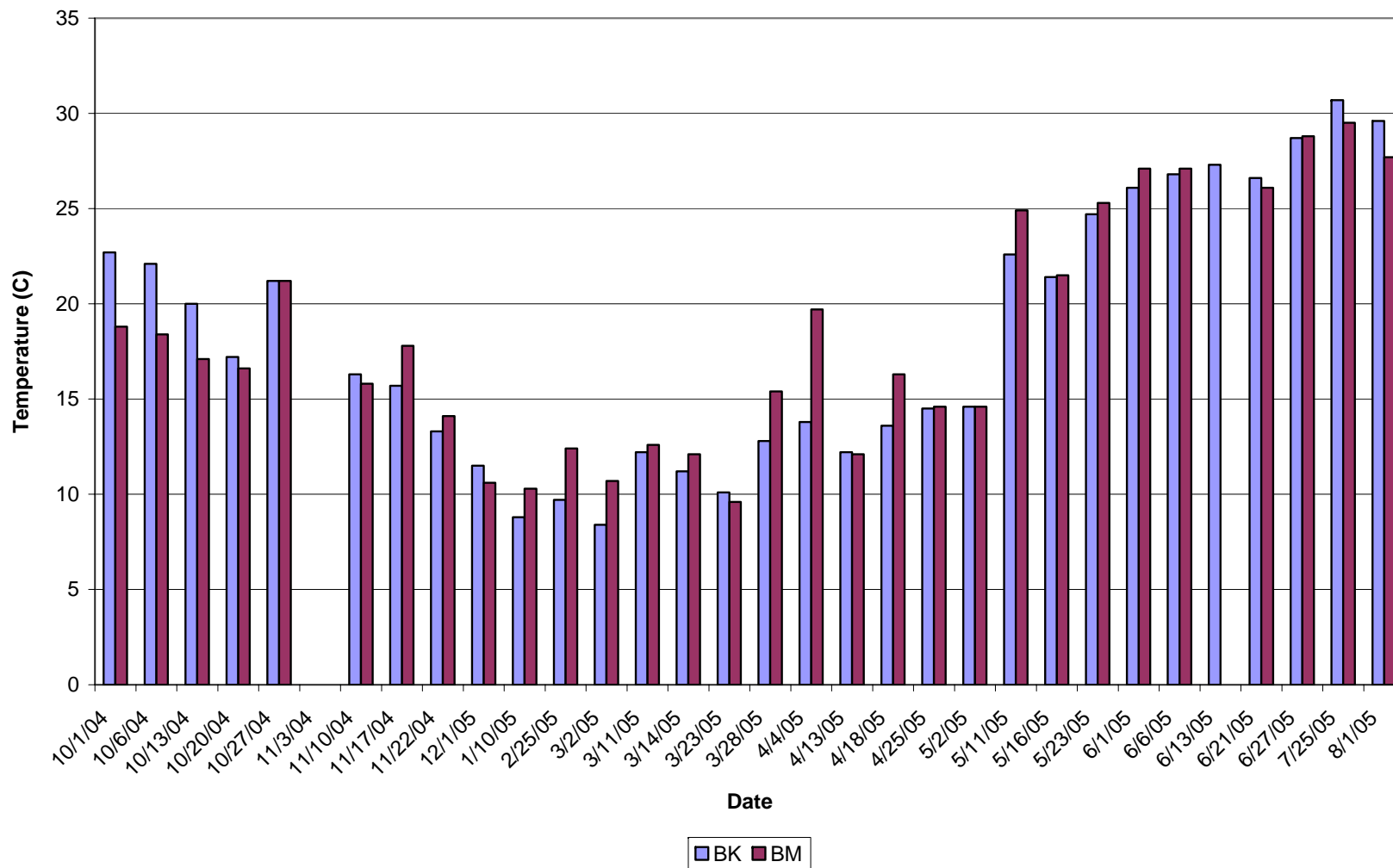
Temperature (C) - Bradleyville Sites - Year 2: 9/22/04-8/1/05



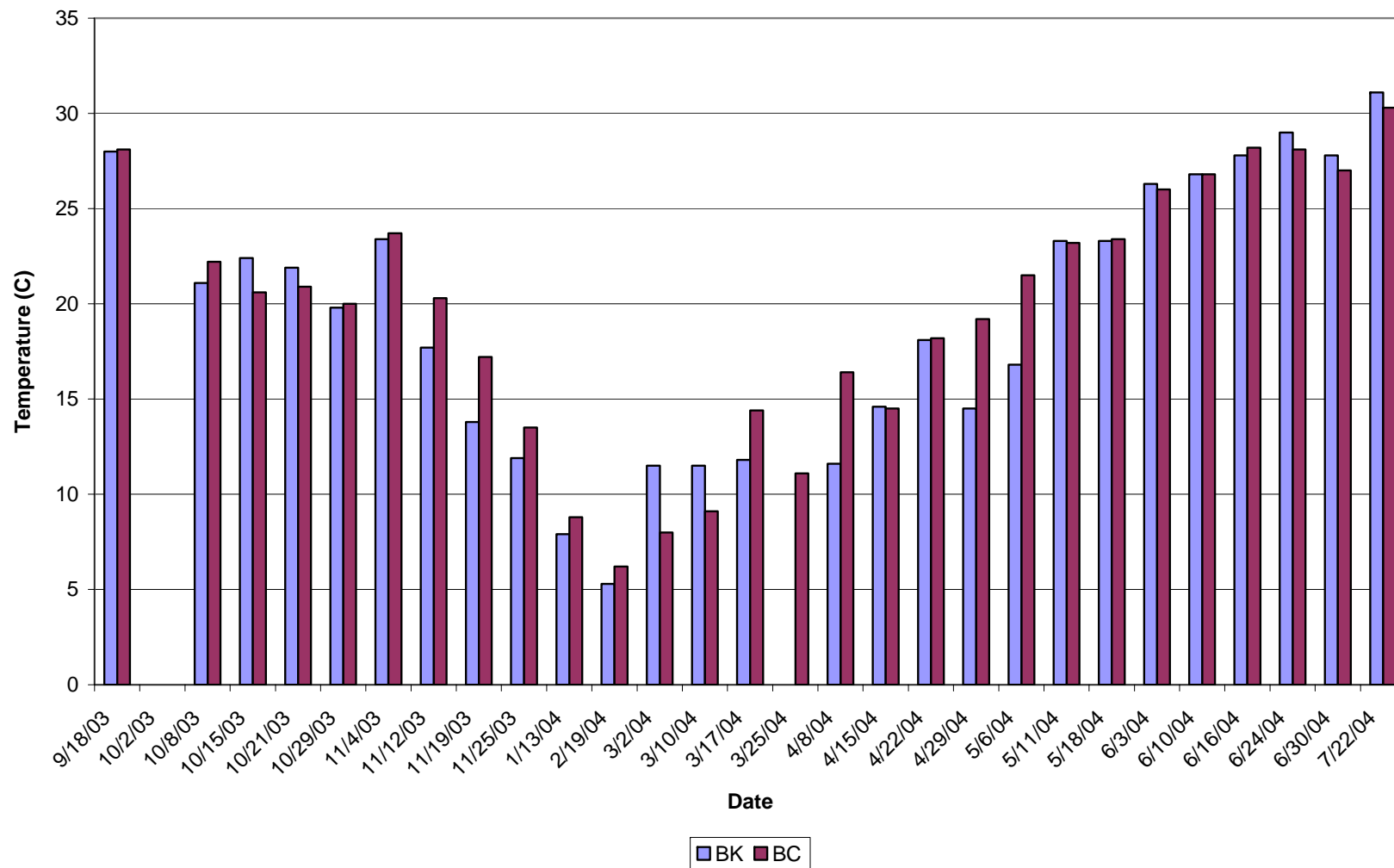
Temperature (C) - Bradleyville Sites - Year 1: 9/18/03-8/25/04



Temperature (C) - KDock/BK and KisseeMills/BM - Year 2: 9/22/04-8/1/05



Temperature (C) - KDock/BK and Buck Creek/BC - Year 1: 9/18/03-8/25/04

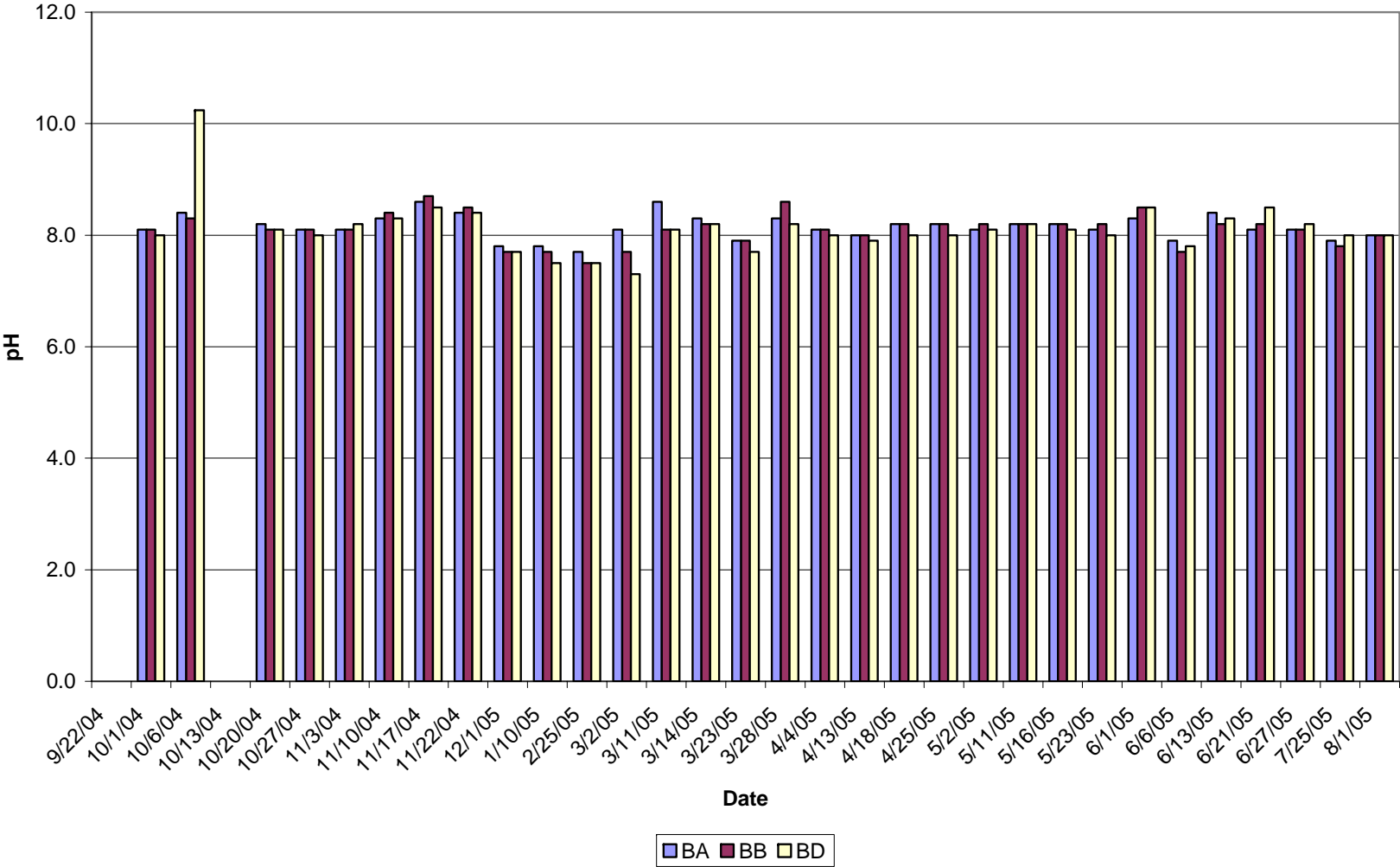


pH

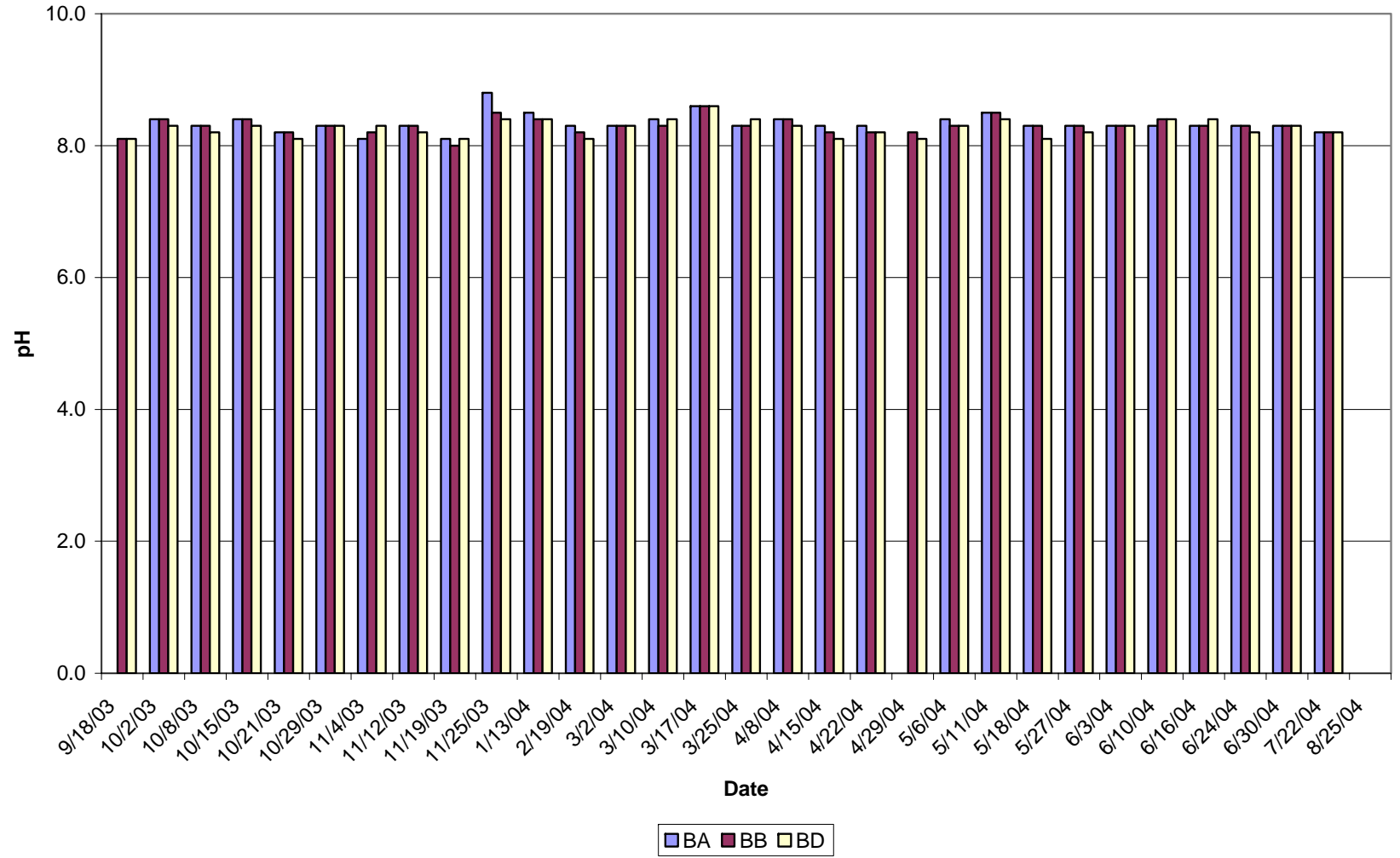
The pH was near or slightly above 8.0 for almost all sample dates. Exceptionally high readings on 10/6/04 for Bradleyville (BD) and 3/11/05 at K-Dock were anomalies.

Dates with missing readings were due to a broken pH meter except 4/29/04, at the BA site, when researchers could not get into the site due to bad roads.

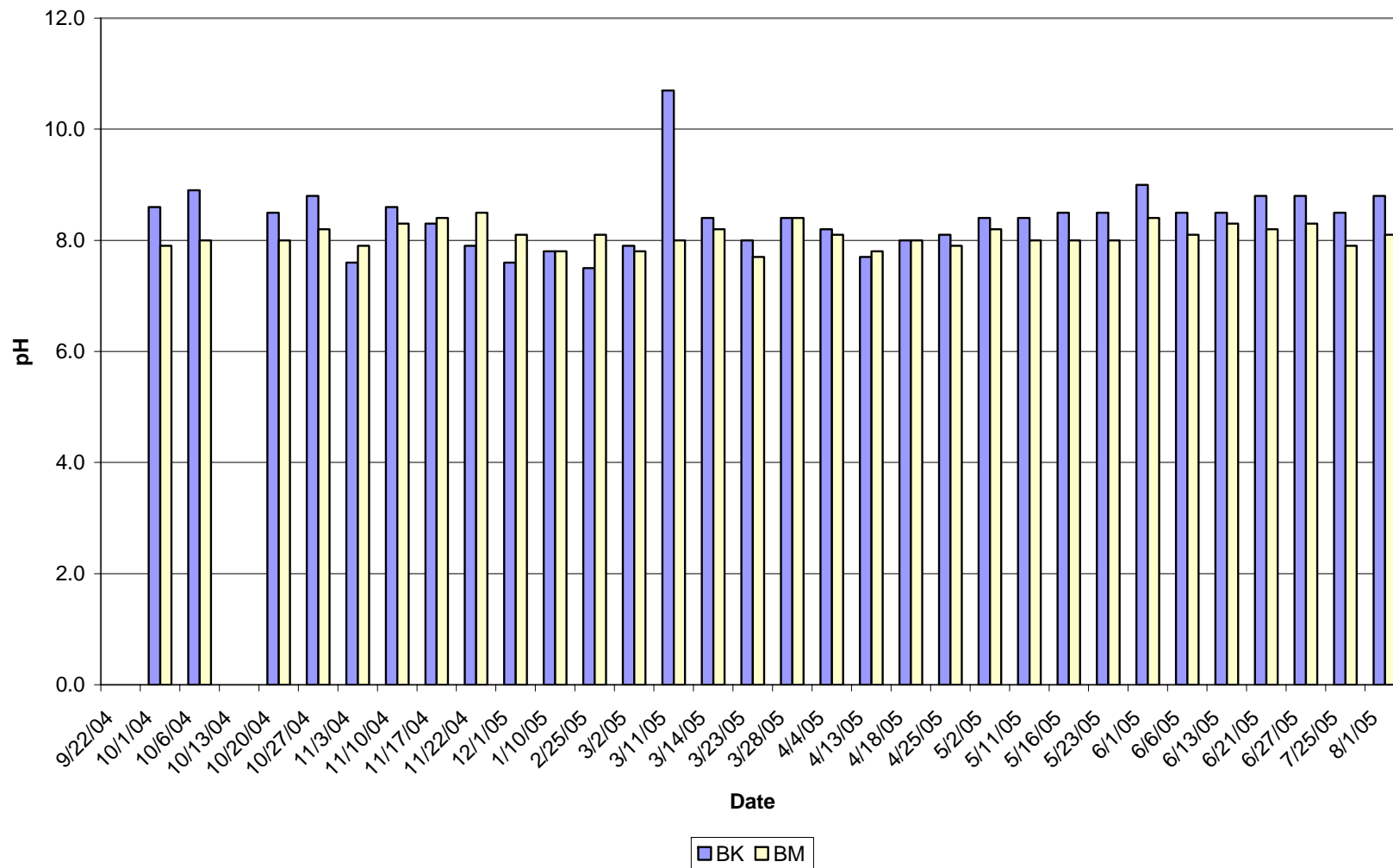
pH - Bradleyville Sites - Year 2: 9/22/04-8/1/05



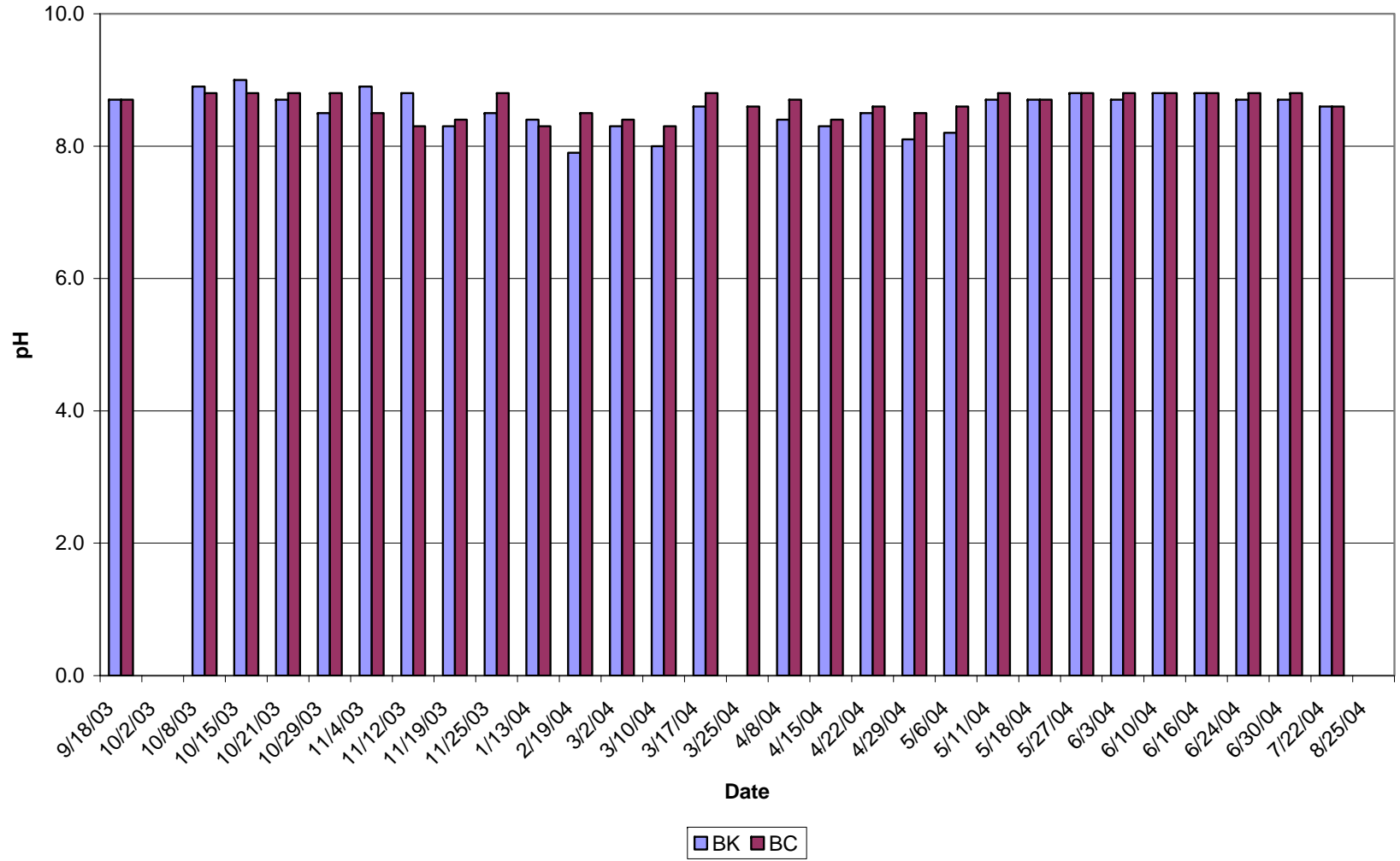
pH - Bradleyville Sites - Year 1: 9/18/03-8/25/04



pH - KDock/BK and KisseMills/BM - Year 2: 9/22/04-8/1/05



pH - KDock/BK and Buck Creek/BC - Year 1: 9/18/03-8/25/04



Dissolved Oxygen (DO)

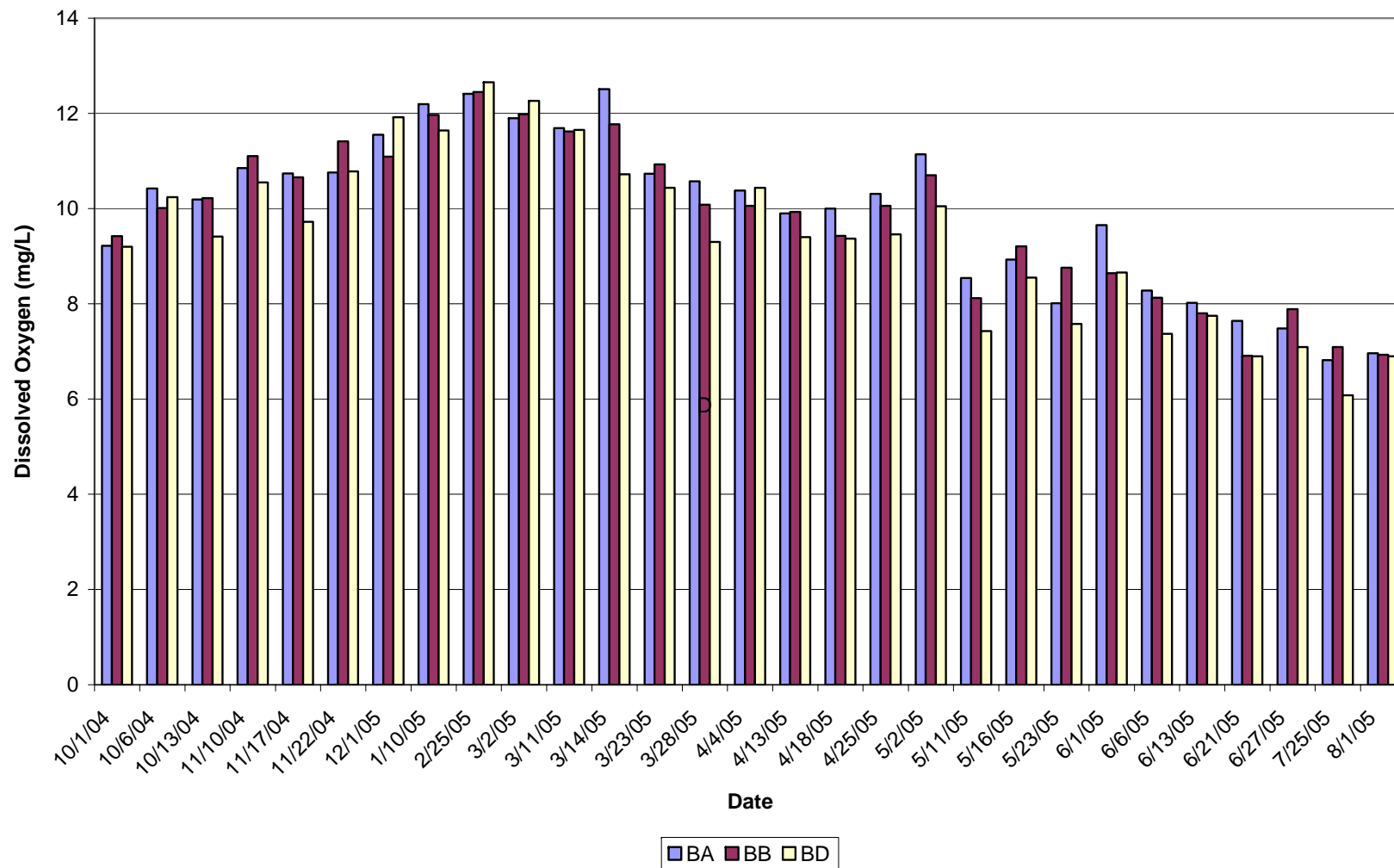
In Year 2, dissolved oxygen was usually in the 9-12 mg/L range except during July and August. This is expected because as temperatures increase, DO levels tend to decrease.

In Year 1, the lower DO values were also found in October, 2003.

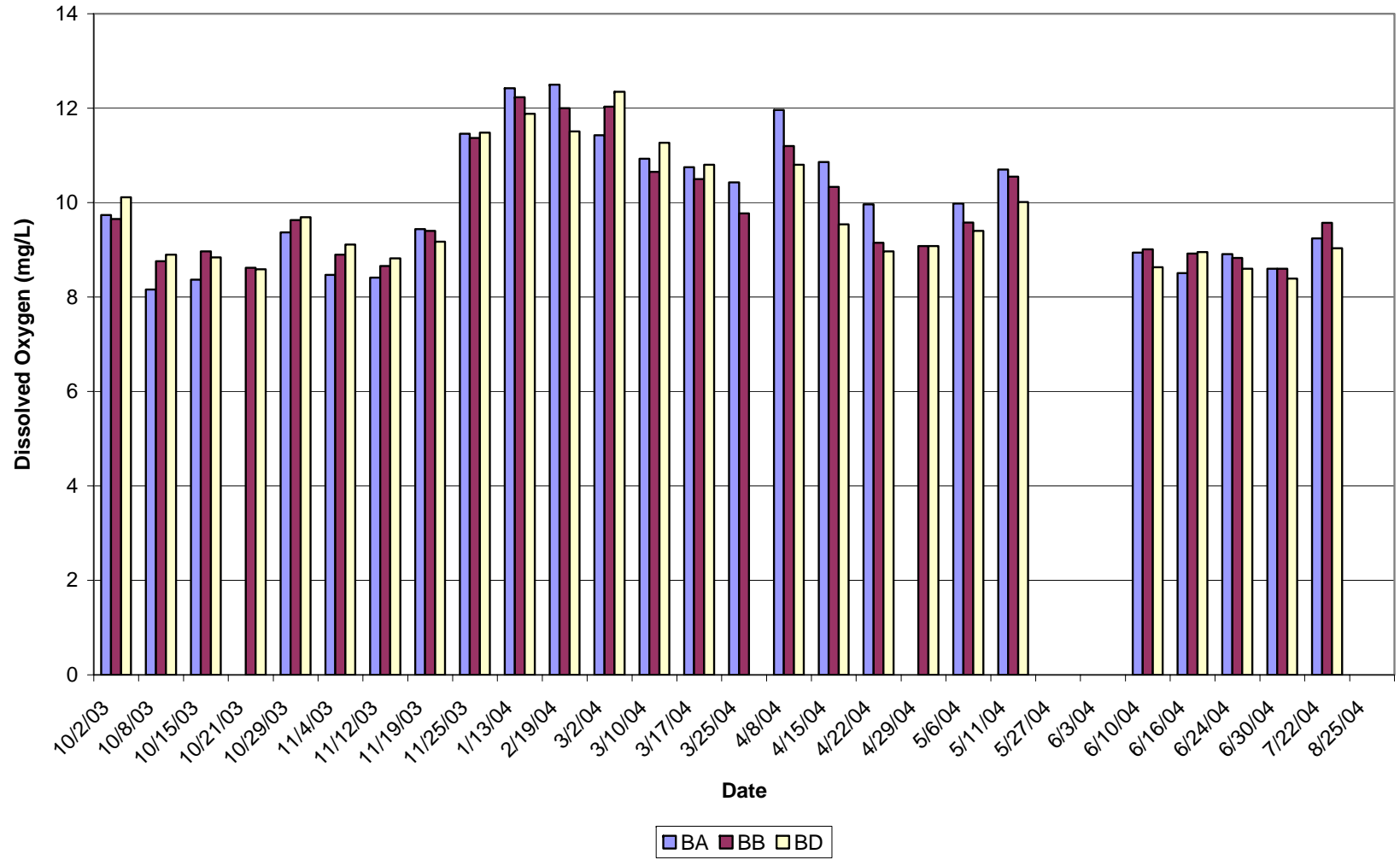
For Year 2 in Beaver Creek, the BD site had lower DO levels than other sites on approximately 20 sample dates, while in Year 1 BD was lower on approximately 12 sample dates.

For Year 2 in the lake sites, the Kissee Mills (BM) site had lower DO levels than K-Dock on approximately 23 sample dates. Higher DO levels at BM in mid-November and December may be due to fall turnover of the lake at K-Dock.

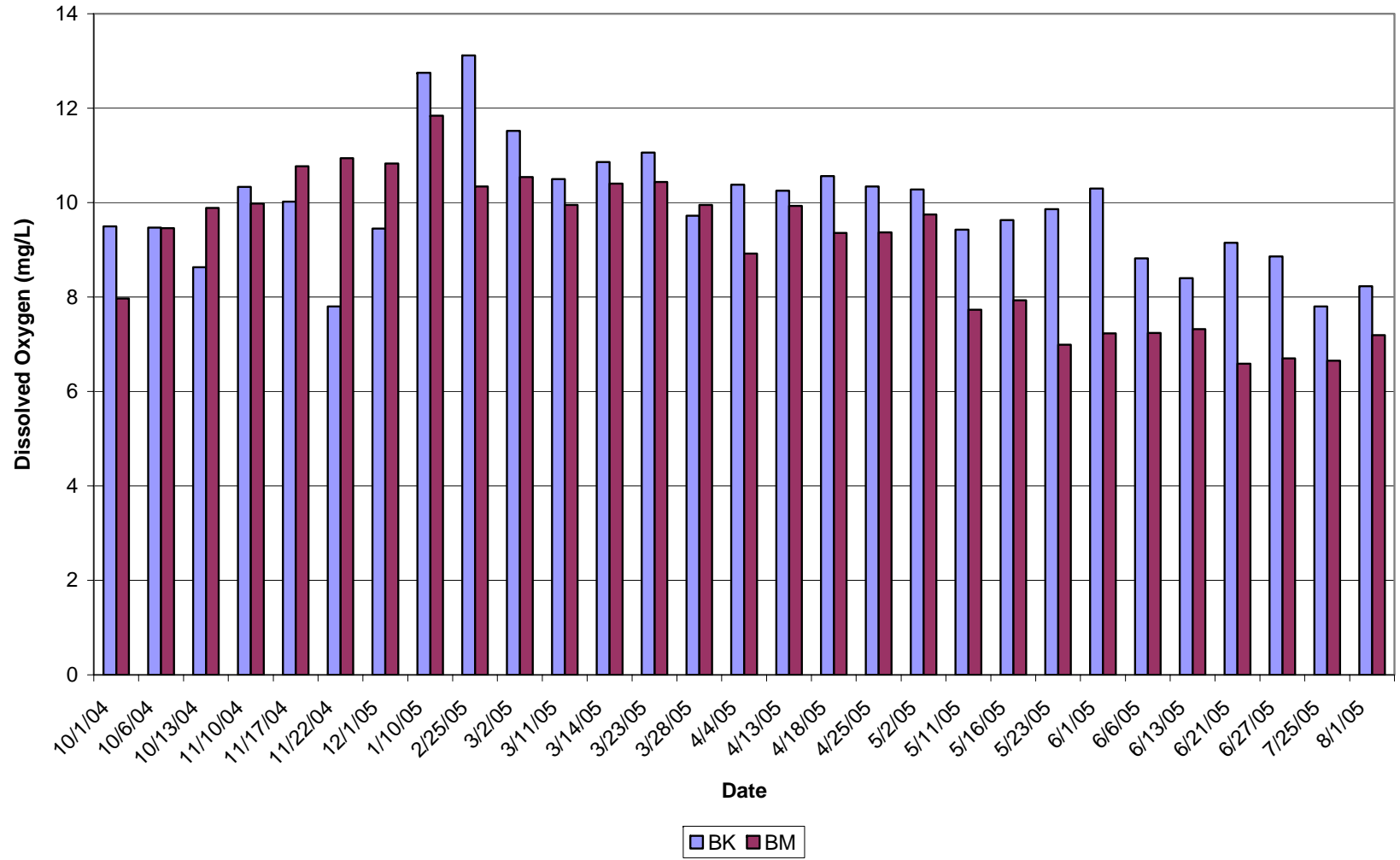
Dissolved Oxygen (mg/L) - Bradleyville Sites - Year 2: 9/22/04-8/1/05



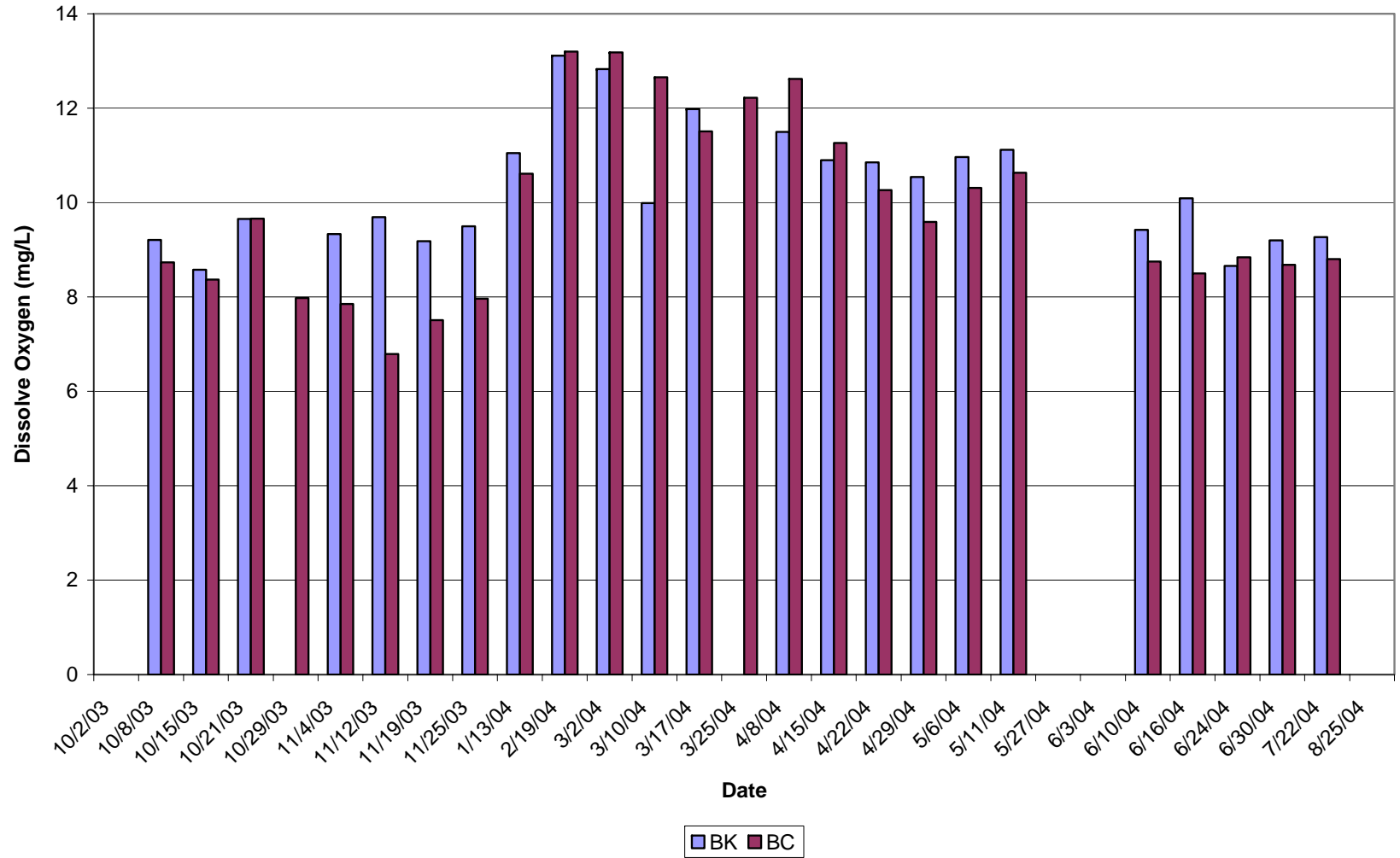
Dissolved Oxygen (mg/L) - Bradleyville Sites - Year 1: 9/18/03-8/225/04



Dissolved Oxygen (mg/L) - KDock/BK and Kisseemills/BM - Year 2: 9/22/04-8/1/05



Dissolve Oxygen (mg/L) - KDock/BK and Buck Creek/BC - Year 1: 9/18/03-8/25/04



E. coli

E. coli graphs are given in two formats: actual numbers of colony forming units (CFU) and in log format. In the graphs with actual CFU numbers, it is difficult to distinguish values that are very small (e.g., < 1 CFU); the log graphs allows a better way to compare values. (Note: log values of zero result from two causes: no data or \log_{10} value of 1CFU is zero.)

For Year 2 in Beaver Creek, the BD site was higher on 13 sample dates while the BA site was higher seven times.

Values were higher than the 126 CFU standard on several dates corresponding to rain event dates from the BSFS weather station.

For Year 1, BD was higher on 12 sample dates while BA was higher six times.

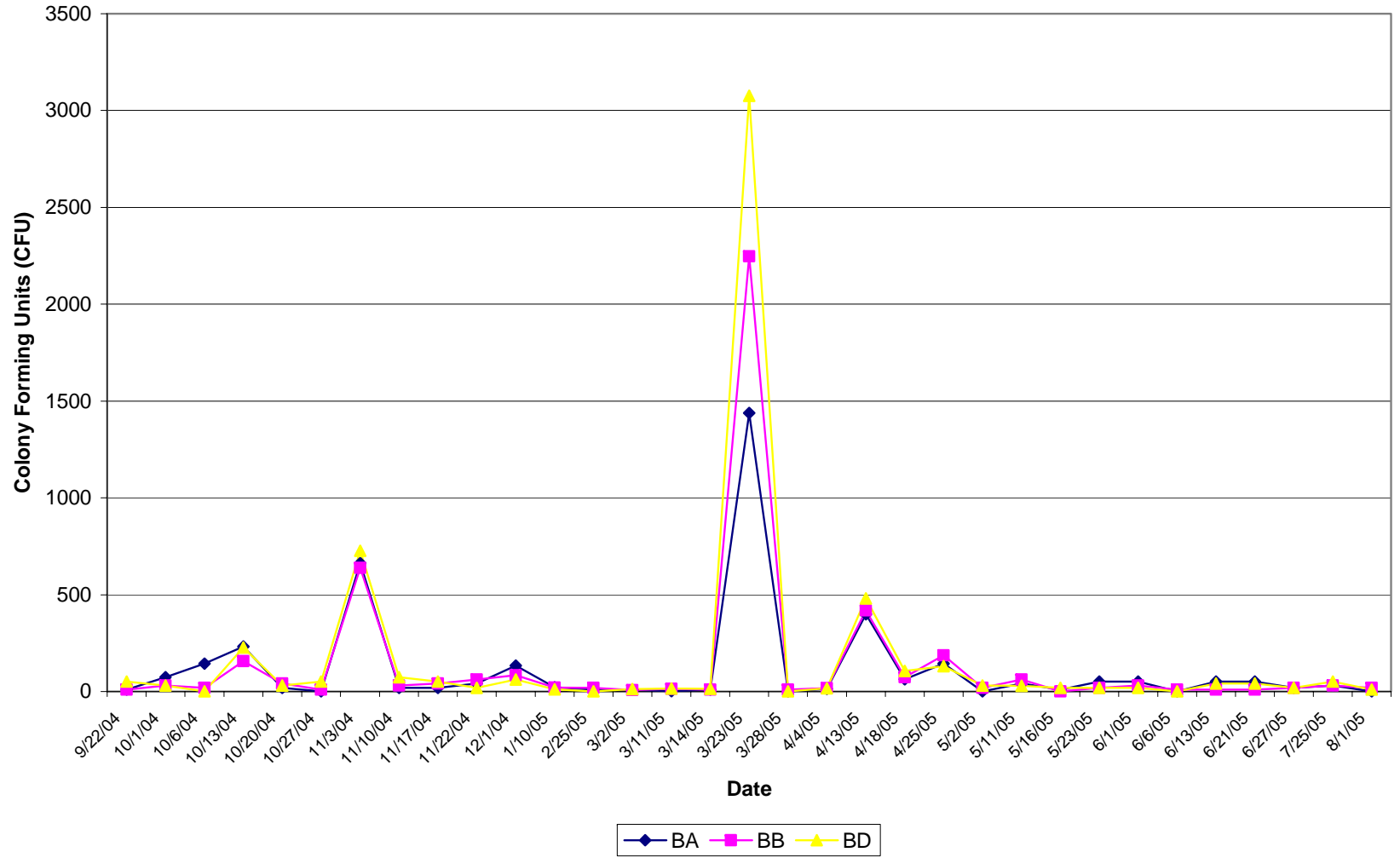
Values were higher than the 126 CFU standard on seven dates.

For Year 2 at the lake sites, Kissee Mills was higher than K-Dock on 15 sampling dates while K-Dock was higher only four times.

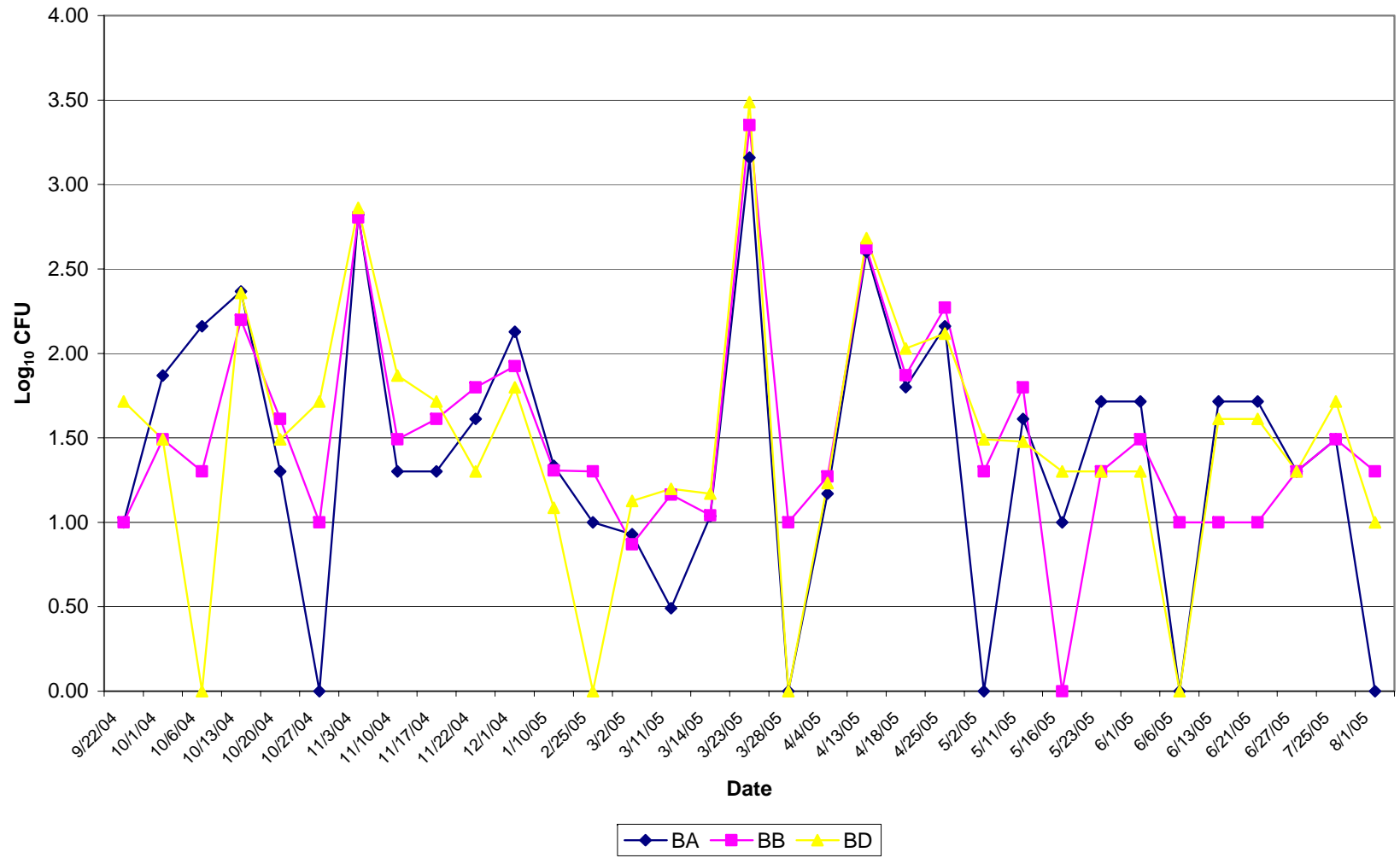
Four sampling dates had values higher than the 126 CFU standard for both Kissee Mills and K-Dock. Three of the four dates correspond with rain event dates from the BSFS weather station.

For Year 1, seven sampling dates were higher at K-Dock (BK) than Buck Creek (BC).

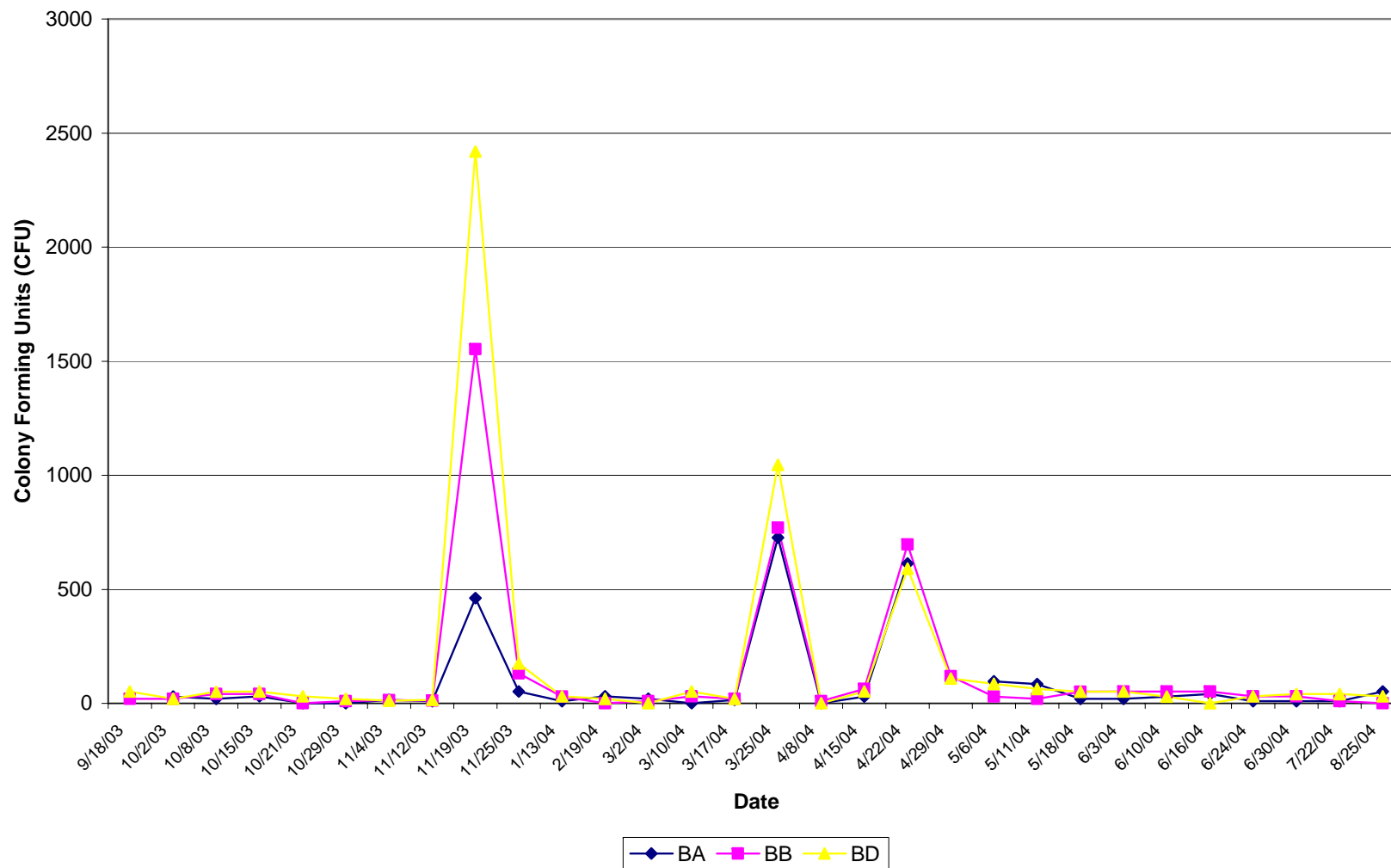
E. coli Colony Forming Units - Bradleyville Sites - Year 2: 9/22/04-8/1/05



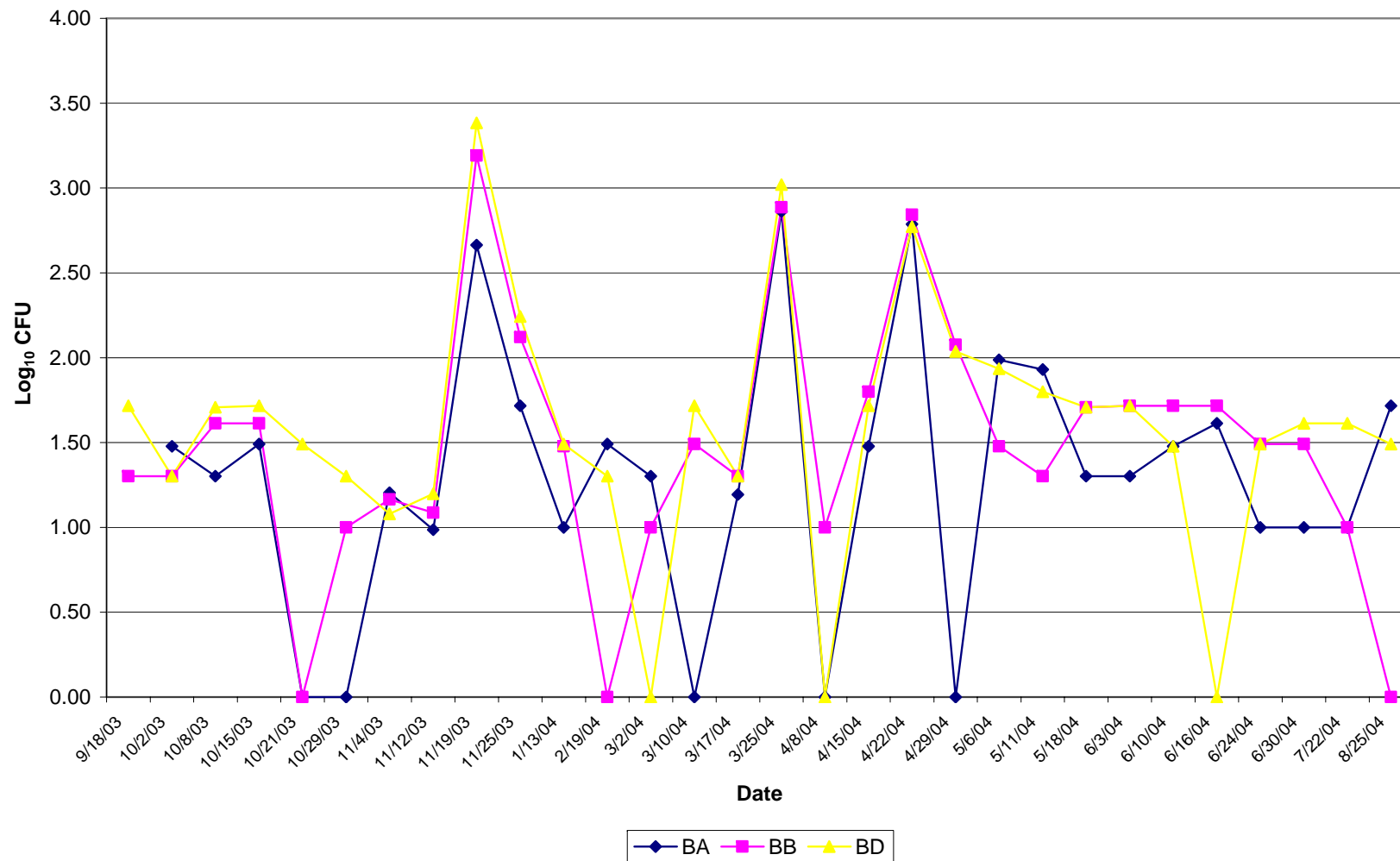
***E. coli* Log₁₀ Colony Forming Units - Bradleyville Sites - Year 2: 9/22/04-8/1/05**



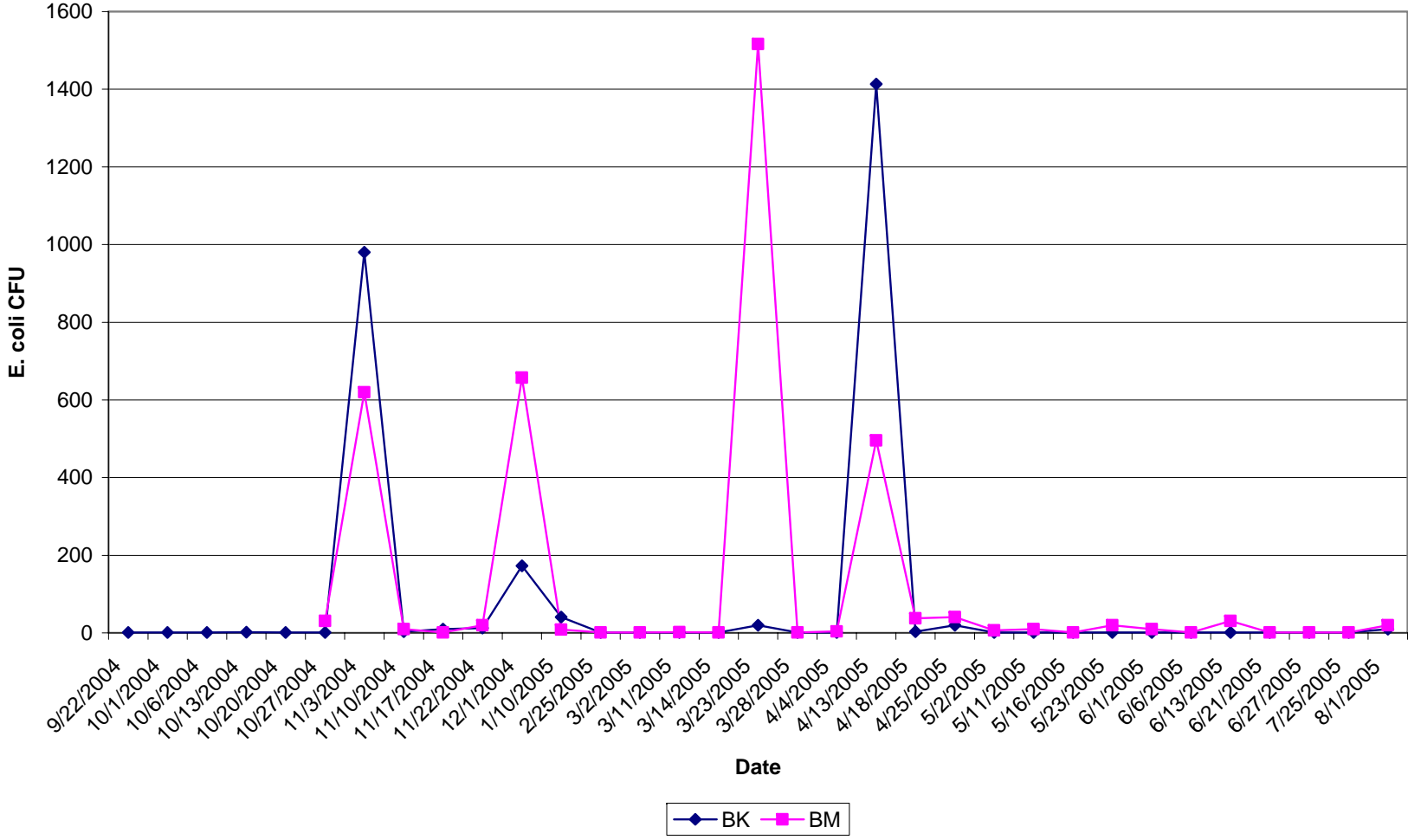
E. coli Colony Forming Units - Bradleyville Sites - Yr 1: 9/18/03-8/25/04



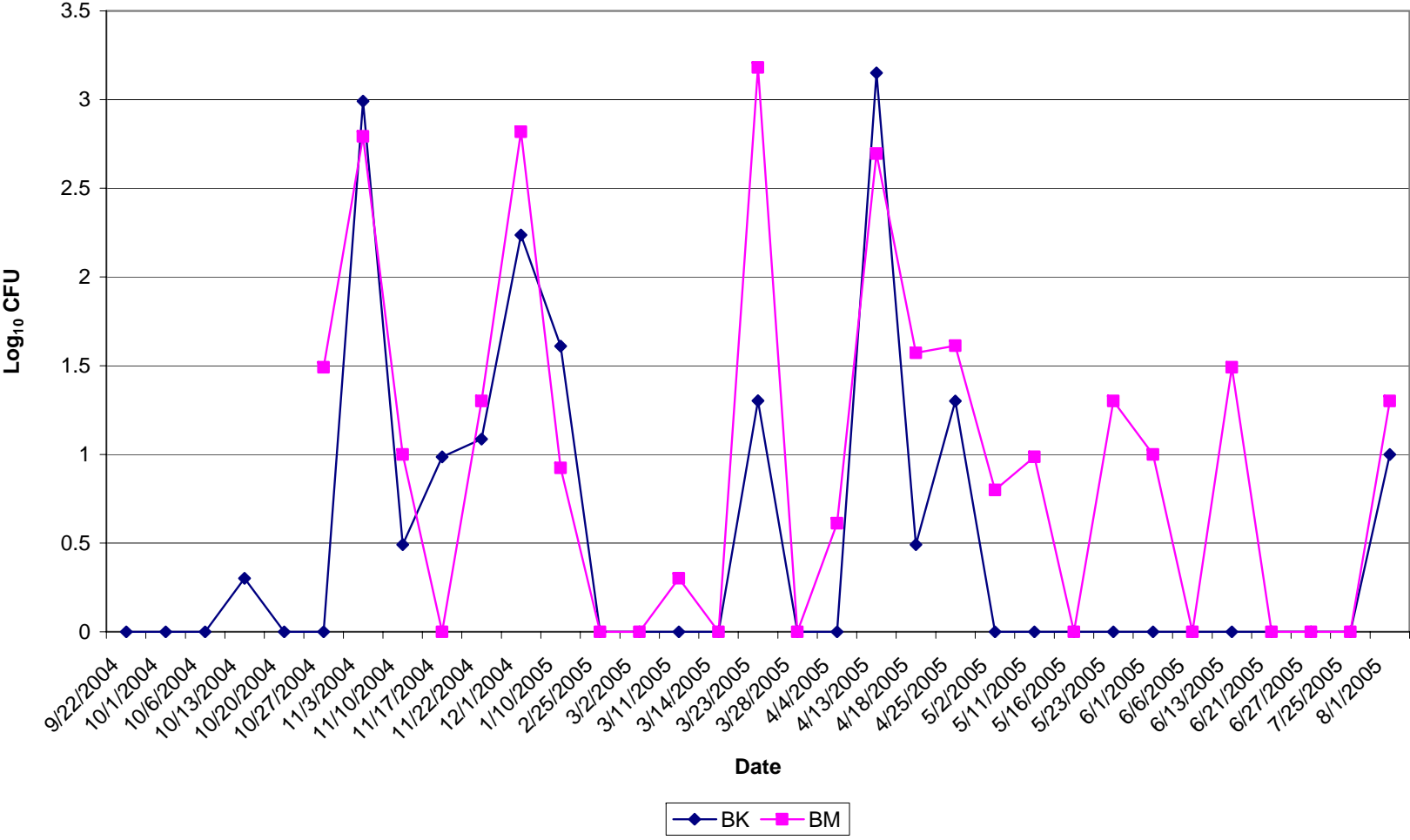
***E. coli* Log₁₀ Colony Forming Units - Bradleyville Sites - Year 1: 9/18/03-8/25/04**



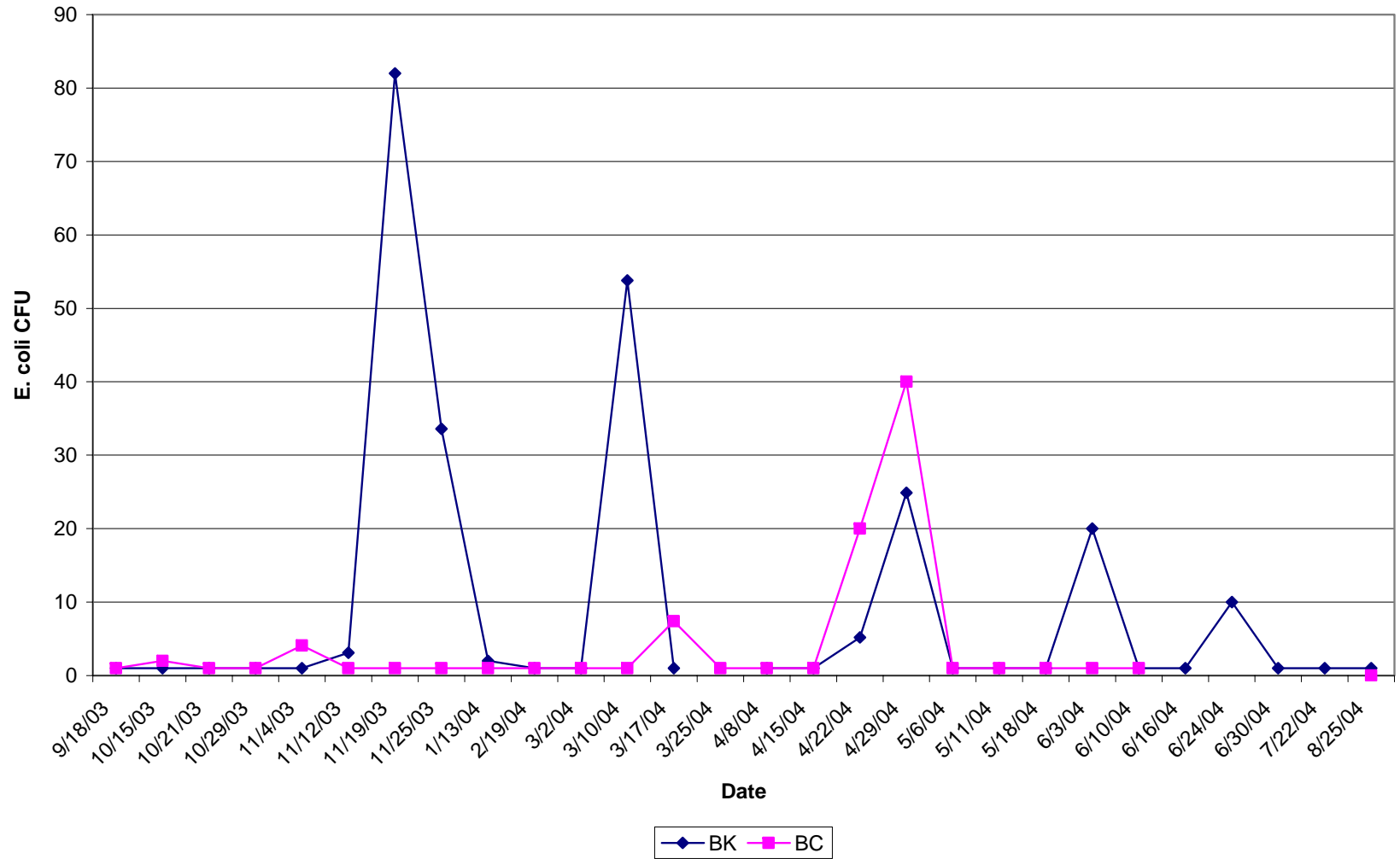
E. coli Colony Forming Units - Year 2
KDock/BK 9/22/04-8/1/05 and KisseMills/BM 10/27/04-8/1/05



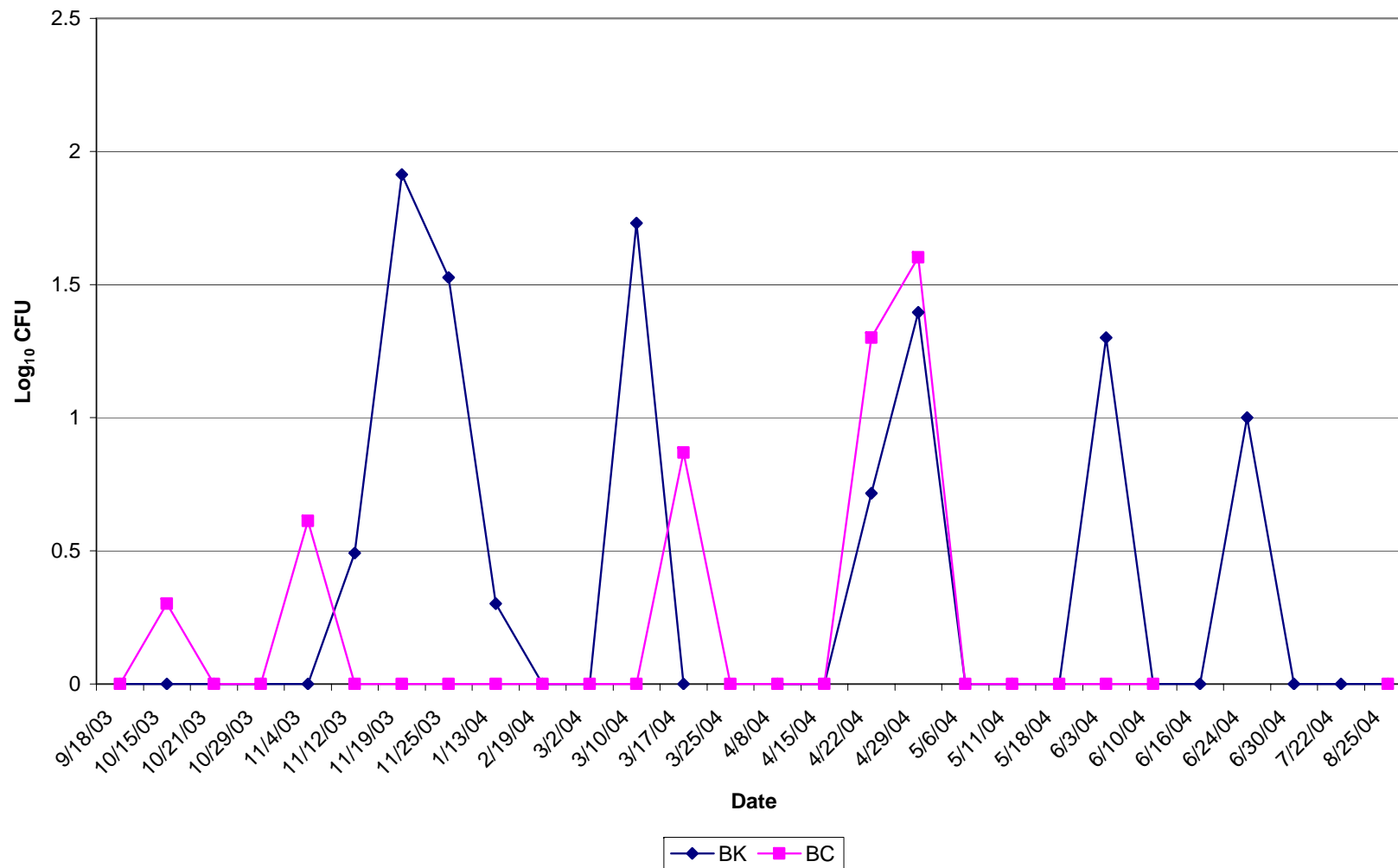
E. coli Log₁₀ Colony Forming Units - Year 2
KDock/BK 9/22/04-8/1/05 and KisseeMills/BM 10/27/04-8/1/05



E. coli Colony Forming Units - Kdock/BK & BuckCreek/BC - Year 1: 9/18/03-8/25/04



E. coli Log₁₀ Colony Forming Units - Kdock/BK & BuckCreek/BC - Year 1: 9/18/03-8/25/04



Total Nitrogen (TN)

For Year 2 on Beaver Creek, the BD site had higher values approximately 36% of the sampling dates while BA had higher values on approximately 30% of the sampling dates.

Spikes, in Year 2, correspond to rain events on 10/13/04, 11/3/04, 1/10/05, and 3/23/05.

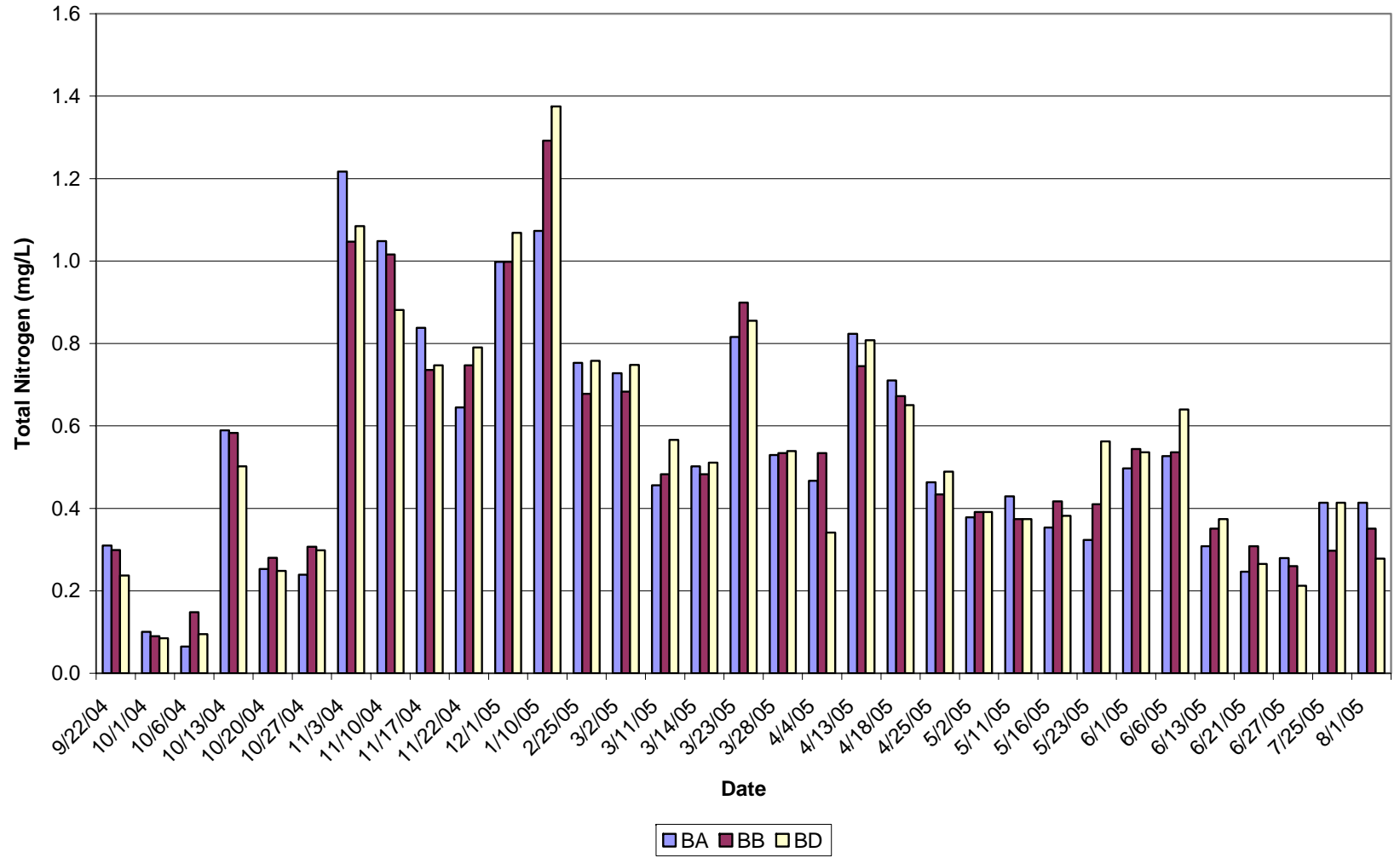
TN values appear to have a seasonal fluctuation in Year 2 in Beaver Creek.

In Year 1, BD site was higher than the other sites on 61% of the sampling dates.

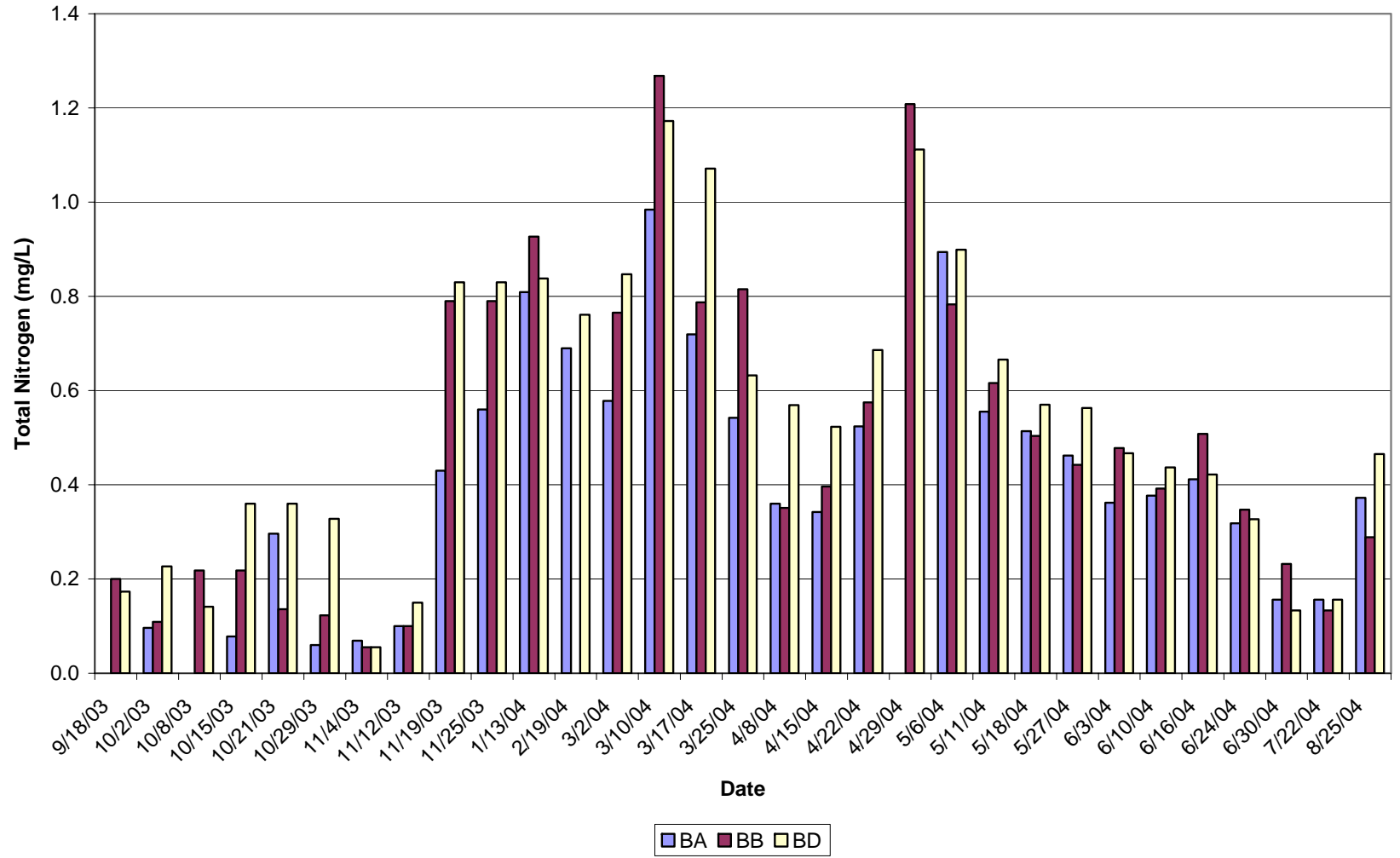
For Year 2, K-Dock had higher TN values than Kissee Mills on approximately 75% of the sampling dates with some dates as much as two times as high. This can be explained by K-Dock receiving additional TN from Lake Taneycomo and upstream tributaries.

In Year 1, K-Dock had higher TN values than Buck Creek approximately 65% of sample dates. Buck Creek is on the Arkansas border. From this data and previous studies, values decrease as you move further downstream from Lake Taneycomo and upstream tributaries.

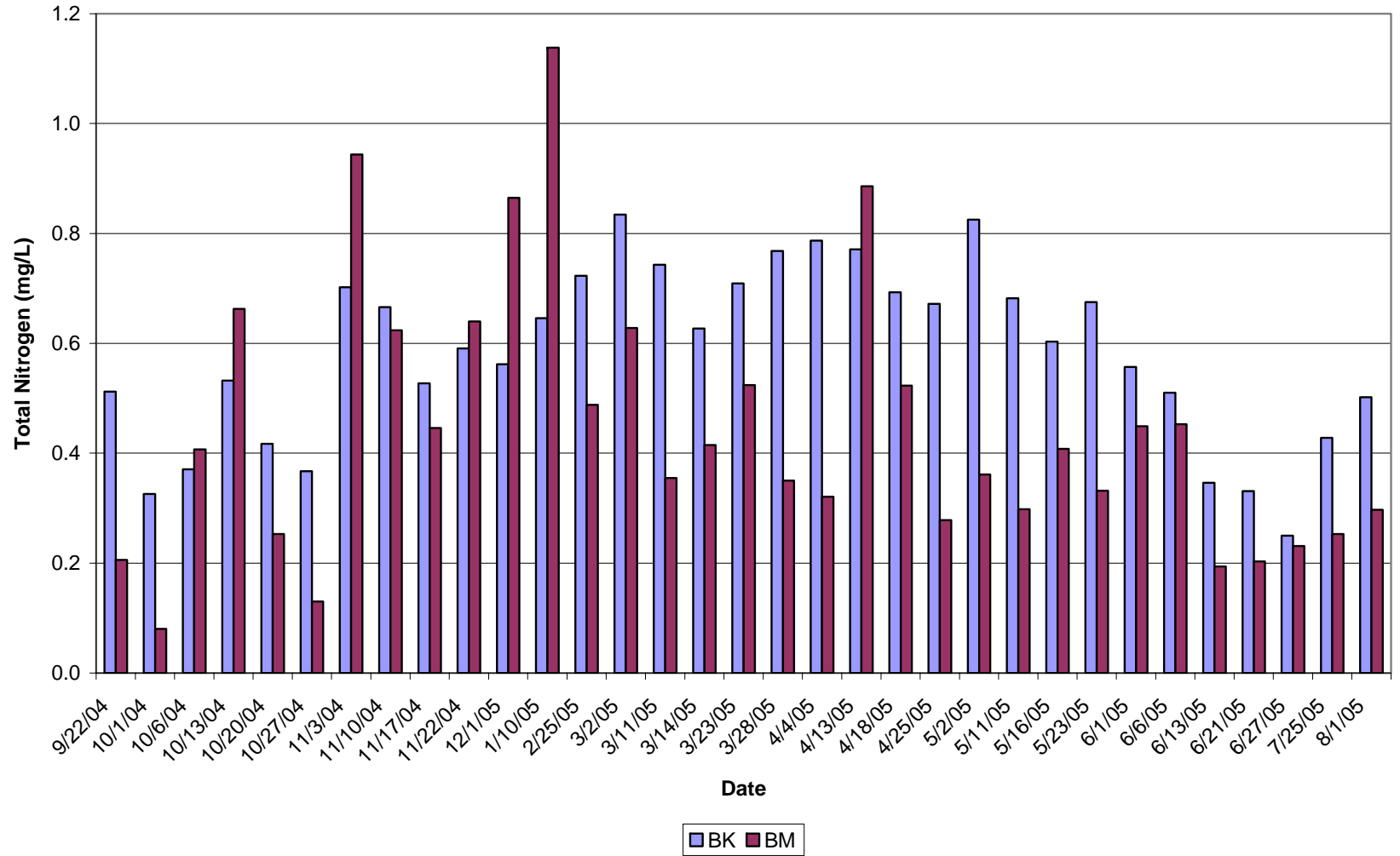
Total Nitrogen (mg/L) - Bradleyville Sites - Year 2: 9/22/04-8/1/05



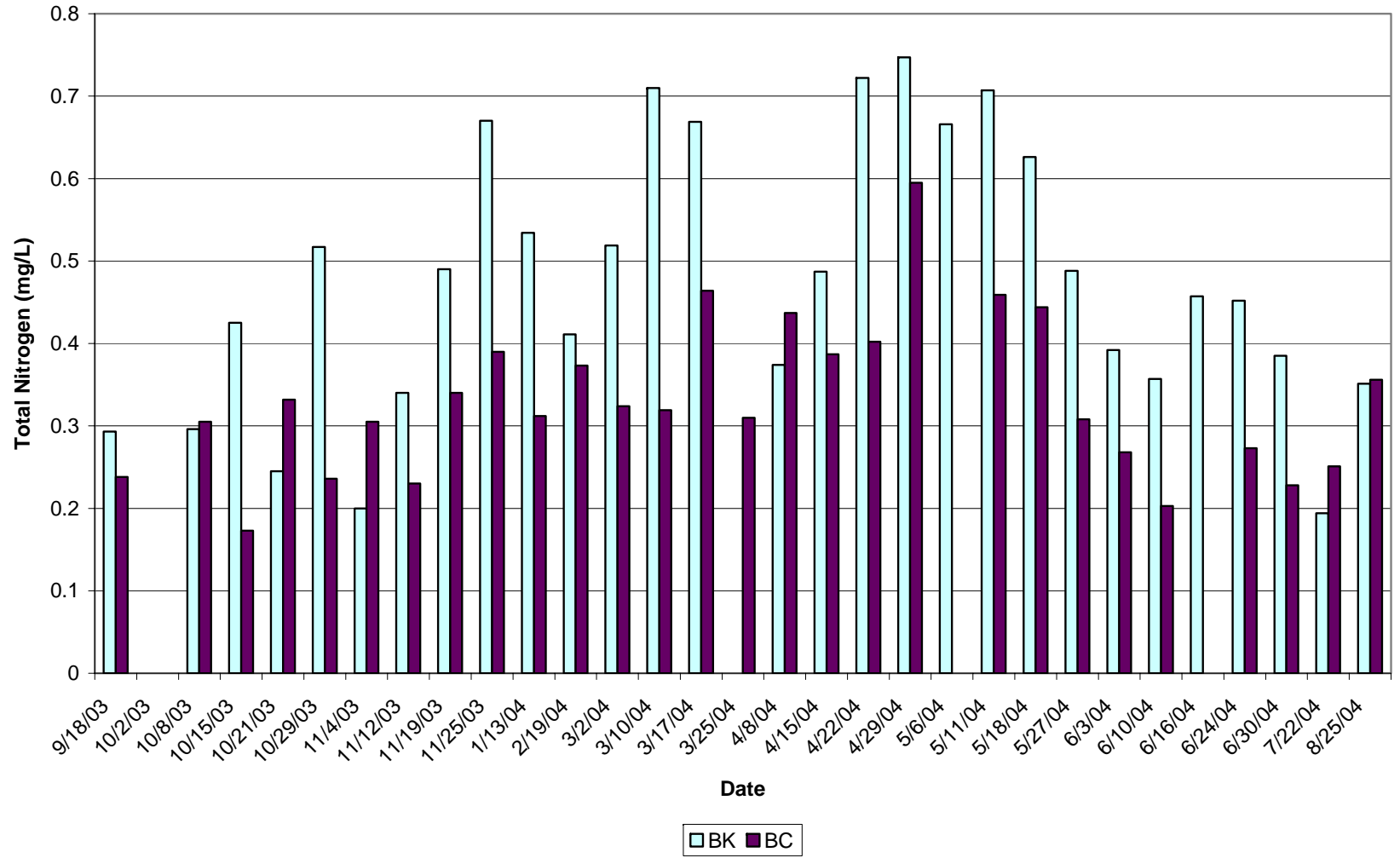
Total Nitrogen (mg/L) - Bradleyville Sites - Year 1: 9/18/03-8/25/04



Total Nitrogen (mg/L) - KDock/BK and Kisseemills/BM - Year 2: 9/22/04-8/1/05



Total Nitrogen (mg/L) - KDock/BK and Buck Creek/BC - Year 1: 9/18/03-8/25/04



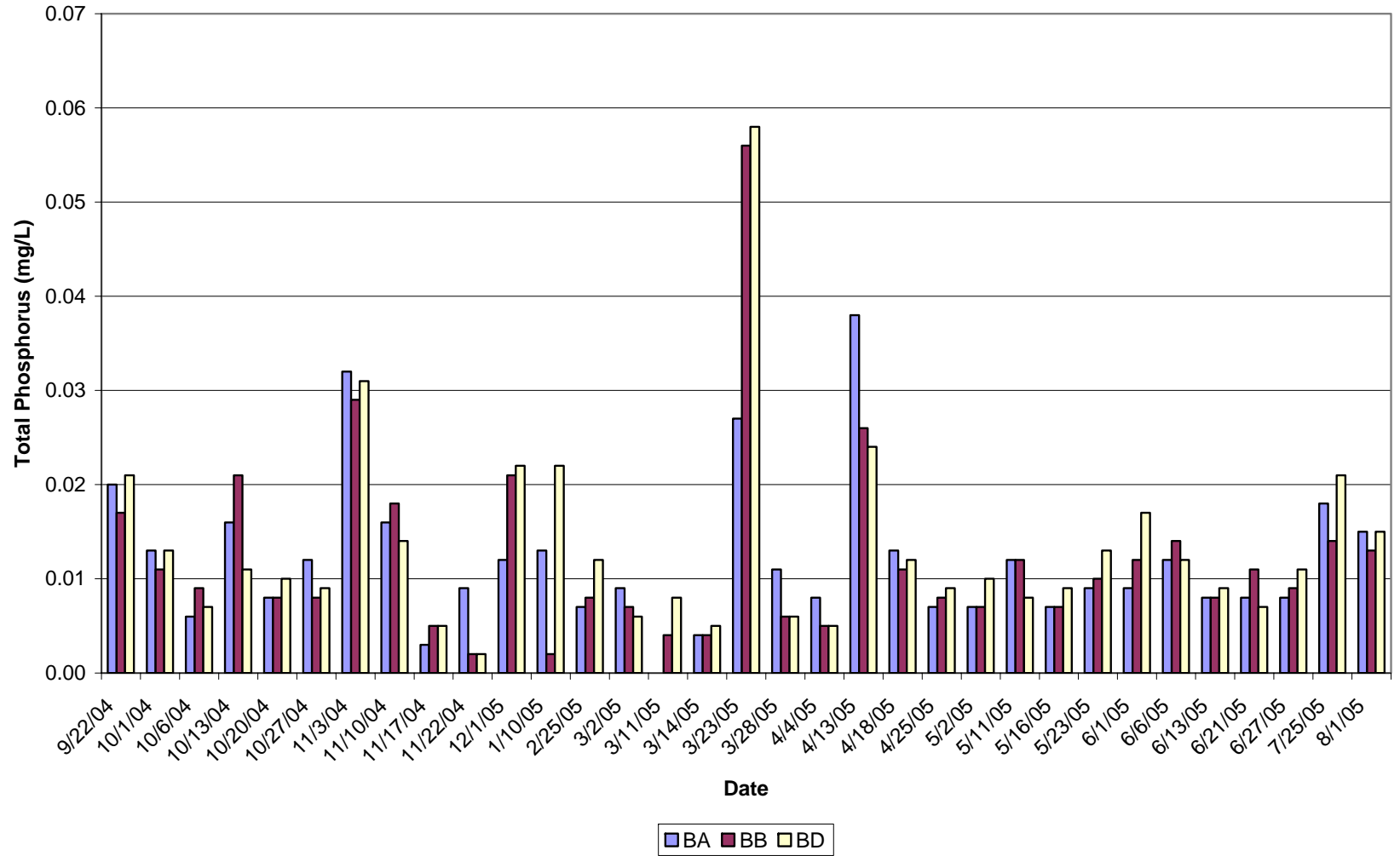
Total Phosphorus (TP)

For Year 2 on Beaver Creek, the BD site had higher TP values than other sites on approximately 42% of the sampling dates. Spikes in TP did correspond to rain events.

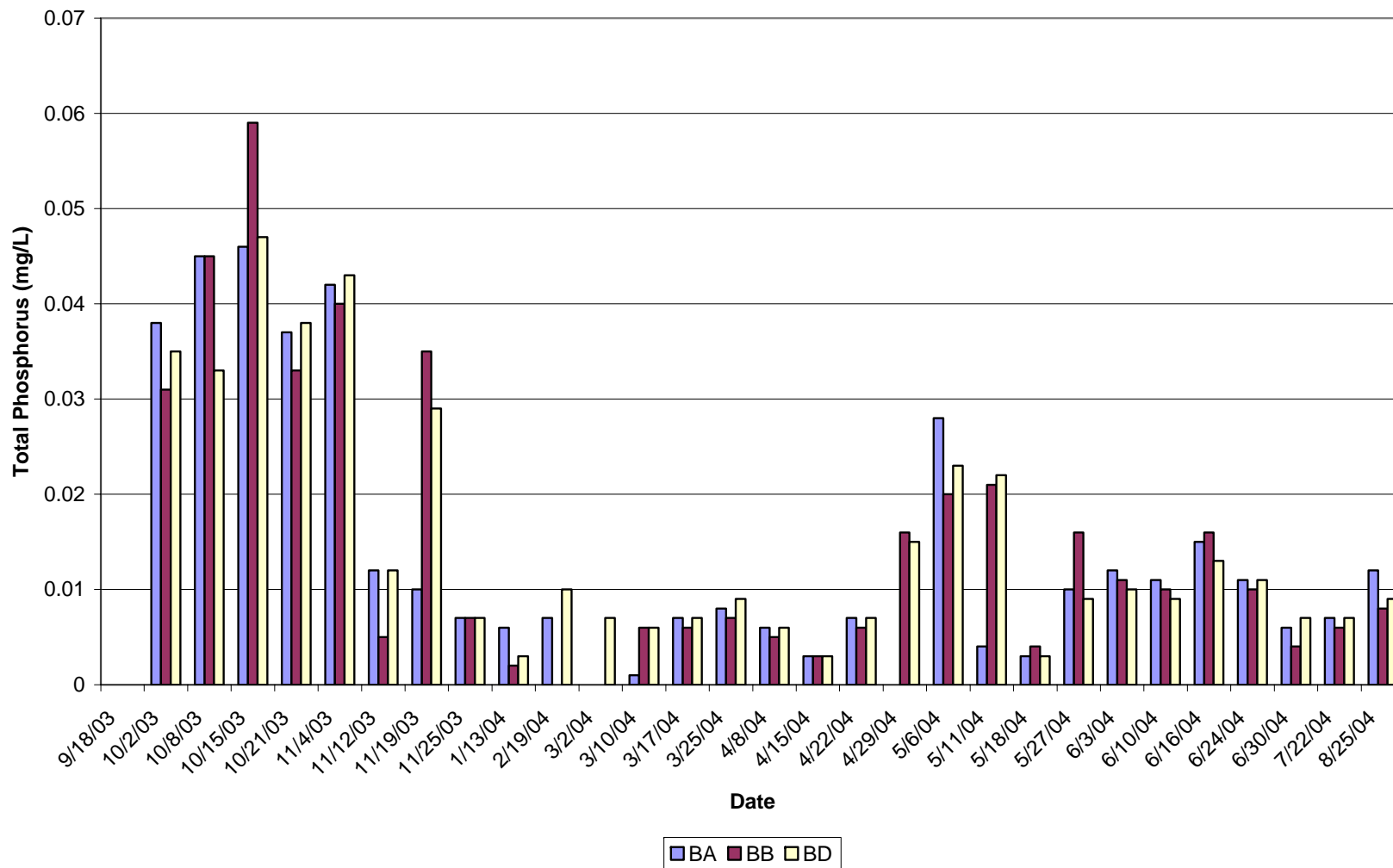
For Year 2 on the lake sites, K-Dock was higher than Kissee Mills on approximately 78% of the sampling dates sometimes being twice as high.

In Year 1, K-Dock was higher than Buck Creek on approximately 64% of the sampling dates. Again as with TN, the further distance from Lake Taneycomo, the smaller the TP values.

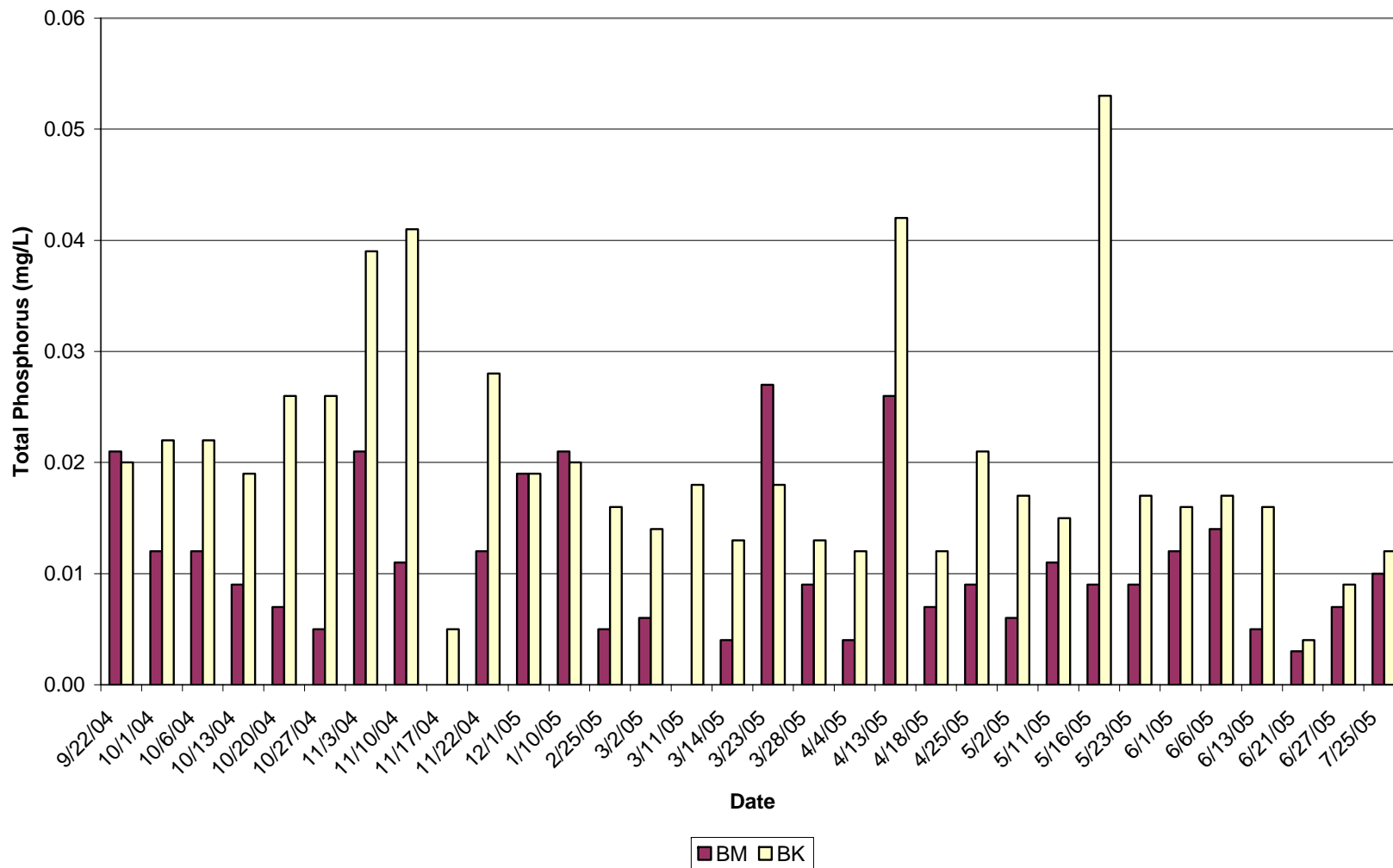
Total Phosphorus (mg/L) - Bradleyville Sites - Year 2: 9/22/04-8/1/05



Total Phosphorus (mg/L) - Bradleyville Sites - Year 1: 9/18/03-8/25/04



Total Phosphorus (mg/L) - KDock/BK and Kisseemills/BM - Year 2: 9/22/04-8/1/05



Total Phosphorus (mg/L) - KDock/BK and Buck Creek/BC - Year 1: 9/18/03-8/25/04

