

12 Perry Lake

12.1 General Background

Perry Lake was impounded in 1969 and reached full pool in 1970. The main water quality threats to Perry Lake are sedimentation, nutrients and bacterial contamination. The lake is listed on the state’s 2004 303(d) list for water quality impairment due to eutrophication and fecal bacteria (inflows). The Delaware River Watershed Restoration

and Protection Strategy (WRAPS), under the direction of Marlene Bosworth, held numerous meetings throughout the past year and is in the process of developing a draft watershed management plan. The purpose of WRAPS is to develop goals and strategies to improve water quality within the watershed over a 10-year period.

12.1.1 Location

Perry Lake, the fourth largest lake in Kansas, is located approximately 20 km (12 miles) northwest of Lawrence, Kansas. The dam is located at river km 8.5 (river mile 5.3) on the Delaware River. The watershed includes portions of Brown, Jefferson, Atchison, Jackson and Nemaha counties. Historic water quality sample sites at Perry Lake include 3

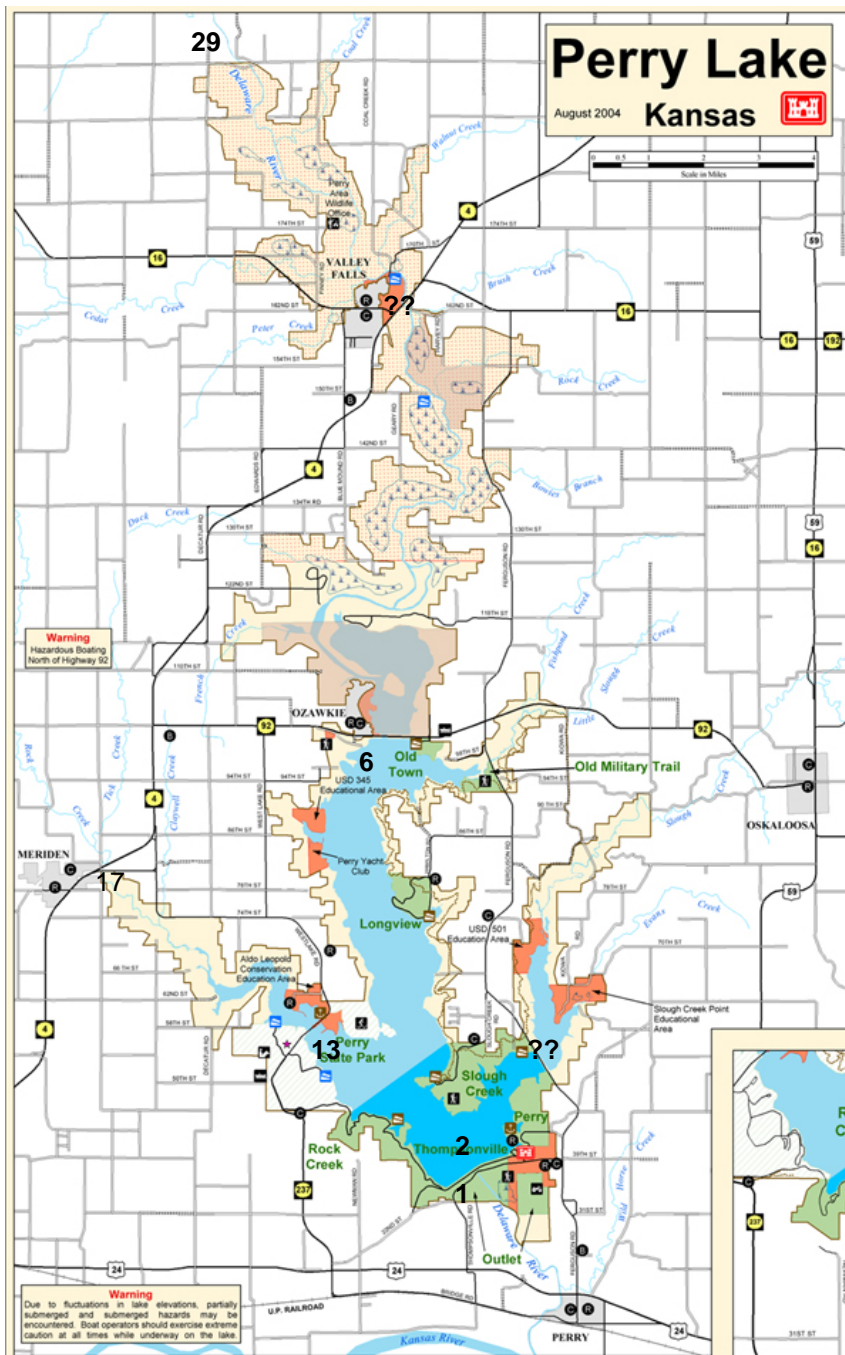


Figure 12.1. Perry Lake area map with sample site locations and site numbers.

lake, 1 outflow, and 2 inflow (Figure 12.1).

12.1.2 Authorized Purposes: Flood control, water storage, fish and wildlife habitat, navigation support, and recreation.

12.1.3 State Use Designations: Primary contact recreation, special aquatic life support, drinking water, food procurement, industrial water supply.

12.1.4 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	920.6	509.3	25,347	
Multipurpose	891.5	206.7	11,146	160
Total		716.0		

Total watershed area: 1,117 sq miles (714,880 A)
 Watershed ratio: 28.2 FC / 64.14 MP
 Average Annual Inflow: 585,391 acre-feet
 Average Annual outflow: 000 acre-feet
 Average flushing rate: 0.38 years
 Sediment inflow (measured): 49,057 acre-feet (1962 – 2000)
 Water management Plan: Approved July 1973; minor revisions approved January 1995
 Historic stage hydrograph: 1996 – 2006 (Figure 12.2)

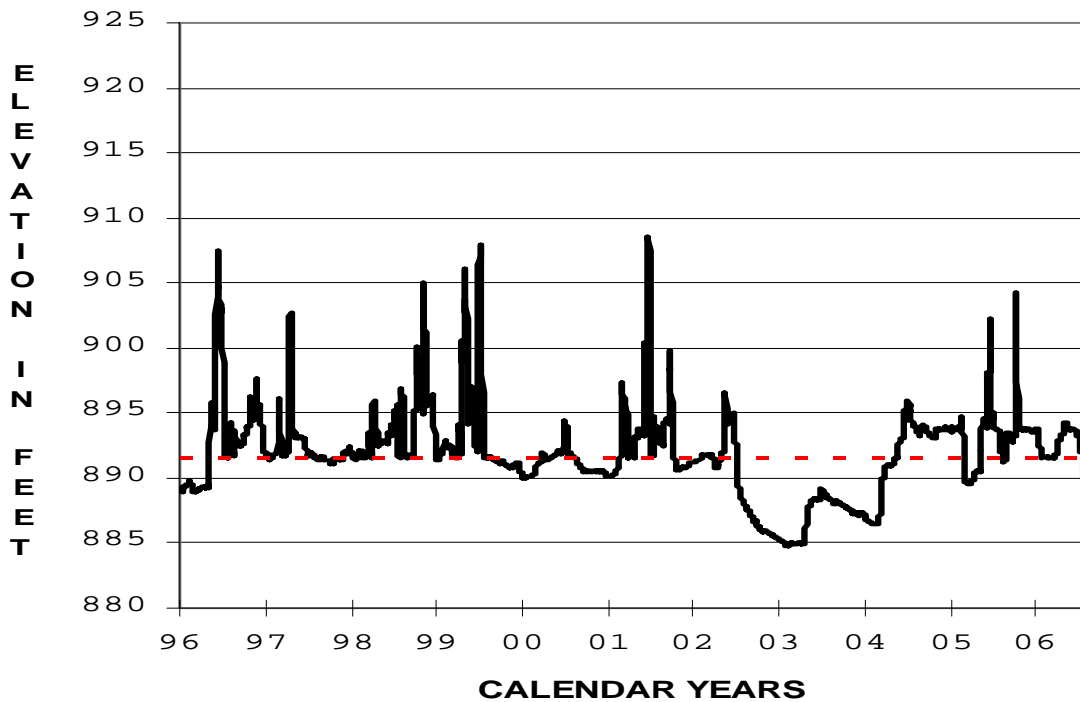


Figure 12.2. Pool elevation hydrograph from 1996 – 2006 (red-dashed line is the multipurpose pool elevation – 891.5 msl).

12.2 2006 Activities

Perry Lake was categorized as an ‘ambient’ lake during 2006, thus only surface samples were collected at three lake sites. Sample collections occurred from May through September 2006, while vertical profiles were recorded at the three lake sites during May and August. Perry Lake staff (OF-PE) providing field assistance with the WQP during 2006 included Bunnie Watkins. Additional assistance was provided by the Jefferson County Sheriffs Department.

12.3 2006 Data

Comparative historic water quality data consists of monthly (April – September) data collected from 1996 through 2005. Samples were collected from May through September during 2006.

12.3.1 Inflow

No inflow samples were collected from the Perry Lake watershed during 2006. Historically, nutrient concentrations (nitrogen and phosphorus) are most variable at these sites due to influences of runoff events within the watershed.

12.3.2 Lake

Based on total nitrogen (TN), total phosphorus (TP), and chlorophyll *a*, Perry Lake is classified as eutrophic. Nitrogen is an essential nutrient to aquatic life. However, excessive concentrations can result in algal blooms, low DO levels, taste and odor issues in drinking water, and even fish kills. Total nitrogen concentrations from surface samples are relatively consistent between lake sites ranging from 0.78 – 0.99 mg/L (Figure 12.3). Annual and monthly variability in TN concentrations are evident from both inflow (Site 29) and main lake sample (Site 2) sites (Figures 12.4 and 12.5, respectively). With few exceptions, all samples from the Perry Lake watershed exceed EPA’s proposed ecoregional nutrient criteria value of 0.36 mg/L TN.

Phosphorus is another essential nutrient for aquatic life, and it limits algal growth. Median total phosphorus concentrations from lake sites (0.07 – 0.14 mg/L) were typical of other district lakes (Figure 12.6). Similar to TN, greater concentrations and wider monthly and annual variability in TP concentrations were detected at Site 29 (Delaware River). One aspect of the WRAPS is to determine where to focus efforts, so naturally it is important to determine if differences in TP could be differentiated from subwatersheds. According to the data, the mean TP concentration from the Rock Creek inflow was 0.18 mg/L and 0.35 mg/L from the Delaware River. This would indicate that BMP’s targeting TP should be focused along the main tributary of Perry Lake. All median TP concentrations exceed EPA’s proposed ecoregional nutrient criteria value of 0.02 mg/L TP. The TP concentrations are typical of other district lakes.

The ratio of TN:TP can be used as a surrogate to determine the dominant algal community within a waterbody. Ratios $\geq 20:1$ are indicative of desirable algal communities, whereas ratios $\leq 12:1$ are indicative of bloom-forming cyanobacteria (blue green algae). Median TN:TP ratios at all three lake sites are < 12 , indicating the lake is at risk for cyanobacteria blooms (Figure 12.7). As would be expected, there is high

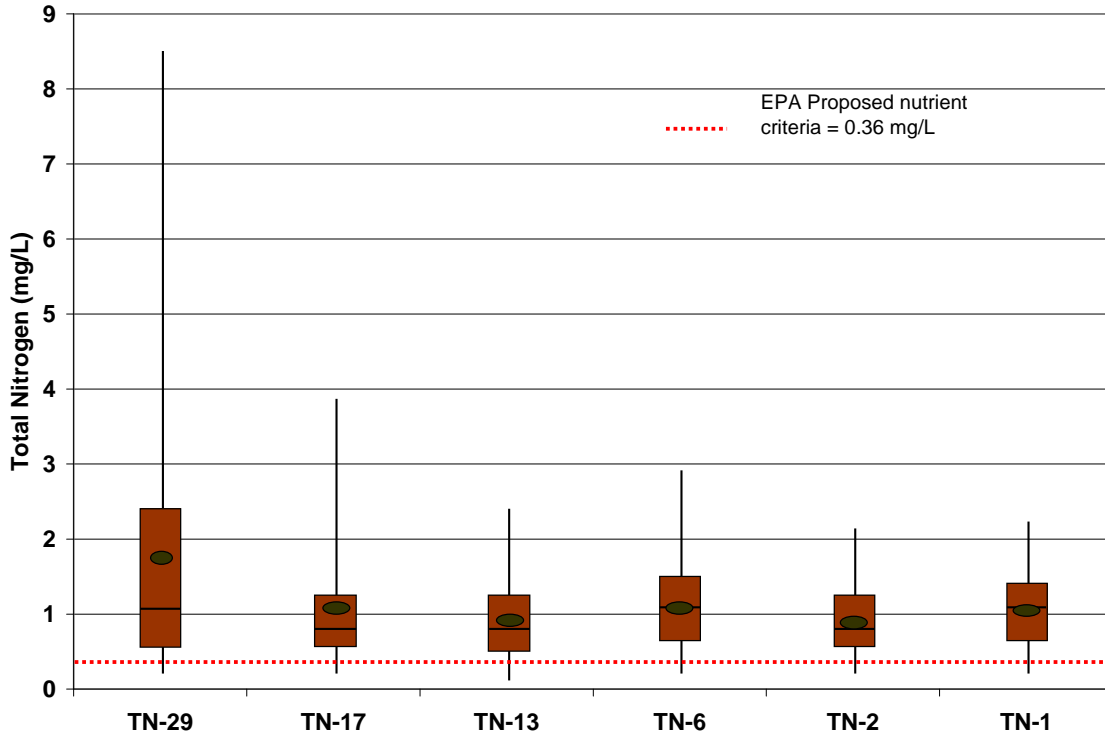


Figure 12.3 Box plots of surface water sample total nitrogen concentrations measured by site from 1996 through 2006 at Perry Lake.

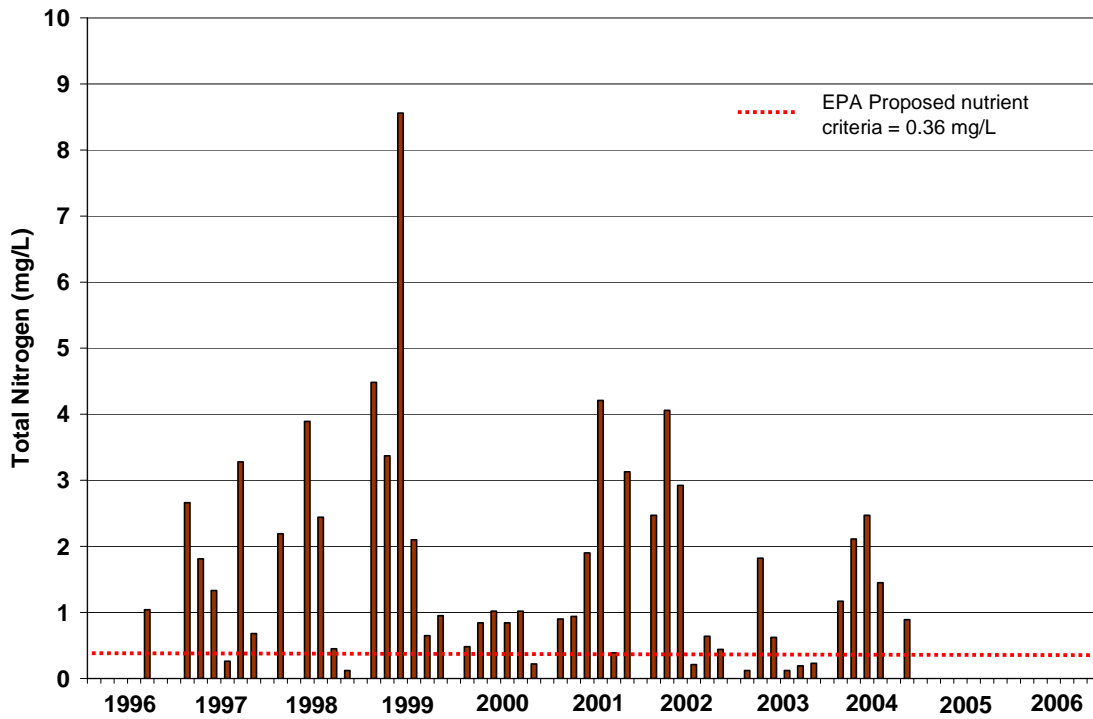


Figure 12.4. Total nitrogen by sample date from surface water samples collected at Site 29 (Delaware River) inflow to Perry Lake from 1996 through 2006.

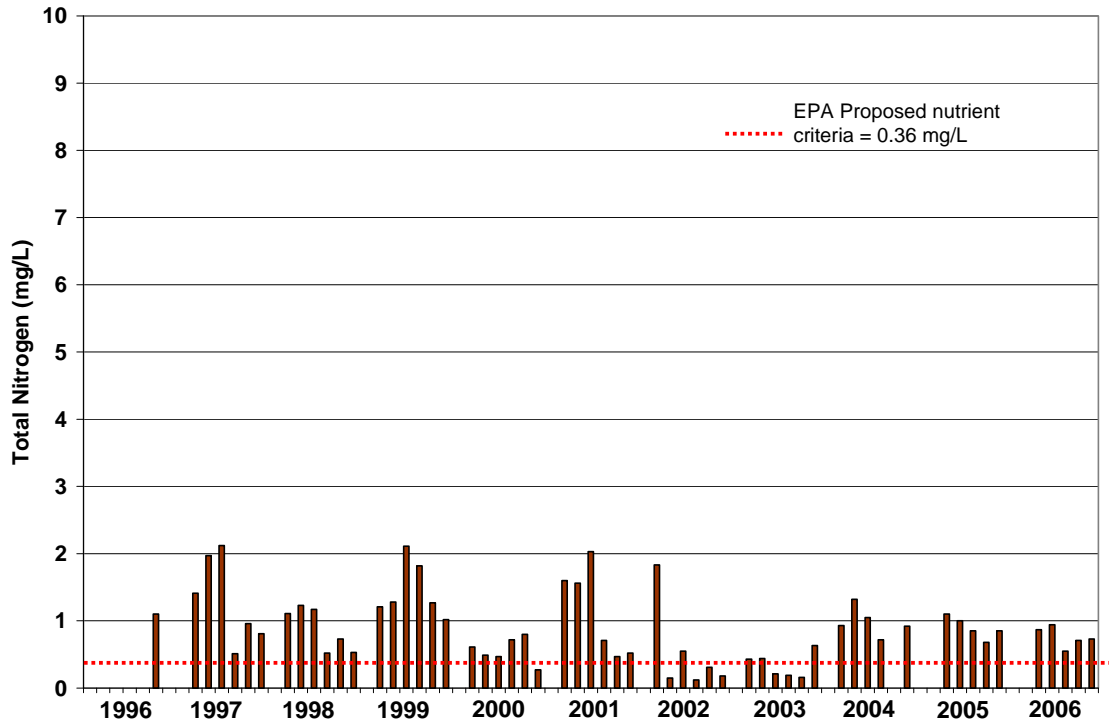


Figure 12.5. Total nitrogen by sample date from surface water samples collected at Site 2 (Tower) in Perry Lake from 1996 through 2006.

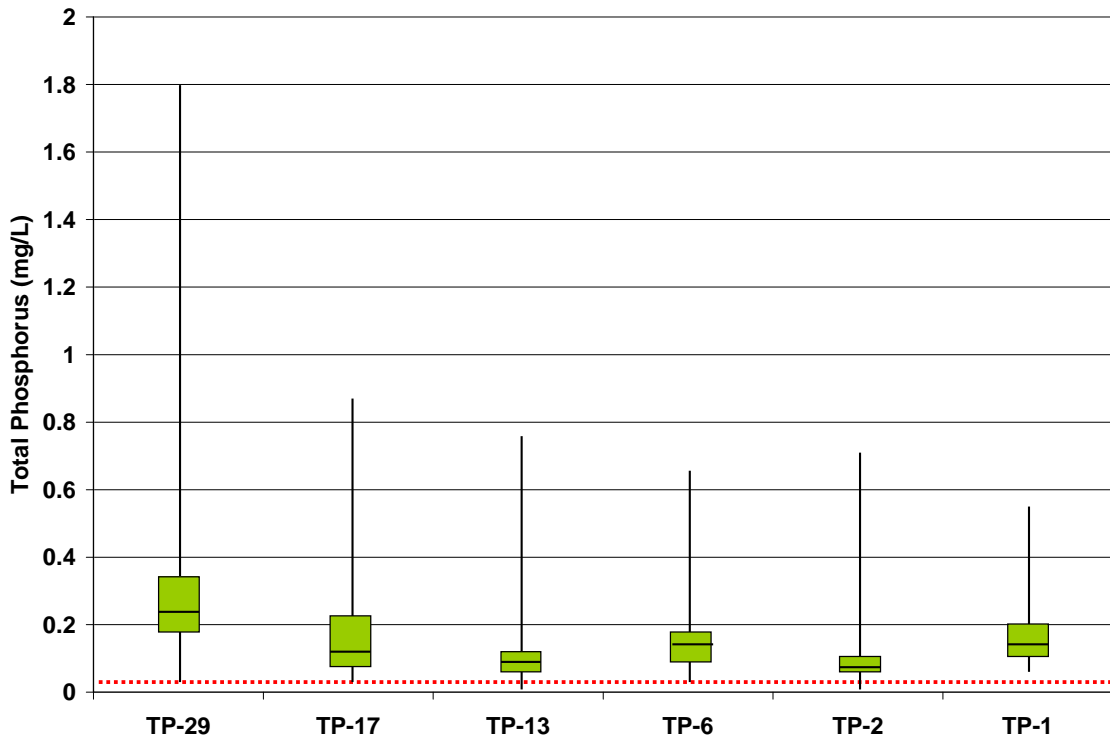


Figure 12.6. Box plots of surface water total phosphorus concentrations measured by site from 1996 through 2006 at Perry Lake.

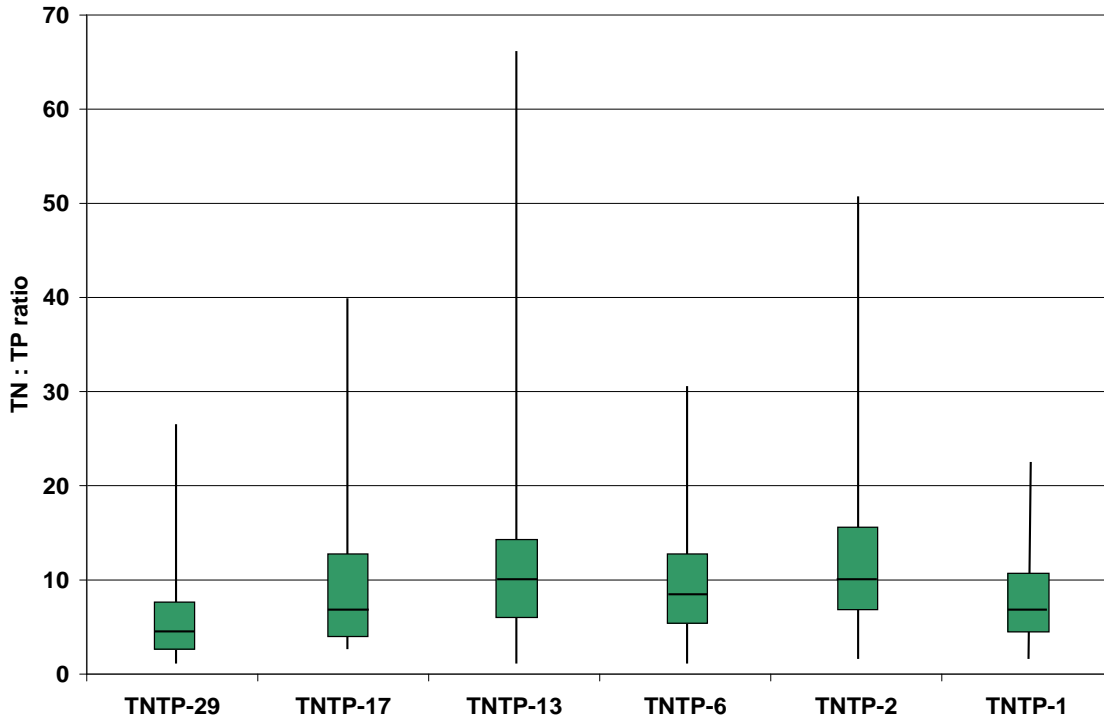


Figure 12.7. Box plots of total nitrogen : total phosphorus ratio (TN : TP) by site from surface water samples collected between 1996 and 2006 at Perry Lake.

monthly and annual variability in the TN:TP ratio at all sites; see Figure 12.8 as an example at Site 13 (Rock Creek arm).

Mean chlorophyll a concentrations ranged from 26 – 28 ug/L for the three lake sites during 2006. Concentrations were consistently more than 2x higher at Site 6 versus the other two lake sites. This data corroborates TP data collected at lake sites.

Secchi depth (water clarity) was measured at all lake sites during May, July, August, and September 2006 (Figure 12.9). Water clarity was relatively clear at Site 2 (1.32 m), slightly clearer at Site 13 (0.68 m), and very limited in the Delaware River arm (Site 6; 0.36 m).

Relative concentrations of phycocyanins, or bluegreen algae, were measured vertically throughout the water column during May and August 2006. Such profiles provided information on monthly as well as within lake distribution changes. Figure 12.10 depicts vertical distribution of phycocyanins measured at Site 2 (Tower). Concentrations were highest in August, and the distribution was relatively consistent throughout the water column during 17 August. A bluegreen algal bloom was observed by lake staff and a sample was collected for algal toxins on 5 September by USGS - Lawrence. Results indicated a concentration of total microtoxins of 3.96 ppb (Total) and 2.22 ppb (Dissolved). World Health Organization protective limits are 1 ug/L for drinking water (dissolved), while recreational protection (total microtoxins) is – low risk range of 1 – 10 ug/L (Chorus and Bartram, 1999).

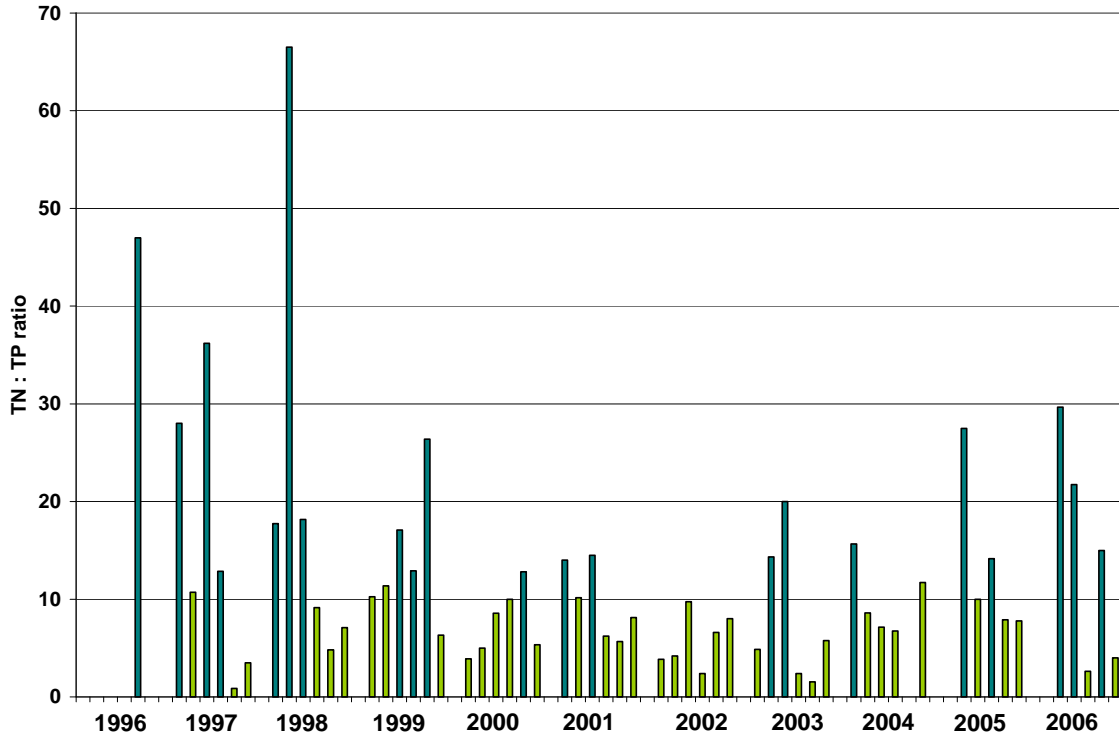


Figure 12.8. Graph of total nitrogen : total phosphorus ratio (TN : TP) by sample date from surface water samples collected at Site 13 in Perry Lake between 1996 and 2006.

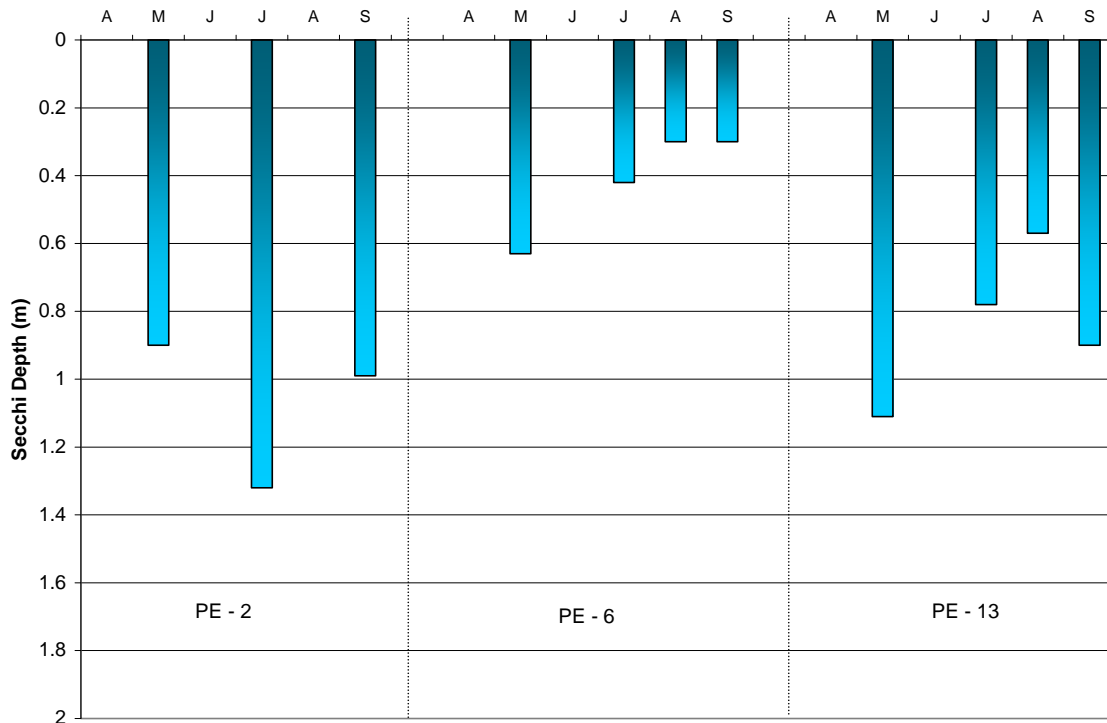


Figure 12.9. Secchi depth (m) measurement by site and sample date at Perry Lake during 2006.

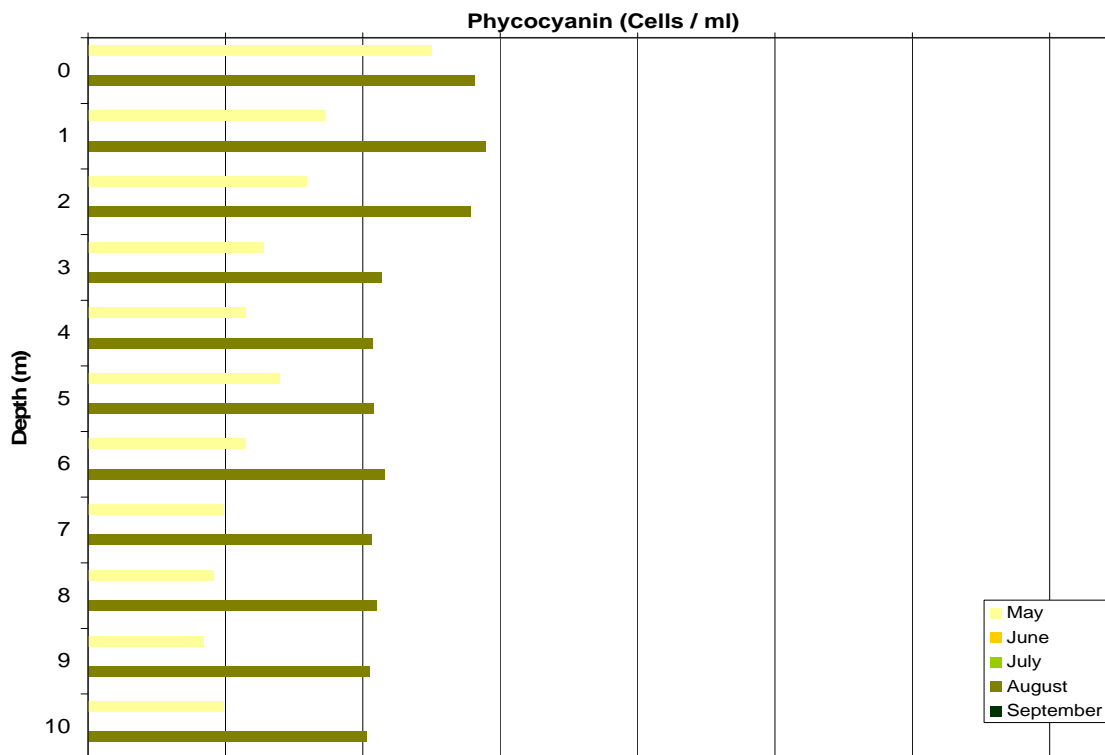


Figure 12.10. Relative concentrations of phycocyanin (bluegreen algae) (cells / ml) measured monthly by depth at Perry Lake Site 2 (Tower) during 2006.

Atrazine samples were collected from the three lake sites during May 2005, and concentrations ranged from 2.7 (Site 2) – 8.3 ug/L (Site 6). Median atrazine concentrations collected from surface water samples since 1996 range from 0.52 – 1.67 ug/L (Figure 12. 11). Although less than EPA’s drinking water maximum contaminant level of 3 ug/L, individual samples measured even during 2006 still exceed the MCL. Figure 12.12 depicts individual sample concentrations and exceedances of the MCL measured by date at Site 6 (Delaware River arm) from 1996 through 2006.

Perry Lake is the only district lake to exceed the Alachlor MCL of 2 ug/L. As with other contaminants, monthly and annual variability in concentrations is detected; see Figure 12.13 as an example from Site 17 (Rock Creek inflow). Exceedances were detected at both inflow sites as well as Site 6 (Delaware River arm). No exceedances have been detected since 2000, which may be an indication of change in herbicide preference or improved application methods.

Vertical profiles were recorded during May and August sampling trips to Perry Lake. Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. Based on these profiles, the lake stratified both chemically and thermally between 4-7 m depth during May (Figure 12.14). No stratification was observed during August.

Fecal bacteria (*E. coli*) samples were collected from three locations at Perry Park beach prior to three major holidays (Memorial Day, July 4th, and Labor Day) during 2006. No samples exceeded the single sample maximum of 732 colonies / 100 ml for a whole-body contact during the recreational season (Figure 12.15). With limited inflows due to

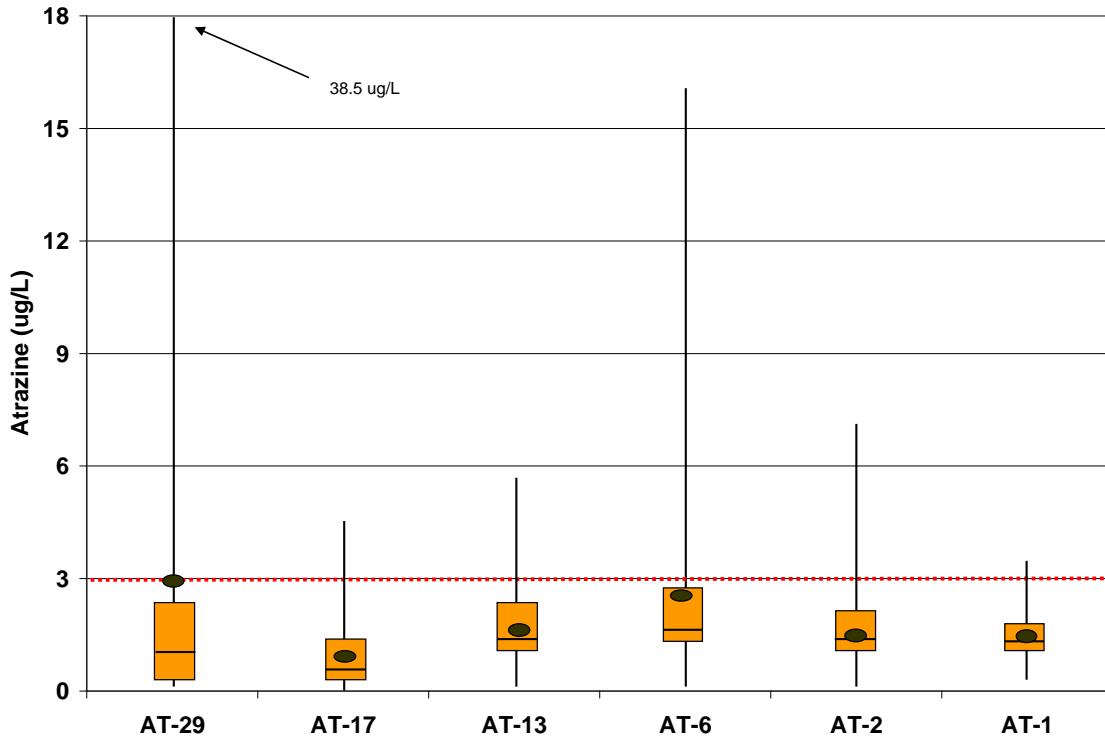


Figure 12.11. Box plots of surface water sample atrazine concentrations measured from 1996 through 2004 at Perry Lake.

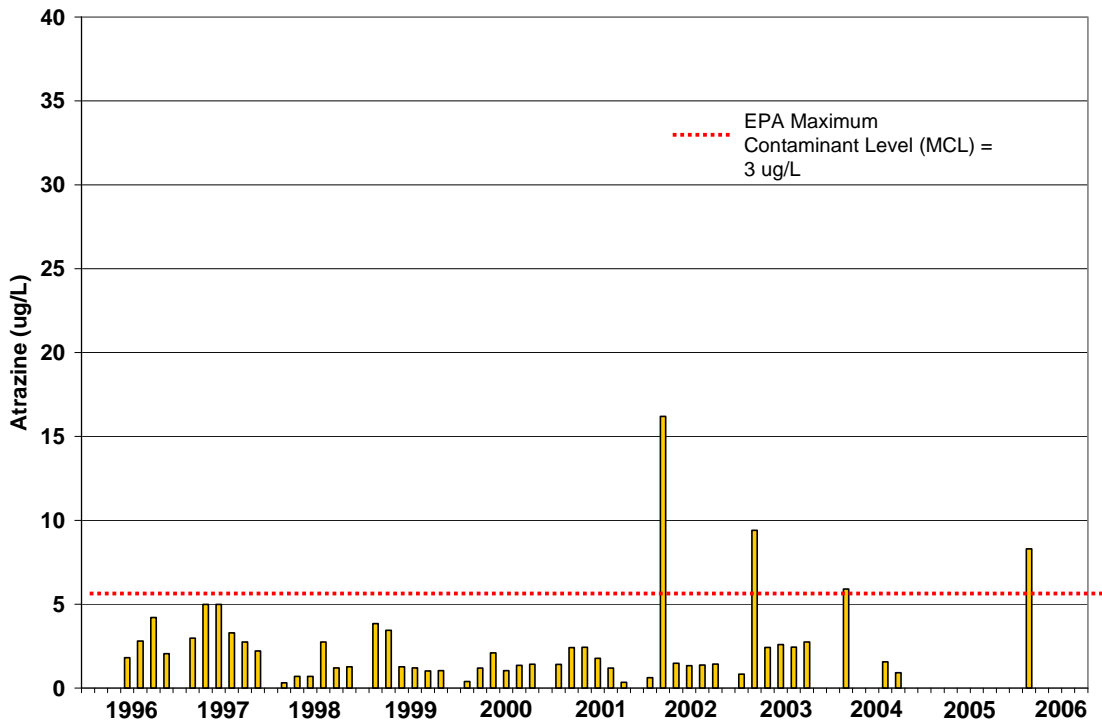


Figure 12.12. Atrazine concentrations by sample date collected from surface water samples at Site 6 -- Delaware River arm -- of Perry Lake between 1996 and 2006.

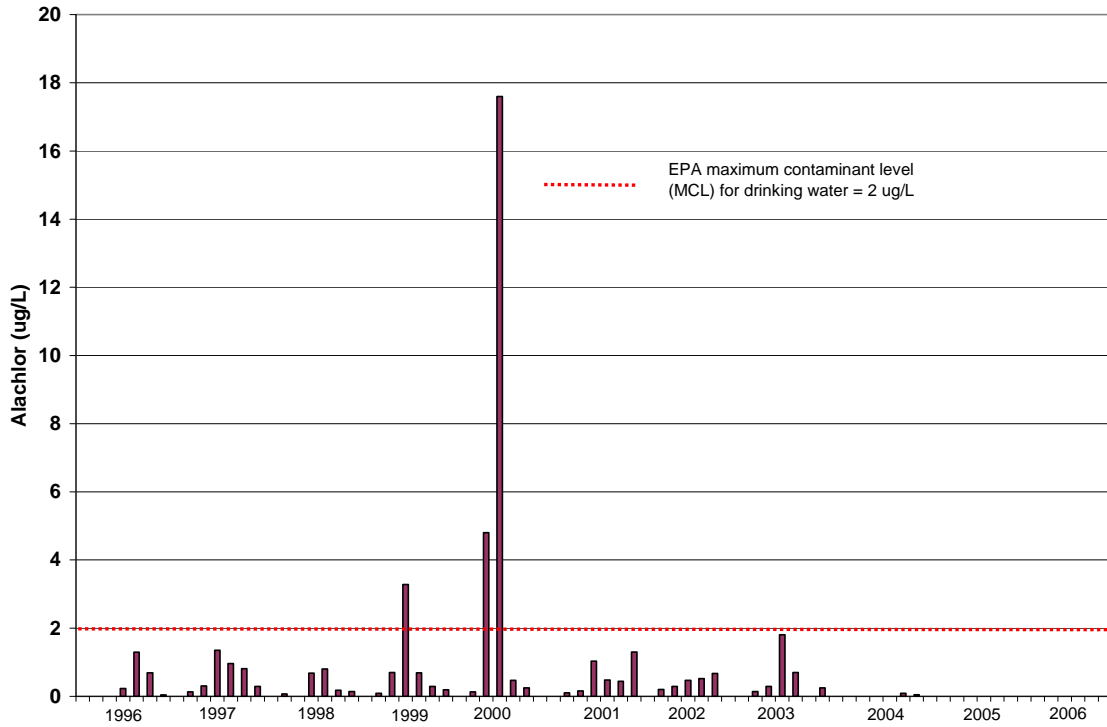
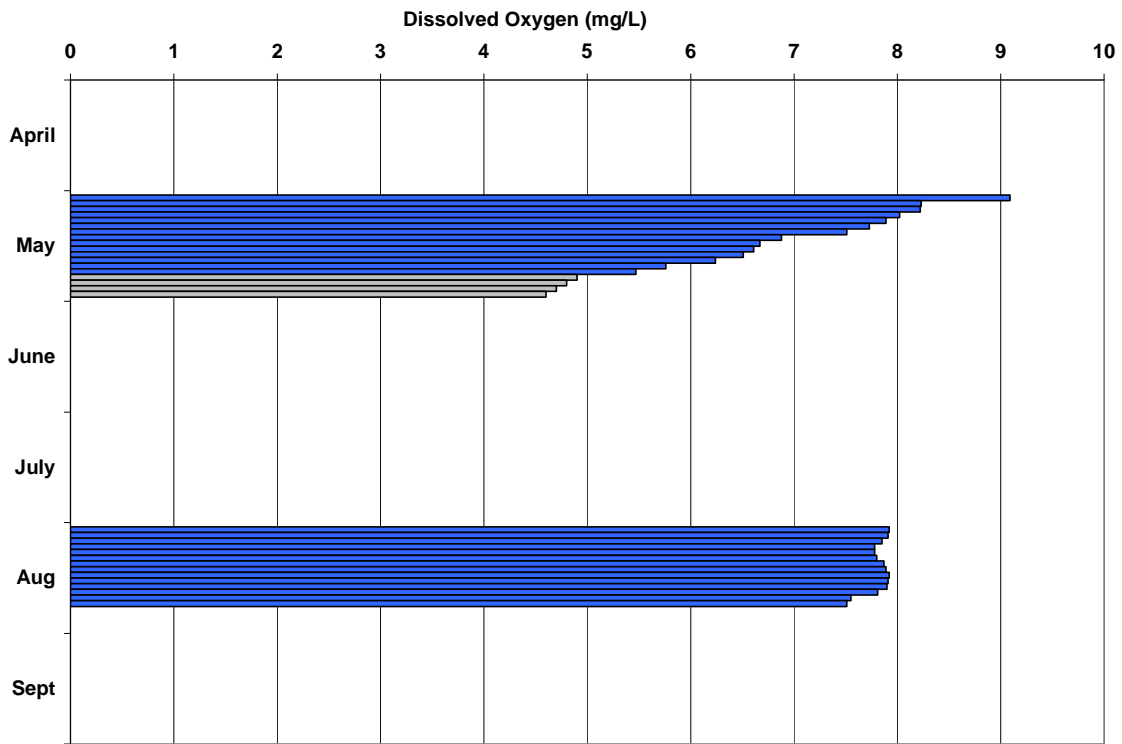


Figure 12.13. Alachlor concentrations by sample date collected from surface water samples at Site 17 (Rock Creek) inflow to Perry Lake between 1996 and 2006.



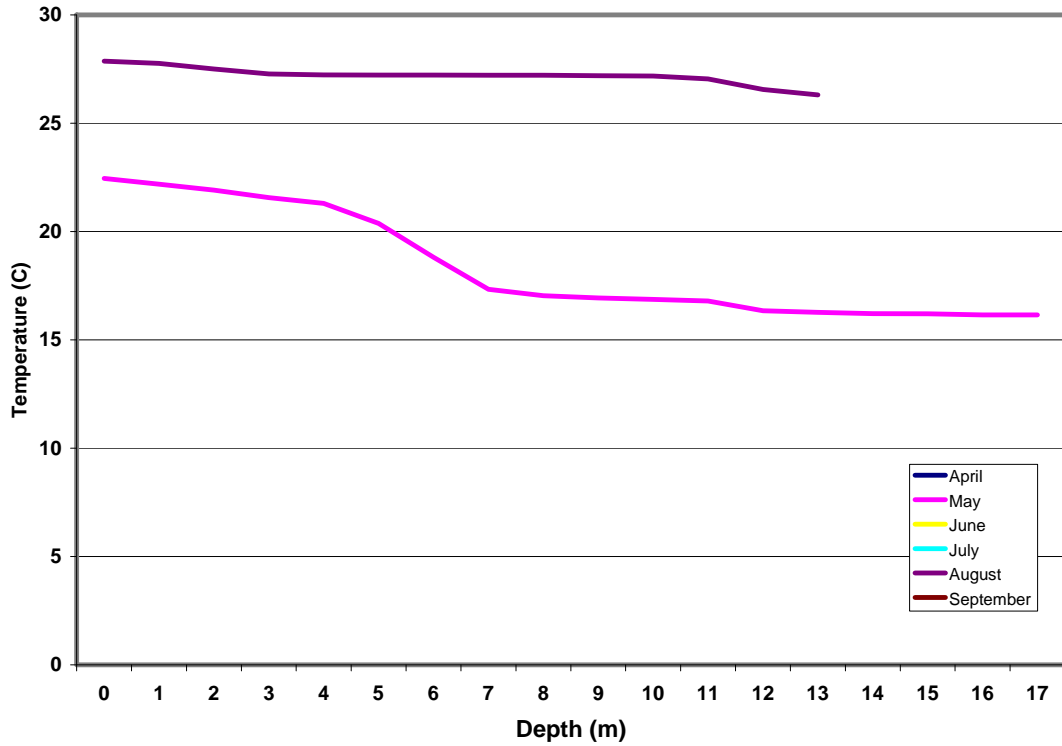


Figure 12.14. Dissolved oxygen concentration (mg/L) histogram and temperature (C) plot from vertical profiles recorded at Site 2 (Tower) during 2005 at Perry Lake.

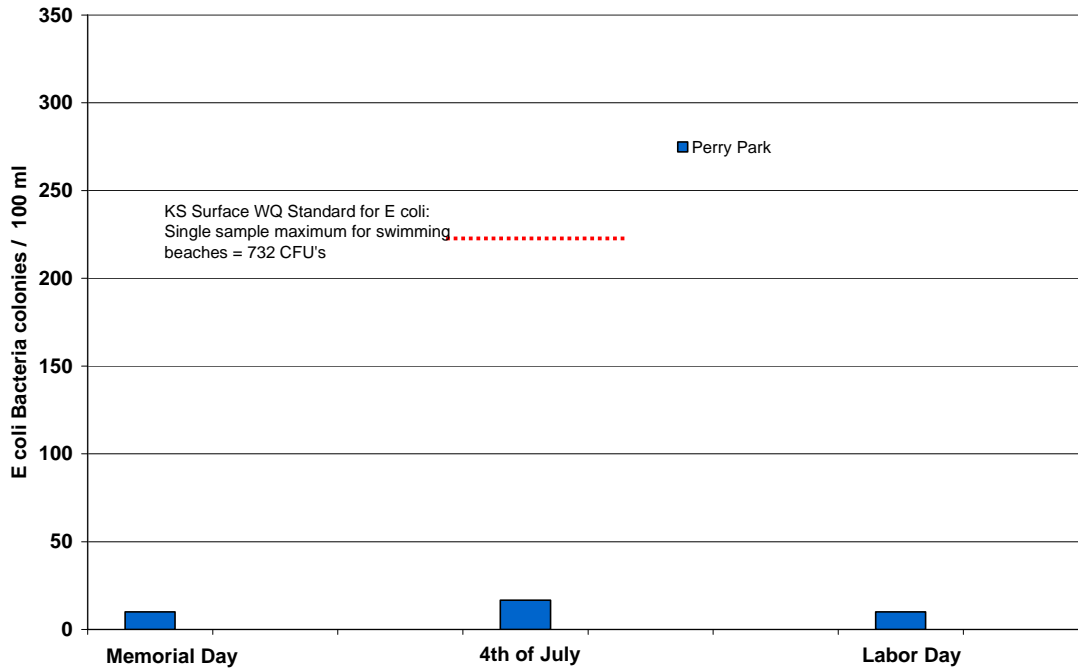


Figure 12.15. Fecal bacteria colonies per 100 ml samples from beach samples collected prior to major holidays at Perry Lake during 2006.

prolonged drought conditions, blooms of fecal bacteria would not have been expected during 2006.

12.3.3 Outflow

No outflow samples were collected from Perry Lake during 2006.

12.4 Future Activities and Recommendations

Sampling activities for 2007 will include transition to monthly 'intensive' monitoring from April through September, as well as conducting monthly vertical profiles at each of the three lake sites. To gain a better understanding of water quality baseline data both within the lake and the watershed, two additional sites will be added during 2007. The new sites will be Site 4 (lake site at Hwy ?? bridge) and Site (inflow site at Valley F???) . Perry Lake will be monitored for the cyanotoxin microcystin during August and September. Geosmin, associated with taste and odor issues in drinking water, will be examined from samples collected near the tower from July through September. Caffeine will be measured at several sites around the lake as a surrogate for human impacts resulting from failing septic systems, WWTP's, illicit dumping from boats, etc. A contaminant group of interest is polyaromatic hydrocarbons (PAHs). These compounds are components of asphalt, fuels, oils, and greases. They enter receiving waters from stormwater runoff, industrial and wastewater treatment discharges, and through atmospheric deposition. They do not dissolve, but attach to particulate material and eventually settle out to the substrate. These compounds are highly toxic to aquatic biota, and thus baseline data is desired to track within district lakes. This is a high priority item when future funding becomes available. The Delaware River watershed WRAPS is will be developing goals and targets during mid-2006. Data sharing and active involvement with the Delaware River WRAPS group will continue in efforts to achieve water quality improvement within the Perry Lake watershed.
