6 Hillsdale Lake

6.1 General Background

Hillsdale Lake was impounded on 19 September 1981 and reached full pool on 23 February 1985. The main threats to water quality in Hillsdale Lake are nutrients, sedimentation, herbicides, and hydrologic changes related to urban sprawl in the northern reaches of the watershed. The lake is listed on Kansas's 303(d) list for water quality impairment due to eutrophication. Therefore, a TMDL was approved in 2001 to address nutrient control within the watershed. The TMDL goal for Hillsdale Lake is a reduction in the lake's trophic state index (TSI) from fully eutrophic (TSI = 59) to slightly eutrophic (TSI < 55), which would require a 46% reduction in the total annual phosphorus load to the lake. Concerned citizens within the watershed initiated the Hillsdale Water Quality Project (HWQP) in 1991 due to concerns of drinking water protection and recreational use. Since 1993, more than $2 million has been received by the HWQP to improve, monitor, and restore water quality in the lake. In addition, the city of Spring Hill initiated efforts in 2005 to develop a WRAPS project within the upper reaches of Hillsdale Lake watershed to protect their drinking water source. Most recently, Burlington Northern Santa Fe railroad has made overtures to develop a large facility within the upper northern section of the watershed.

6.1.1 Location

The lake is located approximately 8 km (5 miles) northwest of Paola, Kansas.
The dam, built on Big Bull Creek, is located 29.1 km (18.2 miles) upstream of the confluence with the Marais des Cygnes River. The watershed includes southern Johnson County, southwest Douglas County, Franklin County, and Miami County. This area includes the expanding communities of Spring Hill, Edgerton, and Gardner. Historic water quality sample sites at Hillsdale Lake include 3 lake, 1 outflow, and limited inflow data from 3-4 sites (Figure 6.1)

6.1.2 Authorized Purposes: flood control, water supply, water quality improvement, recreation, and fish and wildlife management.

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

6.1.4 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	931.0	83.6	7,413	
Multipurpose	917.0	76.3	4,575	51
Total		159.9		

Total watershed area: 144 sq miles (92,160 A)
Watershed ratio: 12.44 FC / 20.12 MP

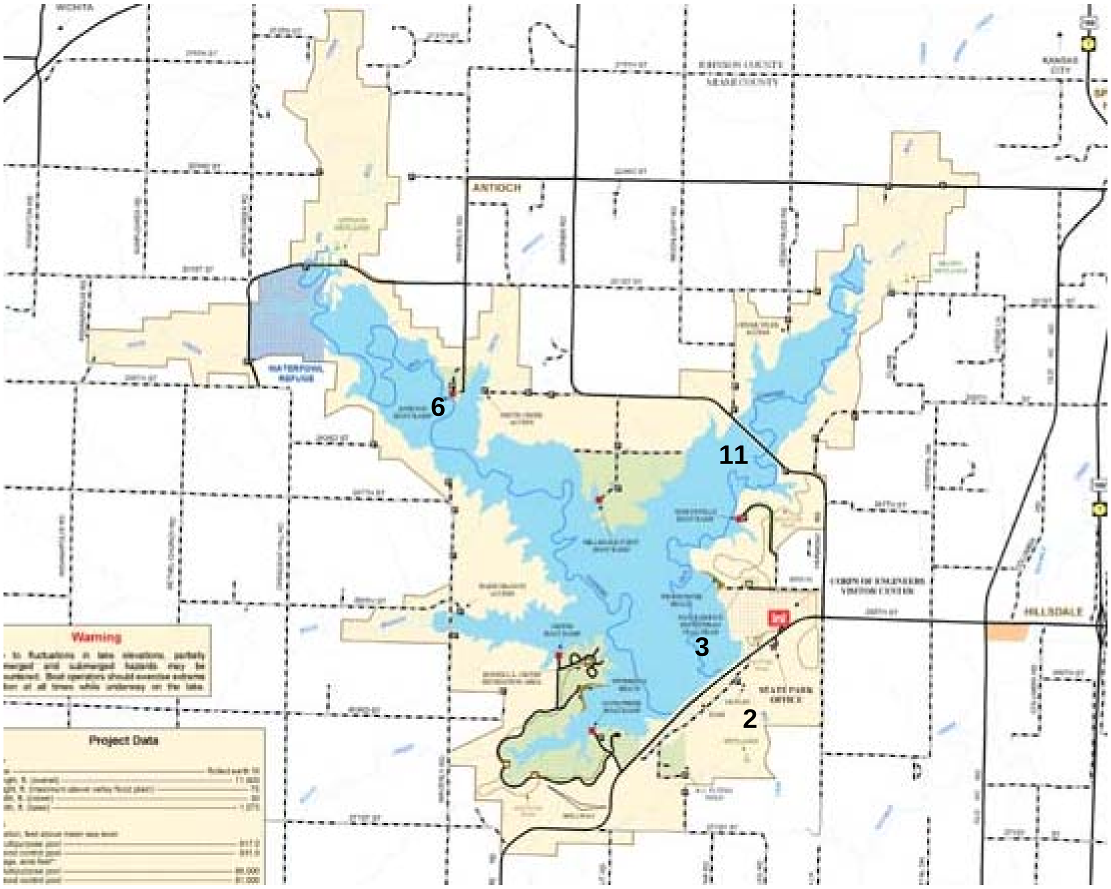

Figure 6.1. Hillsdale Lake area map with sample site locations and sample numbers.

Average Annual Inflow:	91,217 acre-feet (1982 – 2006)
Average Annual outflow:	000 acre-feet
Flushing Rate:	0.84
Sediment inflow:	1,928 acre-feet (1981 – 1991)
Water management Plan:	Submitted for approved 20 May 2005
Historic stage hydrograph:	1995 – 2005 (Figure 6.2)

6.2 2006 Activities

Hillsdale Lake was categorized as an 'ambient' lake during 2006, thus only surface samples were collected at the three lake sites. Sample collections occurred from May through September 2006, with vertical profiles measured at the three lake sites during each monthly sample trip. Jim Bell (OF-HD) provided field sampling assistance during 2006, as well as providing a historic perspective of the lake and watershed. Lew Ruona, OF-CL Operations Manager, provided insight and background regarding Hillsdale Lake.

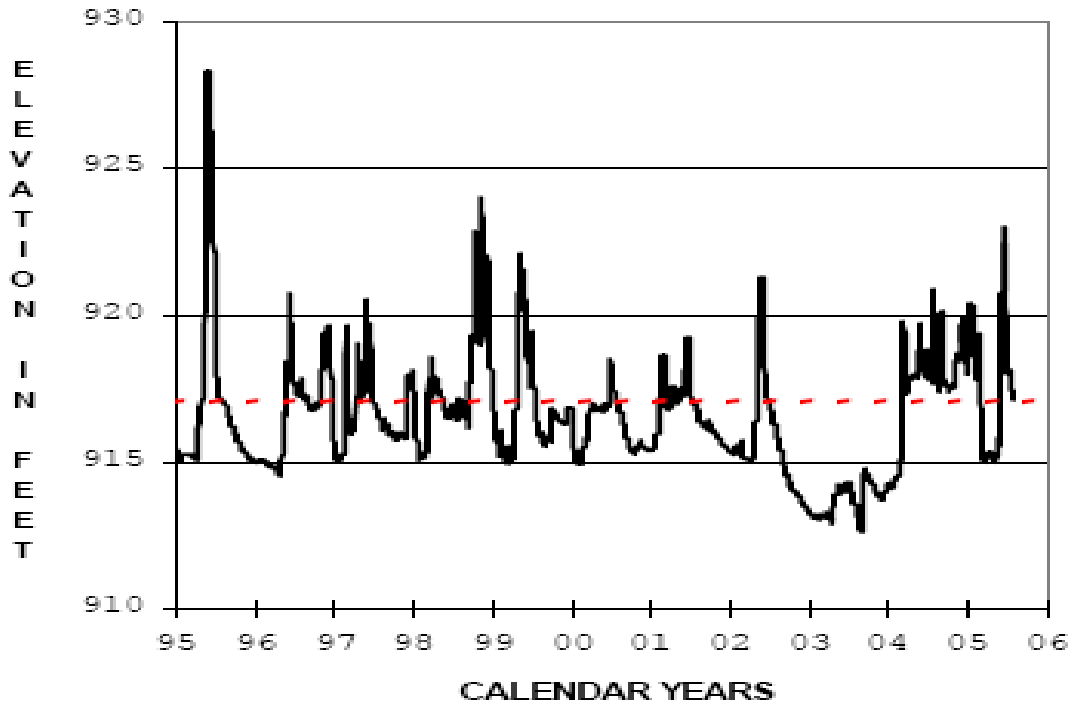

Figure 6.2. Pool elevation hydrograph from 1995 – 2005 (red dashed line is multipurpose pool elevation).

6.3 2006 Data

Comparative historic data consists of monthly (April – September) data collected from 1999 through 2005. Samples were collected from May through September 2006.

6.3.2 Inflow

No inflow samples were collected from Hillsdale Lake during 2006.

6.3.3 Lake

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 (TN) concentrations from surface samples are very consistent between the three lake sites, with median values of samples collected between 1999 and 2006 ranging from 0.81 – 0.82 mg/L (Figure 6.3). The median value for samples collected from the outfall was 0.31 mg/L, which is less than the proposed EPA ecoregional nutrient criteria value of 0.36 mg/L TN. As expected, the lake exhibits annual and monthly variability in TN concentrations. Typically, TN concentration peaks in spring following runoff inputs and then declines through summer months as it is assimilated within the lake; see Figure 6.4 for an example from Site 3.

Phosphorus is another essential nutrient for aquatic life, and it limits algal growth. Total phosphorus (TP) concentrations are low compared to other district lakes, with median values ranging from 0.04 – 0.07 mg/L (Figure 6.5). The highest concentrations within

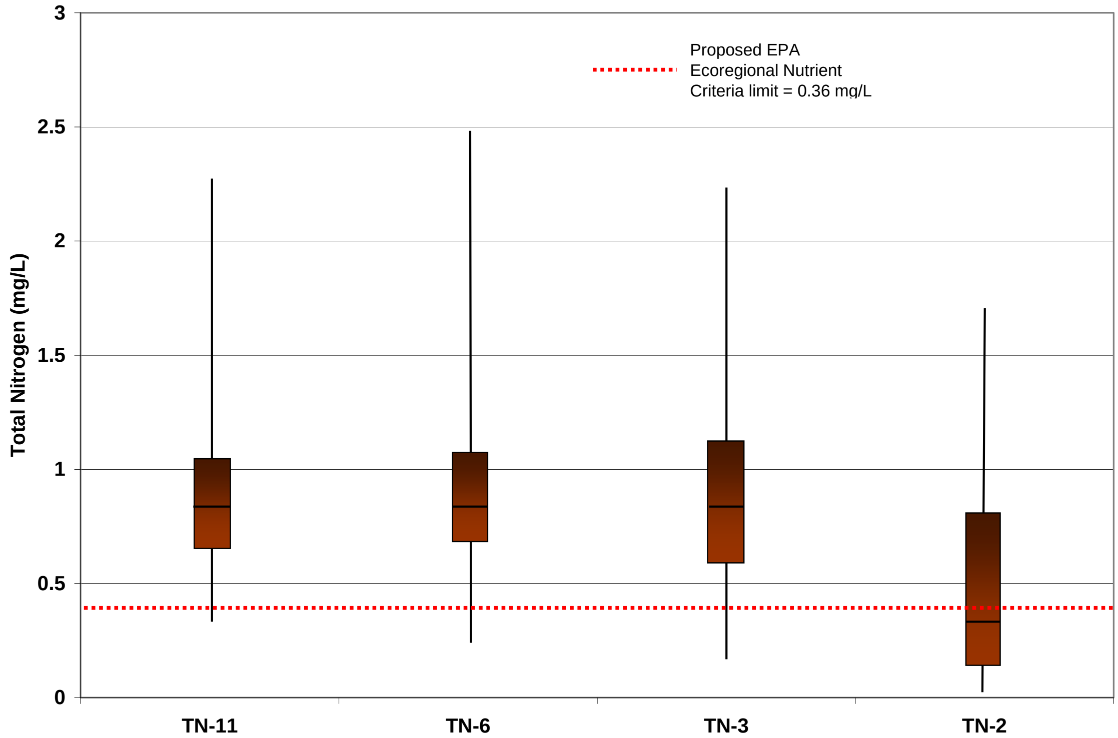

Figure 6.3. Box plots of surface water sample total nitrogen concentrations measured by site from 1999 through 2006 at Hillsdale Lake.

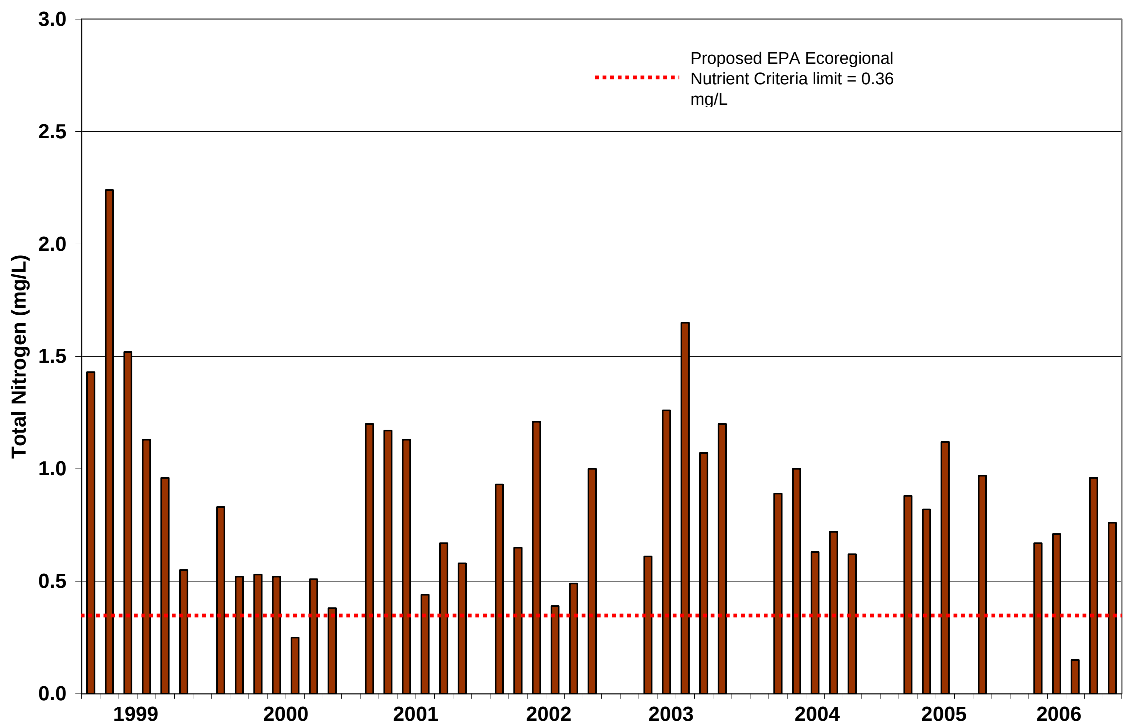

Figure 6.4. Total nitrogen concentrations by sample date collected at Site 3 (Tower) from 1999 through 2006 at Hillsdale Lake.

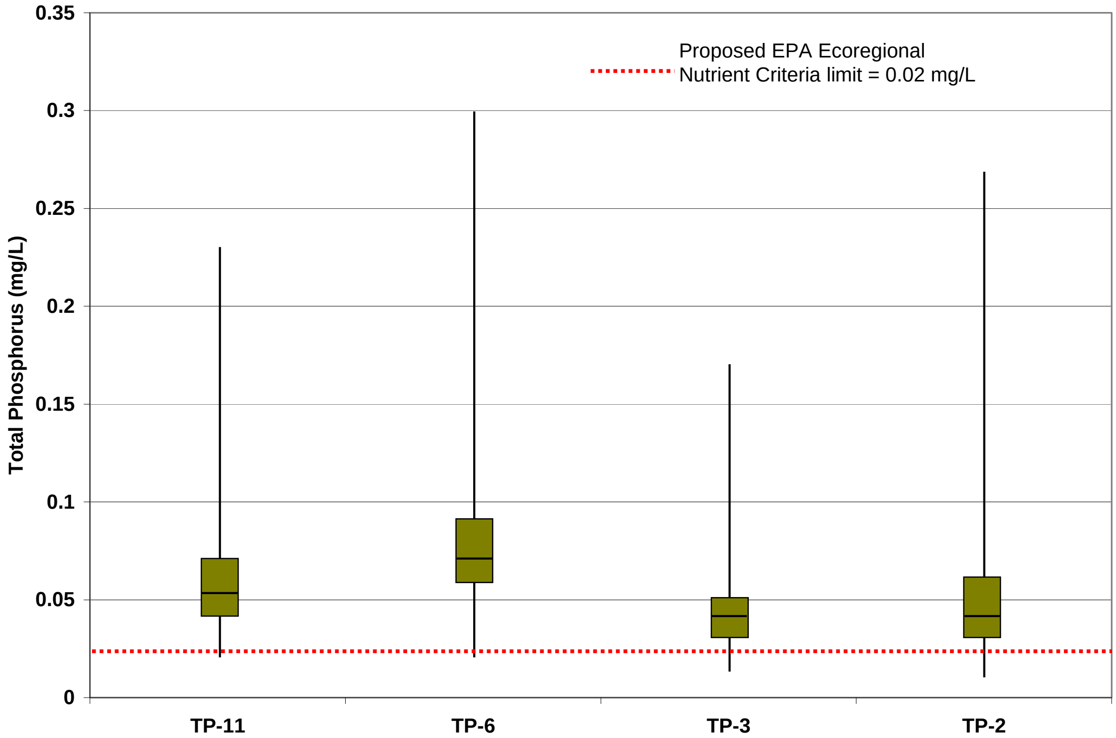

Figure 6.5. Box plots of surface water sample total phosphorus concentrations measured by site from 1999 through 2006 at Hillsdale Lake.

the lake have been measured at Site 6 (Rock Creek). Figure 6.6 depicts annual and monthly variability in TP concentrations measured at Site 6. All values exceed EPA's proposed ecoregional nutrient criteria value of 0.02 mg/L.

The ratio of TN:TP can be used as a surrogate to determine the dominant algal community within a waterbody. Ratios ≥ 20:1 are indicative of desirable algal communities, whereas ratios ≤ 12:1 are indicative of bloom-forming cyanobacteria (blue green algae). As would be expected, there is high monthly and annual variability in the TN:TP ratio at all sites; see Figure 6.7 as an example from Site 3. Median TN:TP ratios from the upper lake sites were slightly greater than 12, indicating the lake could potentially be at risk for cyanobacteria blooms (Figure 6.8). Incidentally, no microcystis toxins were detected in Hillsdale during a single sample collected during 2001 by the University of Missouri – Columbia (Dr. Jennifer Graham – USGS, personal communication).

Relative concentrations of phycocyanins, or bluegreen algae, were measured vertically throughout the water column during each monthly sample trip. Such profiles provided information on monthly as well as within lake distribution changes. Figure 6.9 depicts vertical distribution of phycocyanins measured at Site 3 (Tower) from May through September. Concentrations increased from May into August, before declining slightly in September.

An increase in mean annual chlorophyll *a* concentrations is observed at all three lake sites since 2000 (Figure 6.10). A slight decline in mean chlorophyll a at Site 3 during

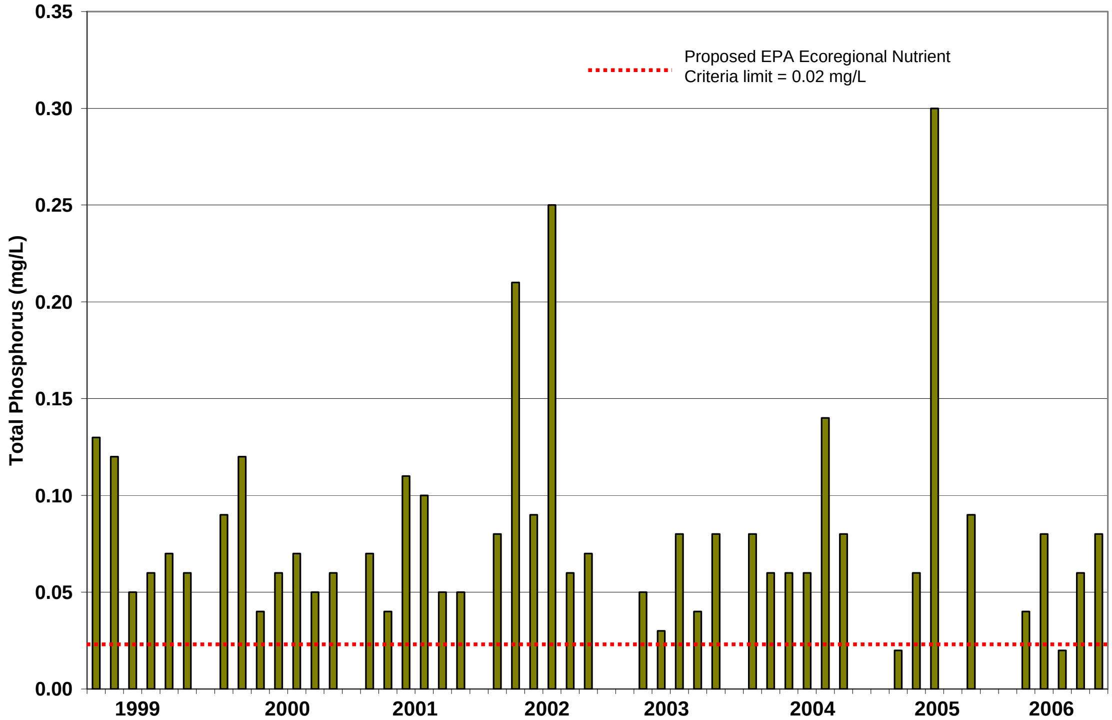

Figure 6.6. Total phosphorus concentrations by sample date collected at Site 6 (Rock Creek) from 1999 through 2006 at Hillsdale Lake.

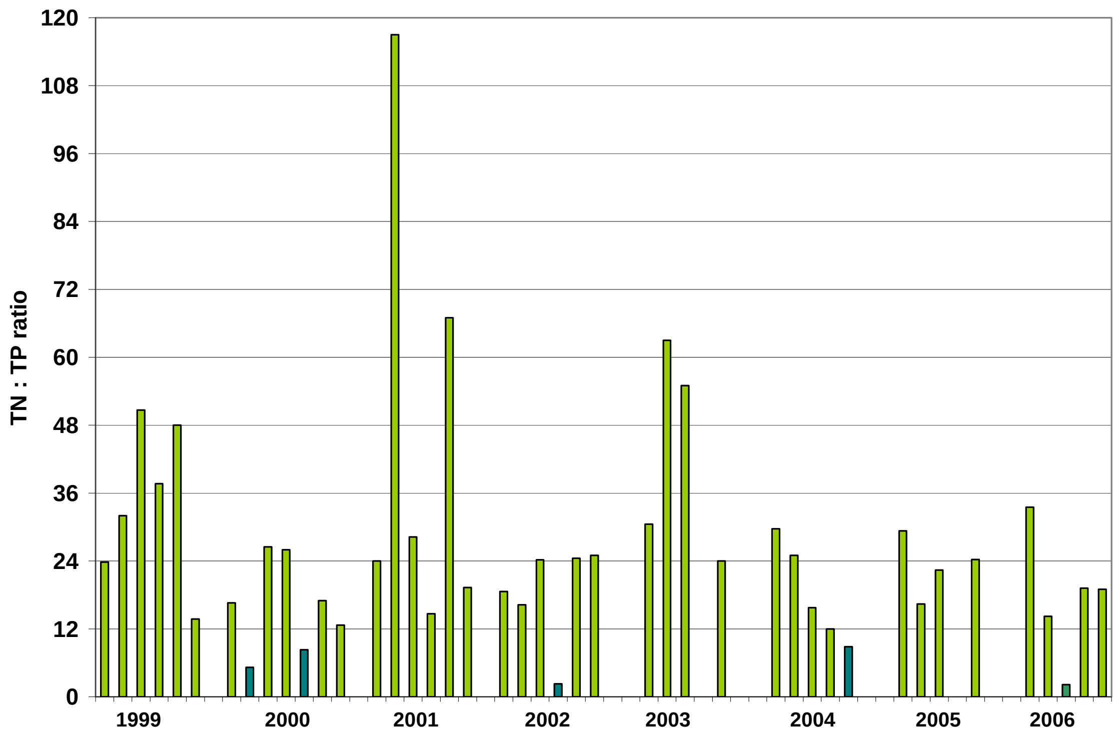

Figure 6.7. Graph of total nitrogen : total phosphorous (TN : TP) ratio by sample date at Site 3 from 1999 through 2006 at Hillsdale Lake.

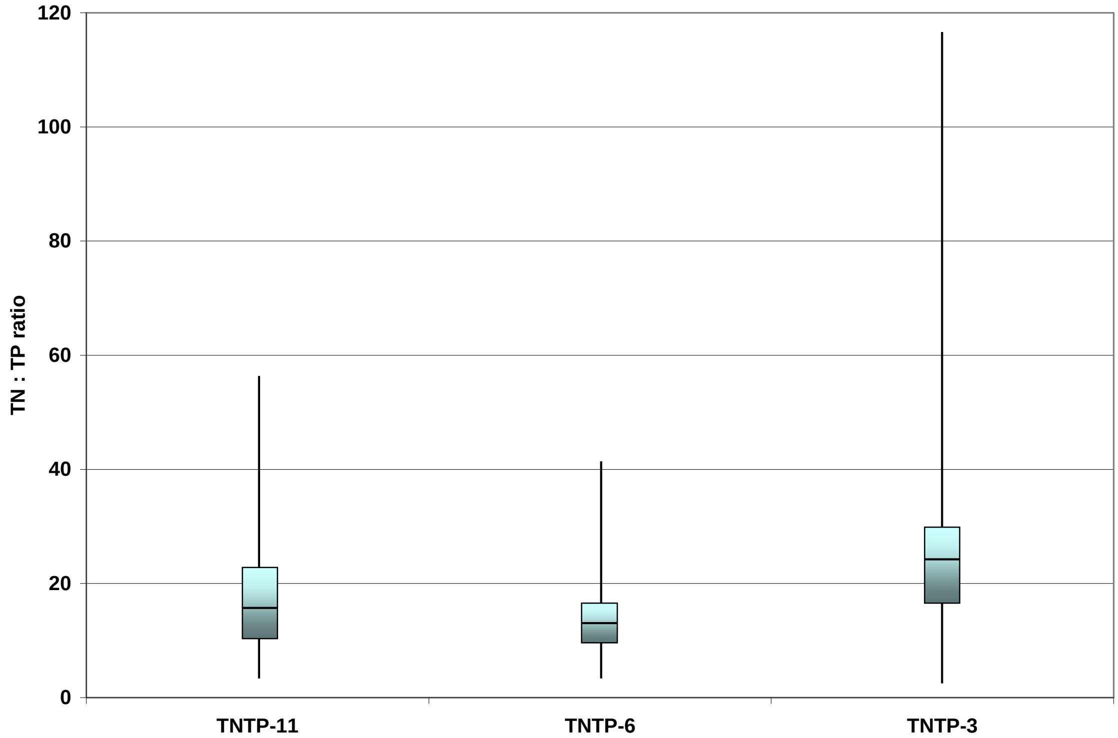

Figure 6.8. Box plots of total nitrogen : total phosphorus ratio (TN:TP) by site from 1999 through 2006 at Hillsdale Lake.

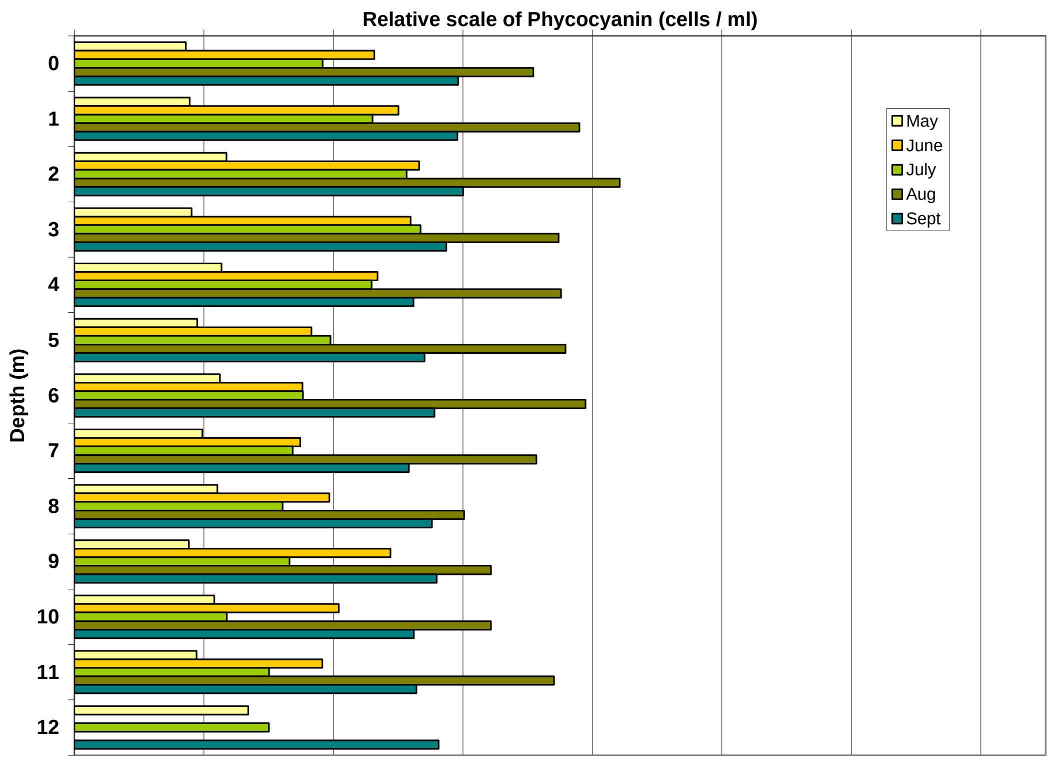

Figure 6.9. Relative concentrations of phycocyanin (bluegreen algae) (cells / ml) measured monthly by depth at Hillsdale Lake Site 3 (Tower) during 2006.

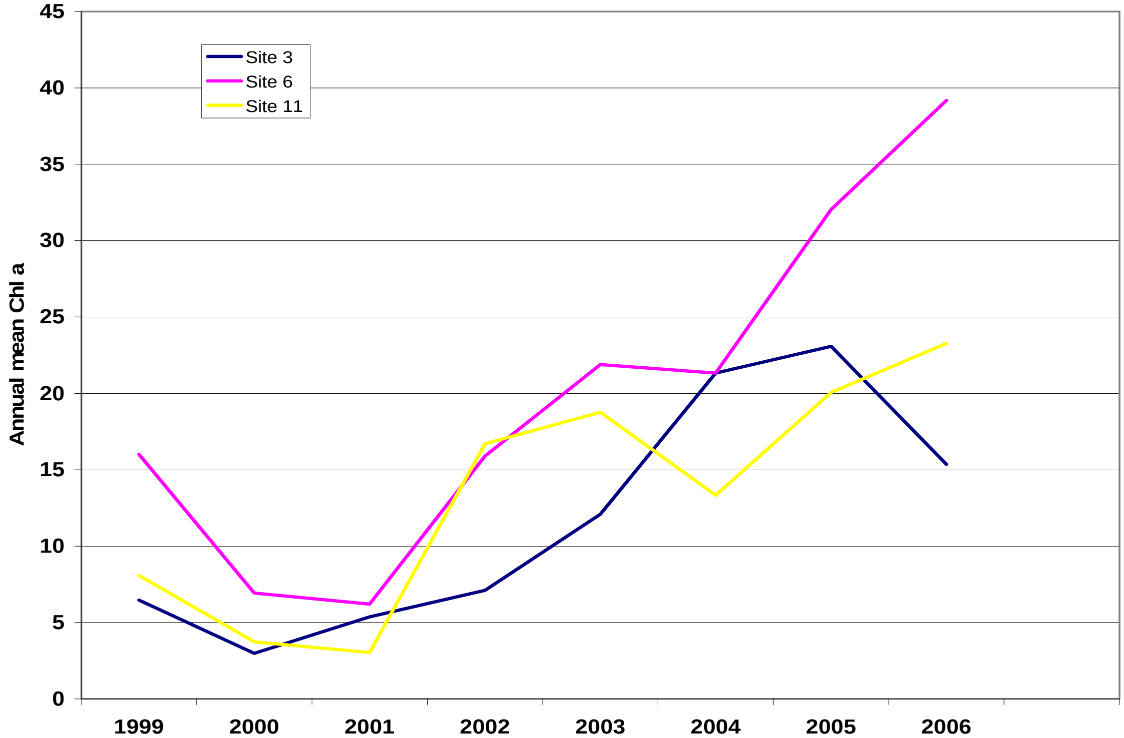

Figure 6.10. Plot of annual mean chlorophyll *a* concentrations measured by site from 1999 through 2006 at Hillsdale Lake.

this past year should be tempered by a high concentration measured in late September. Highest chlorophyll concentrations are routinely measured at Site 6. The increasing trend in chlorophyll *a* at Site 3 during the past four to five years is observed in Figure 6.11. Whether this increasing trend throughout the lake is related to watershed land-use changes is not known at this time.

Differences in secchi depth measurements (0.5 – 0.91 m) were observed between the three lake sites, as depicted in Figure 6.12. The lowest secchi depths are measured at Site 6, which corresponds to the elevated TP and chlorophyll a concentrations. Annual and monthly variability in secchi depth measurements are depicted in Figures 6.13 (Site 3 -- dam) and 6.14 (Site 6 – Rock Creek arm).

The TMDL goal for eutrophication in Hillsdale Lake is a reduction in the lake's trophic state index (TSI) from fully eutrophic (TSI = 59) to slightly eutrophic (TSI < 55). Mean summer TSI values have been increasing at all sites since 2001 (Figure 6.15). An improving trend was detected this past year at Site 3 (Tower) as the mean dropped slightly below 55.

Median atrazine concentrations ranged from 1.8 – 1.9 ug/L for samples collected from 1999 through 2002, 2004 and once during 2006 (Figure 6.16). Although median values are below EPA's drinking water maximum contaminant (MCL) limit of 3 ug/L, seasonal peaks above this value have been measured from samples at the lake – even during 2006. The peak concentration period within the lake occurred in 2002, when all samples

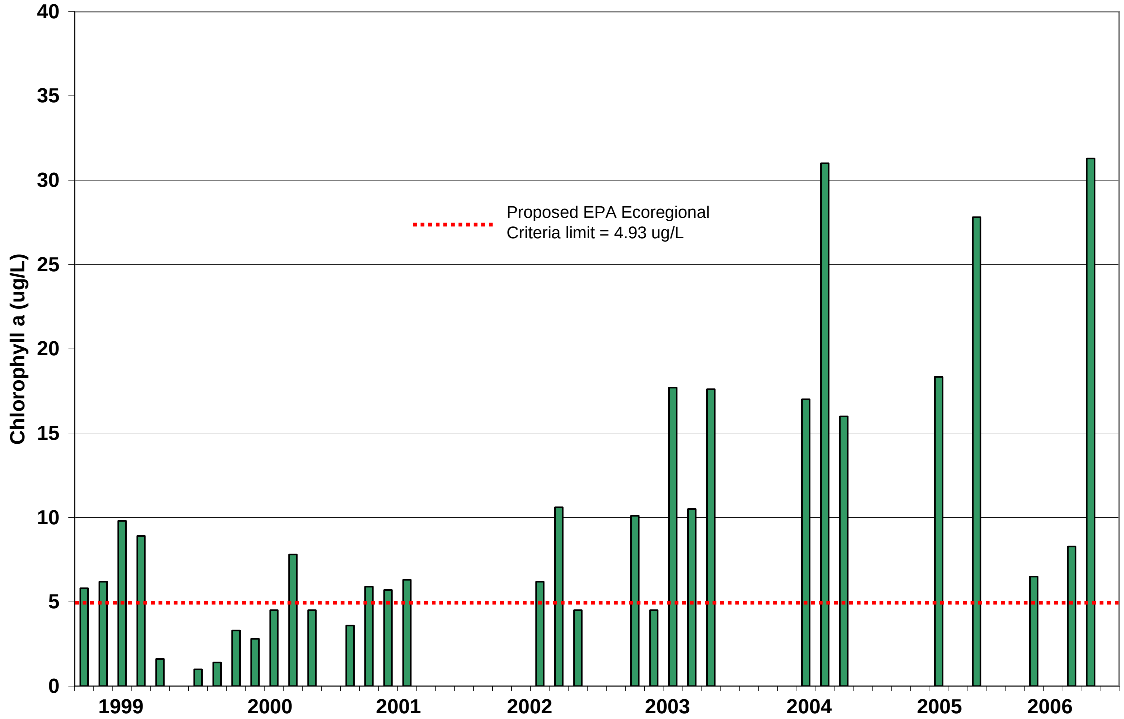

Figure 6.11. Chlorophyll a concentrations by sample date at Site 3 (Tower) from 1999 through 2006 at Hillsdale Lake.

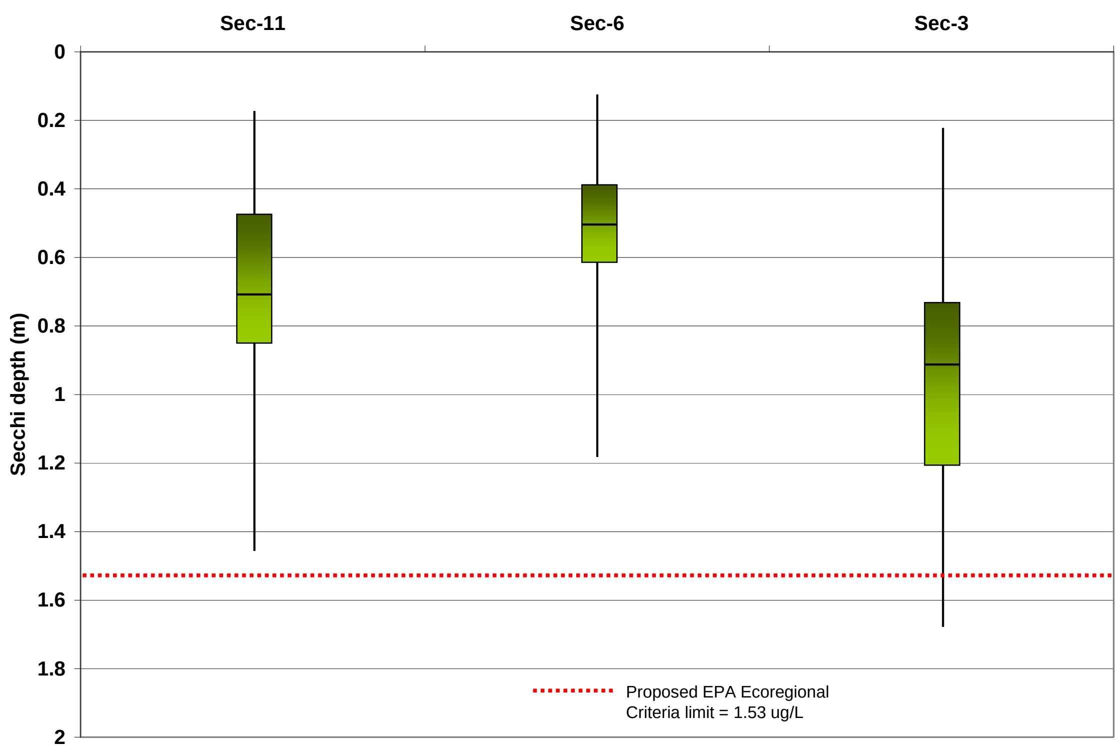

Figure 6.12. Box plots of secchi depth measured by site from 1999 through 2006 at Hillsdale Lake.

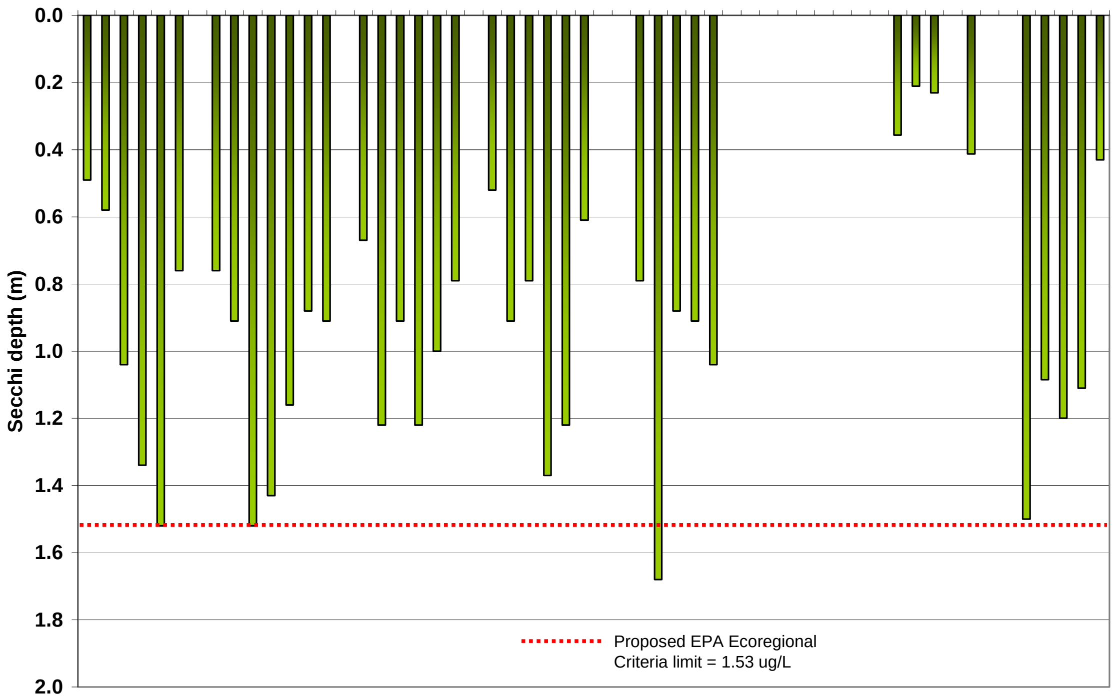

Figure 6.13. Secchi depth measurements by sample date from 1999 through 2006 at Hillsdale Lake Site 3.

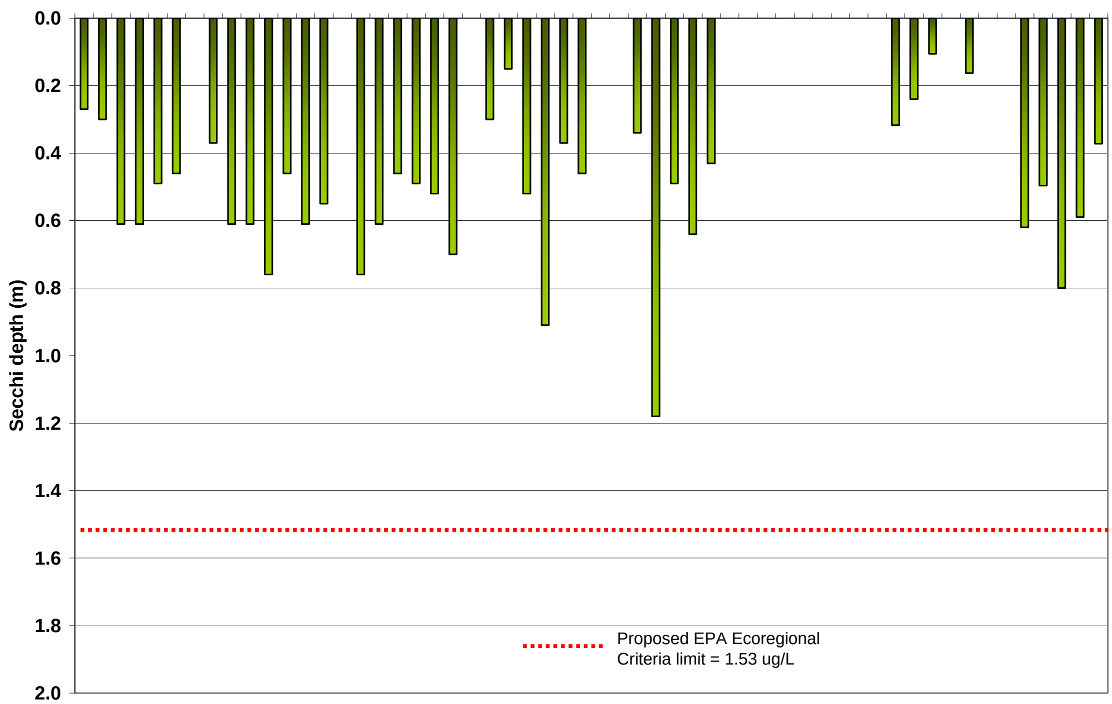

Figure 6.14. Secchi depth measurements by sample date from 1999 through 2006 at Hillsdale Lake Site 6.

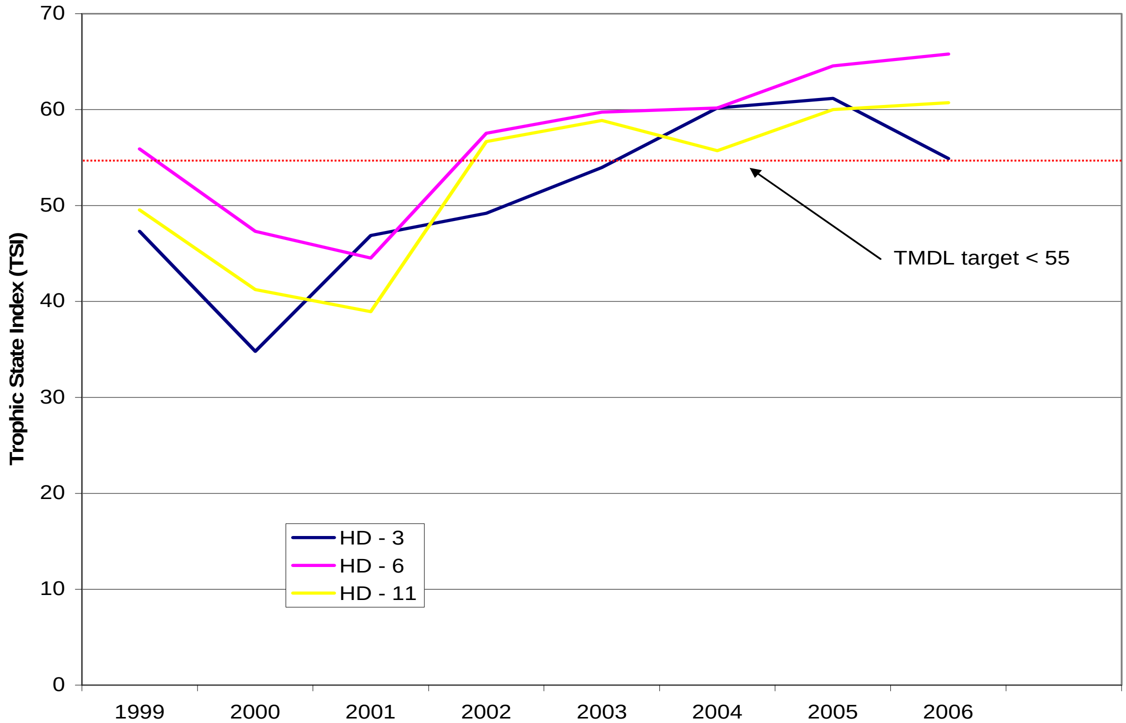

Figure 6.15. Annual mean trophic state index (TSI) scores by year and lake site from 1999 through 2006 at Hillsdale Lake.

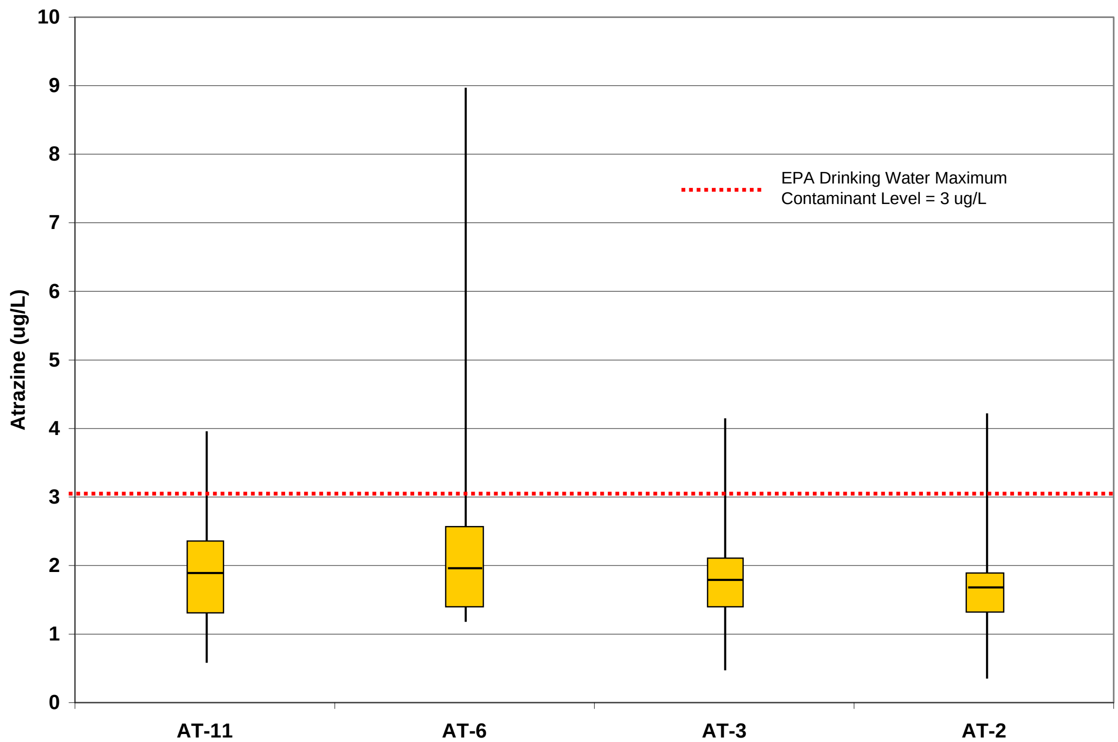

Figure 6.16. Box plots of atrazine concentrations measured from surface lake sites and outflow (Site 2) from 1999 through 2002, 2004, and 2006 at Hillsdale Lake.

collected from Site 6 (Rock Creek arm) during May through September exceeded the MCL (Figure 6.17). A similar annual pattern is observed at Site 11 (Figure 6.18).

Vertical profiles were recorded during monthly sampling trips to Hillsdale Lake in 2006. Parameters included temperature, dissolved oxygen, pH, conductivity, and turbidity. Typical of smaller, eutrophic Midwest reservoirs, the lake stratifies both thermally and chemically. Lake stratification began at 5-6 m in depth during June and July, while DO concentrations throughout the entire water column were below 5 ppm during August (Figure 6.19). The lake had undergone fall turn-over prior to the late September sample trip based on temperature and DO measurements.

6.3.4 Outflow

No outflow samples were collected from Hillsdale Lake during 2006.

6.4 Future Activities and Recommendations

Sampling activities for 2007 will include transition from an ‘ambient’ to an ‘intensively’ monitored lake. This will include monthly sampling from April through September at three lake sites, two inflow sites, and one outflow site. Monthly vertical profiles will be recorded at each of the three lake sites. Bluegreen algae vertical distribution within the water column will be examined during the summer and compared to TP concentrations measured from surface samples. 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 at Hillsdale Lake is PAHs, which are typical components of asphalt, fuels, oils, and grease. These compounds enter receiving waters from atmospheric deposition, stormwater runoff, as well as through industrial and wastewater treatment discharges. It is expected that such compounds are likely to increase with a rapidly urbanizing watershed. They do not dissolve, but will attach to particulate material and eventually settle out to the substrate. Samples will be collected in 2008 if funds are available. In an effort to collect baseline phycocyanin toxins (blue green algae), the 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. Sediment – nutrient and metal samples will be collected from all three lake sites during August 2007. This data will provide a comparative point to identify possible resuspension sources.

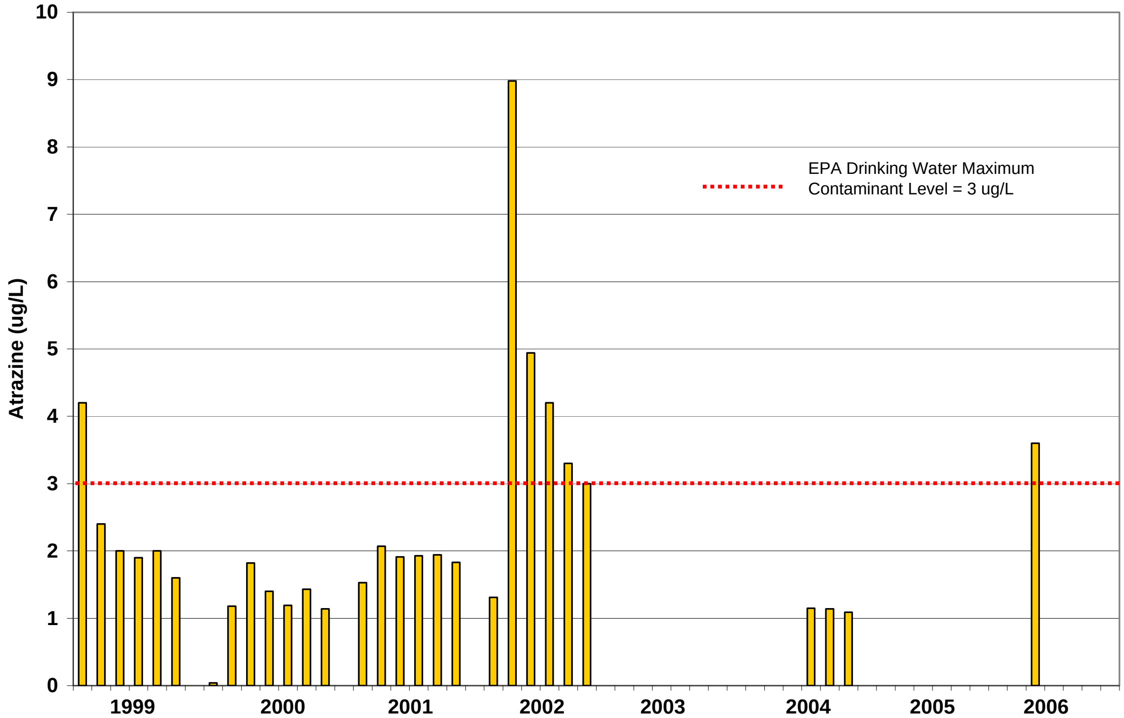

Figure 6.17. Atrazine concentrations by sample date collected at Hillsdale Lake's Site 6 (Big Bull / Rock Creek arm) from 1999 through 2002, 2004, and 2006.

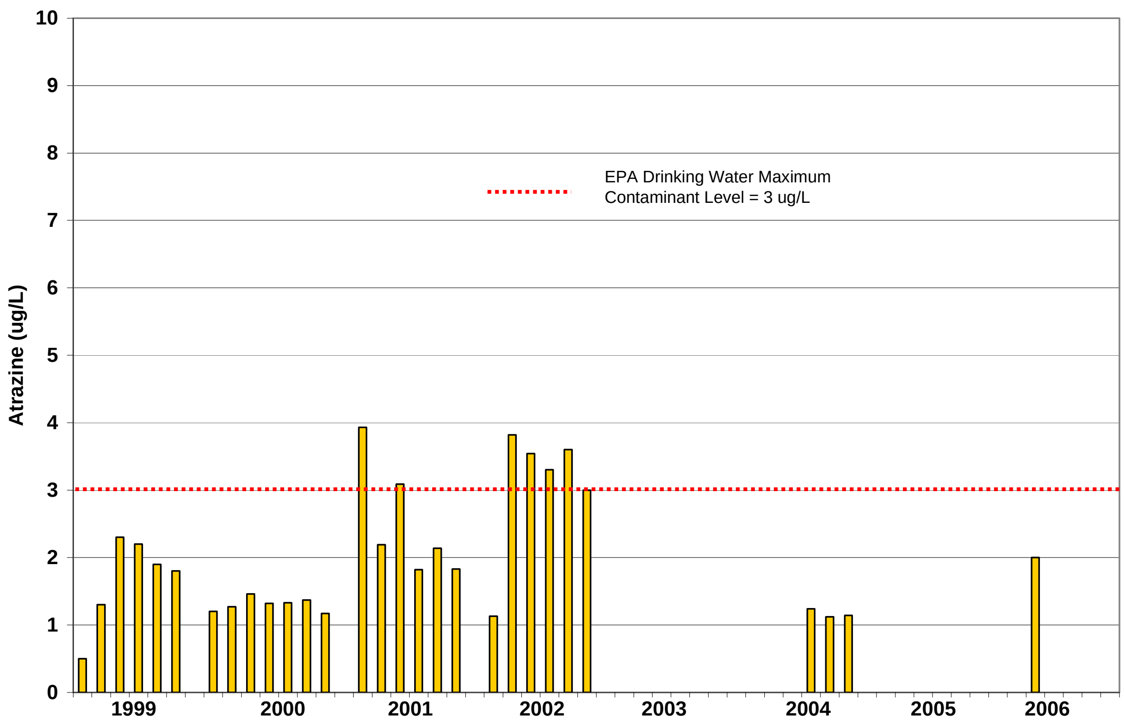

Figure 6.18. Atrazine concentrations by sample date collected at Hillsdale Lake's Site 11 (Little Bull / Spring Creek arm) from 1999 through 2002, 2004, and 2006.

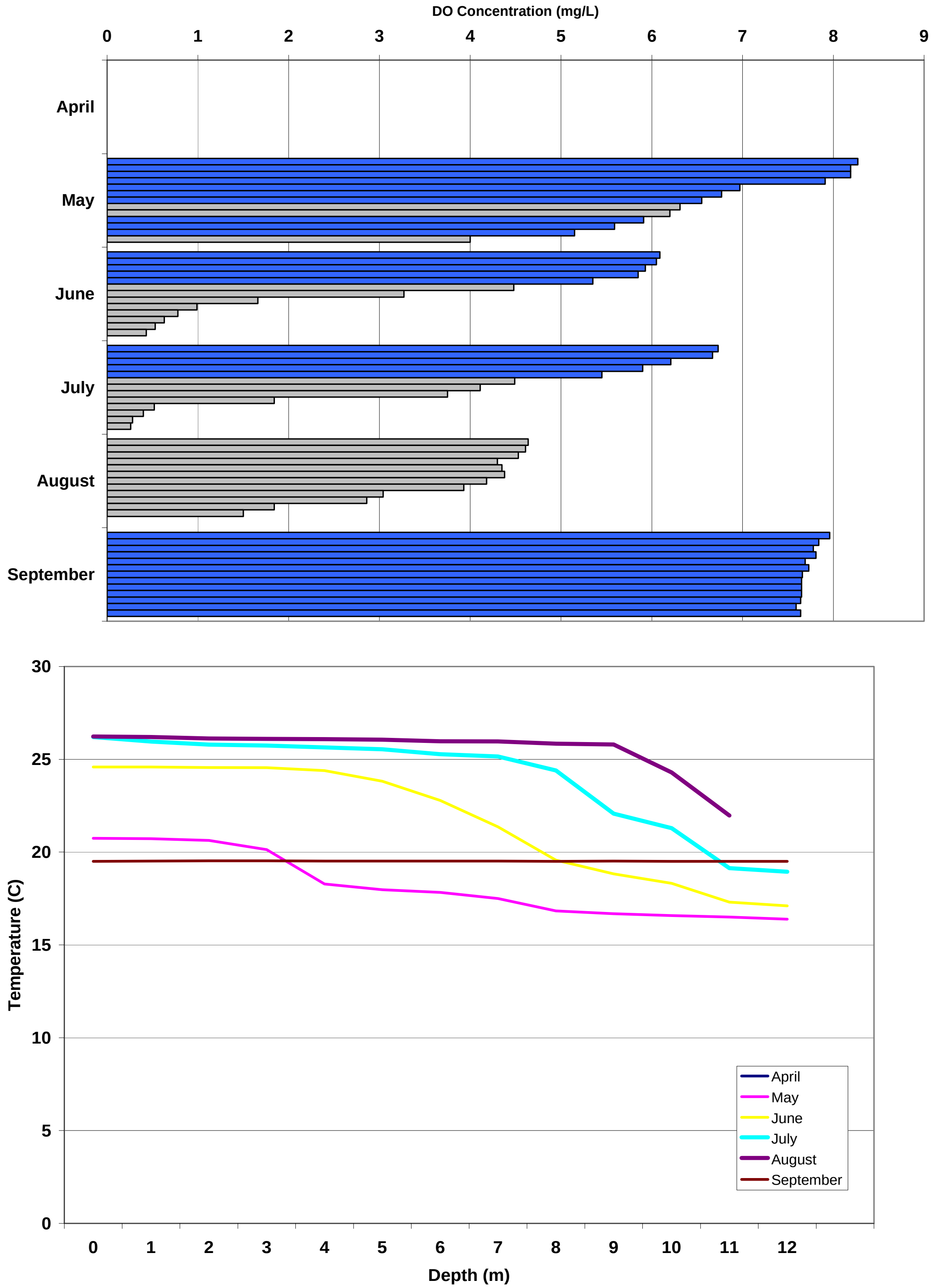

Figure 6.19. Dissolved oxygen concentration (mg/L) histogram and temperature (C) plots by sample dates from vertical profiles recorded at Site 3 during 2005 at Hillsdale Lake.