3 Clinton Lake

3.1 General Background

Clinton Lake was impounded in 1977 and reached full pool in 1980. The main threats to Clinton Lake's watershed are sedimentation, nutrients and bacterial contamination. The lake is listed on the state's 303(d) list for water quality impairment due to eutrophication and fecal bacteria. Therefore, TMDL's have been developed for the watershed to reduce nutrients, total suspended solids (TSS), and fecal bacteria, and increase dissolved oxygen. Specific TMDL targets are < 100 mg/L TSS at flows < 10 cfs, and total phosphorus (TP) < 0.1 mg/L. The Kaw Valley Heritage Alliance, formed in 1996, is a citizen-based watershed group active within the upper Wakarusa watershed. The Upper Wakarusa Watershed Restoration and Protection Strategy (WRAPS) was approved by the Kansas Department of Health and Environment during 2003. The goals and objectives of this WRAPS are to protect Clinton Lake and ultimately remove it from the 303(d) list of impaired waters.

3.1.1 Location

Clinton Lake is located approximately 6.4 km (4 miles) southwest of Lawrence, Kansas. The dam is located at river km 35.5 (river mile 22.2) of the Wakarusa River, which is a tributary of the Kansas River. The watershed encompasses the counties of Douglas, Shawnee, Osage, and Wabaunsee. Historic water quality samples sites at Clinton Lake include 3 lake, 1 outflow, and 1 inflow (Figure 3.1).

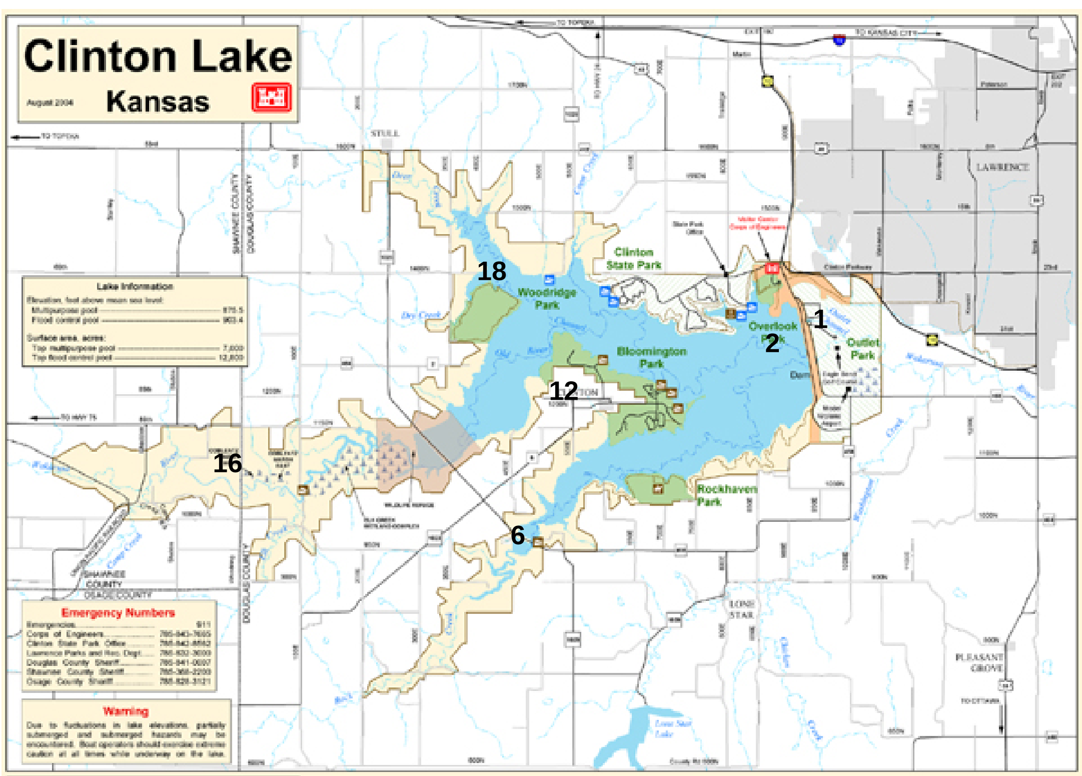

Figure 3.1. Clinton Lake area map with sample site locations and site numbers.

3.1.2 **Authorized Purposes:** Flood control, water supply, low flow supplementation, fish and wildlife conservation, and recreation.

3.1.3 **State Use Designations:** Primary contact recreation, food procurement, domestic water supply, special aquatic life support.

3.1.4 Lake and Watershed Data

Pools	Surface Elevation (ft. above m.s.l.)	Current Capacity (1000 AF)	Surface Area (A)	Shoreline (miles)
Flood Control	903.5	268.8	12,891	
Multipurpose	875.5	125.3	7,006	82
Total		394.1		

Total watershed area:	367.0 sq. miles (234,880 A)
Watershed ratio:	18.22 FC / 33.5 MP

Average Annual Inflow:	189,849 acre-feet / yr (1982 – 2006)
Average Annual outflow:	000 acre-feet
Flushing Rate:	0.66 years
Sediment inflow (measured):	3,421 acre-feet (1977 – 1991)
Water management Plan:	Approved 12 February 1980
Historic stage hydrograph:	1995 – 2005 (Figure 3.2)

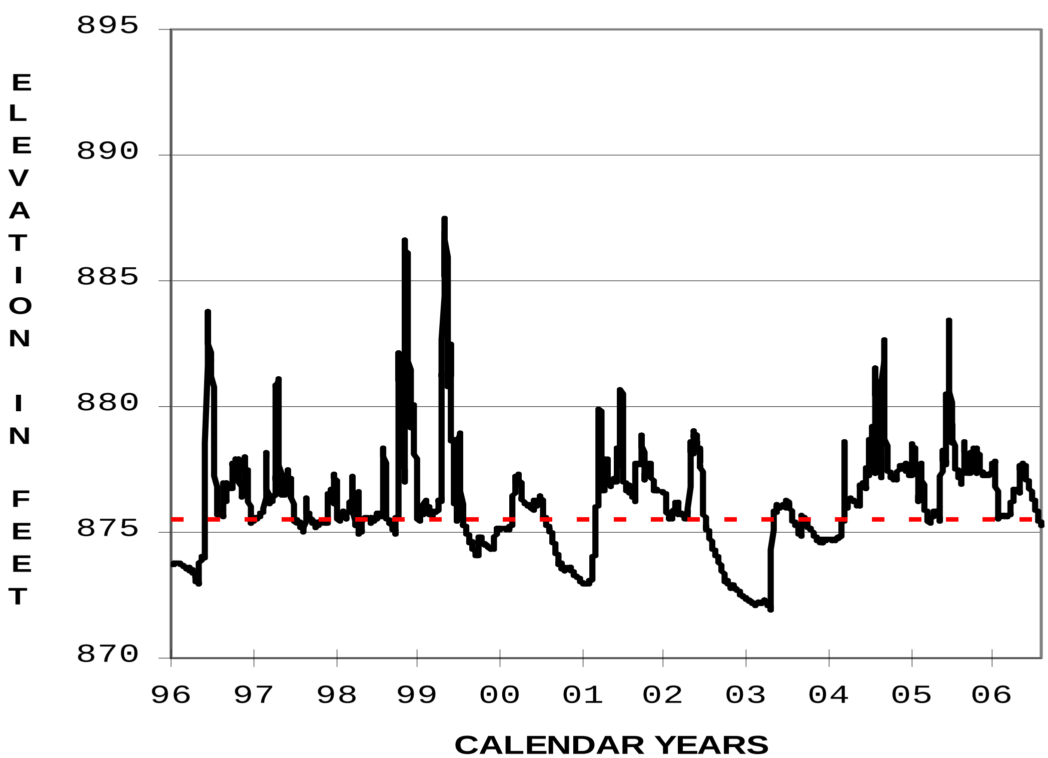

Figure 3.2. Pool elevation hydrograph from 1996 – 2006 (red dashed line is multipurpose level elevation).

3.2 2006 Activities

To address watershed development concerns in Deer Creek, an additional lake site was included during 2006 (Site 18). Clinton Lake was categorized as an 'ambient' lake during 2006, thus only surface samples were collected at the four lake sites. Sample collections occurred from May through September 2006, with vertical profiles recorded at the four lake sites during August. Clinton Lake staff (OF-CL) providing field assistance with the WQP during 2006 included Kipp Walters and Dave Rhoades. Lew Ruona, OF-CL Operations Manager, provided technical insight and background knowledge on Clinton Lake and the Upper Wakarusa watershed. I participated in the Kaw Valley Heritage Alliance's annual meeting, which was held during September. A water quality status and trend poster has been on display in the Clinton Lake visitor center since May.

3.3 2006 Data

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

3.3.1 Inflow

No inflow samples were collected from the Clinton Lake watershed during 2006. Historically, nutrient concentrations (nitrogen and phosphorus) are most variable at this site due to influences of runoff events within the watershed. Please see comments for lake sites below on specific parameters.

3.3.2 Lake

Nitrogen and phosphorus are essential nutrients for 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) and total phosphorus (TP) median concentrations and chlorophyll a values indicate that Clinton Lake is nutrient-rich or eutrophic. Monthly and annual variability in total nitrogen is evident at all sites. Median concentrations range from 0.62 – 0.96 mg/L (Figure 3.2), which is above the proposed EPA nutrient criteria value of 0.36 mg/LTN. The measured values are typical for lakes within this region. Median total phosphorus concentrations (0.06 – 0.13mg/L) for all sites exceed the proposed EPA nutrient criteria value (0.02 mg/L)(Figure 3.3). Currently, the median TP values exceed the WRAPS target value of < 0.1 mg/L at all sites except the tower and outflow sites. The TP concentrations are typical of our district lakes.

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 3.4 as an example at Site 2. Median TN:TP ratios at all three lake sites are < 12, indicating the lake is at risk for cyanobacteria blooms (Figure 3.5).

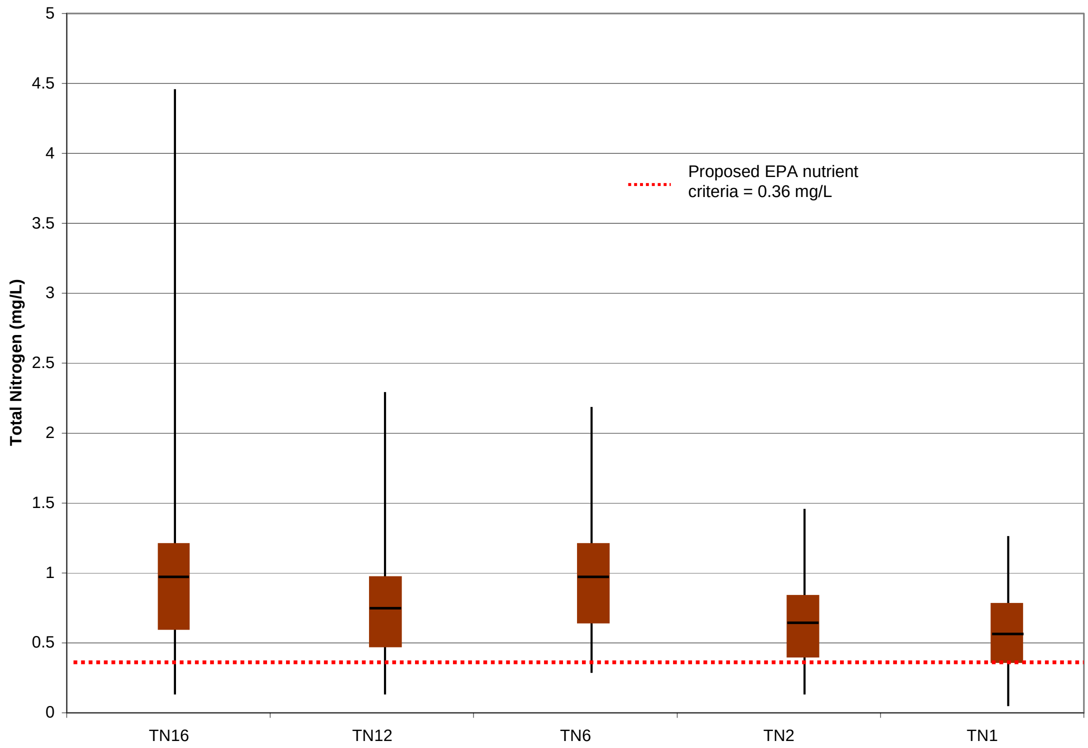

Figure 3.2. Box plots of surface water sample total nitrogen concentrations measured at lake sites from 1996 through 2006 at Clinton Lake.

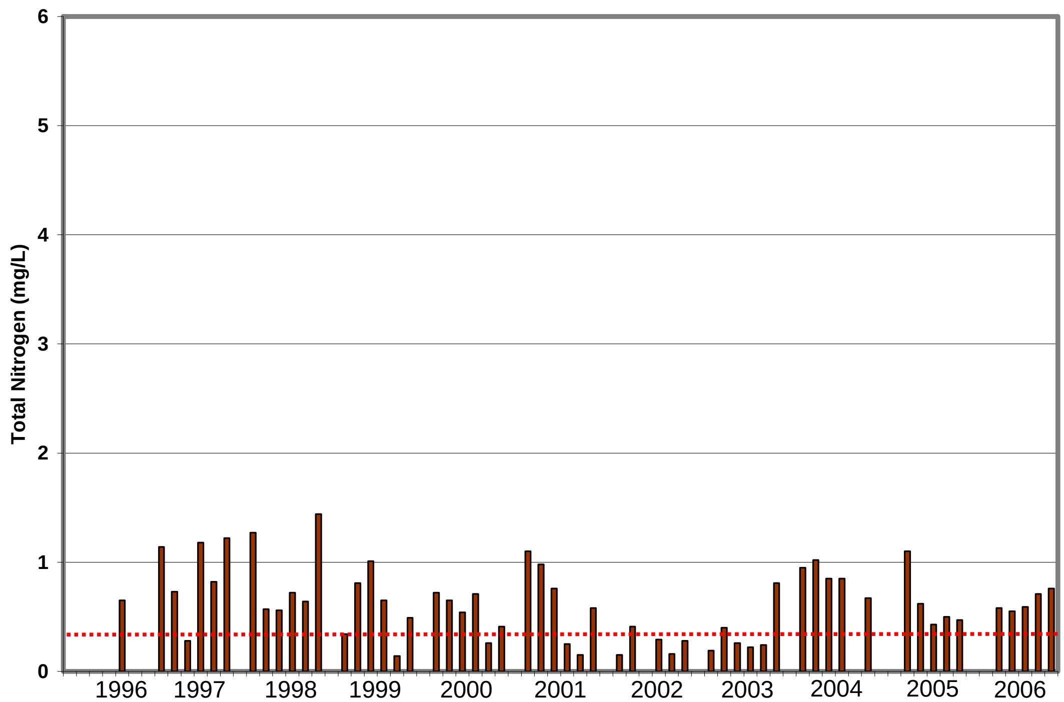

Figure 3.3. Total Nitrogen concentrations (mg/L) by sample date from 1996 – 2006 at Site 2 (Tower site) in Clinton Lake.

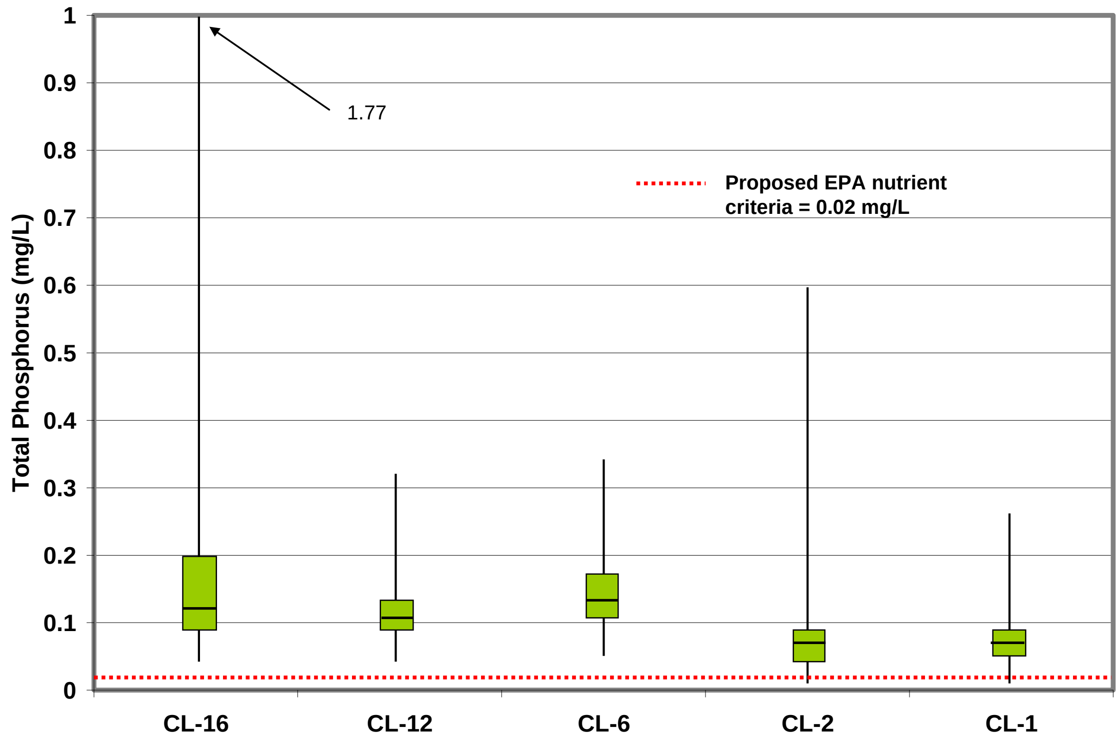

Figure 3.3. Box plots of surface water sample total phosphorus concentrations measured at lake sites from 1996 through 2006 at Clinton Lake.

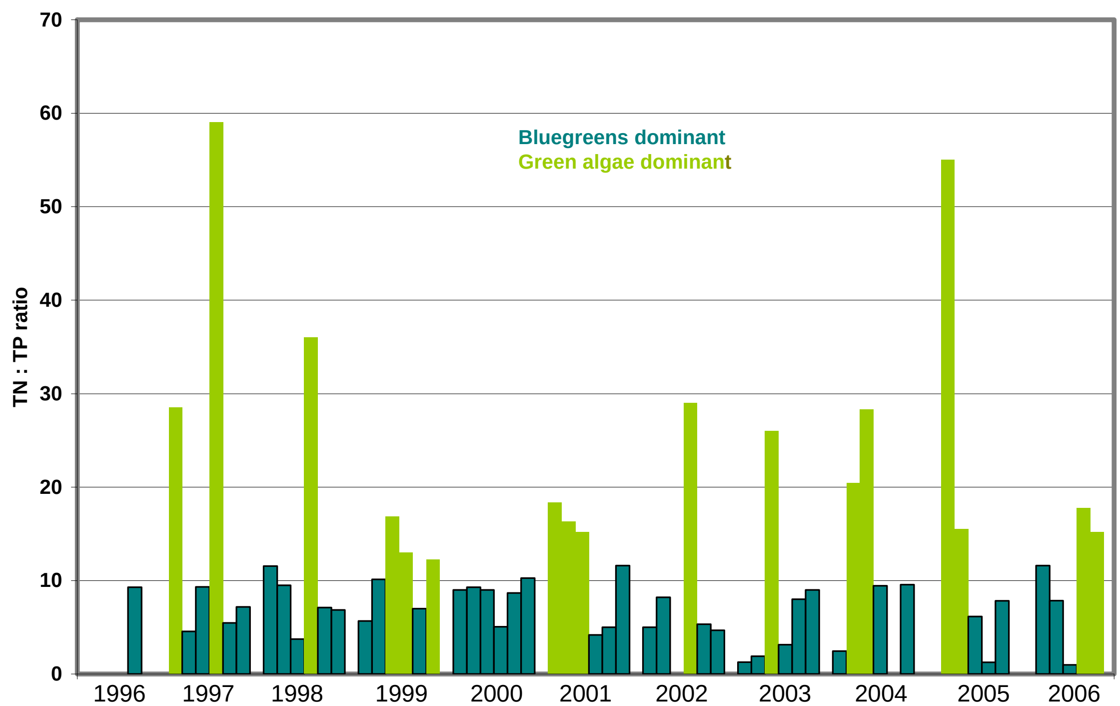

Figure 3.4. Graph of total nitrogen : total phosphorus ratio (TN:TP) by sample at Site 2 of Clinton Lake from 1996 through 2006.

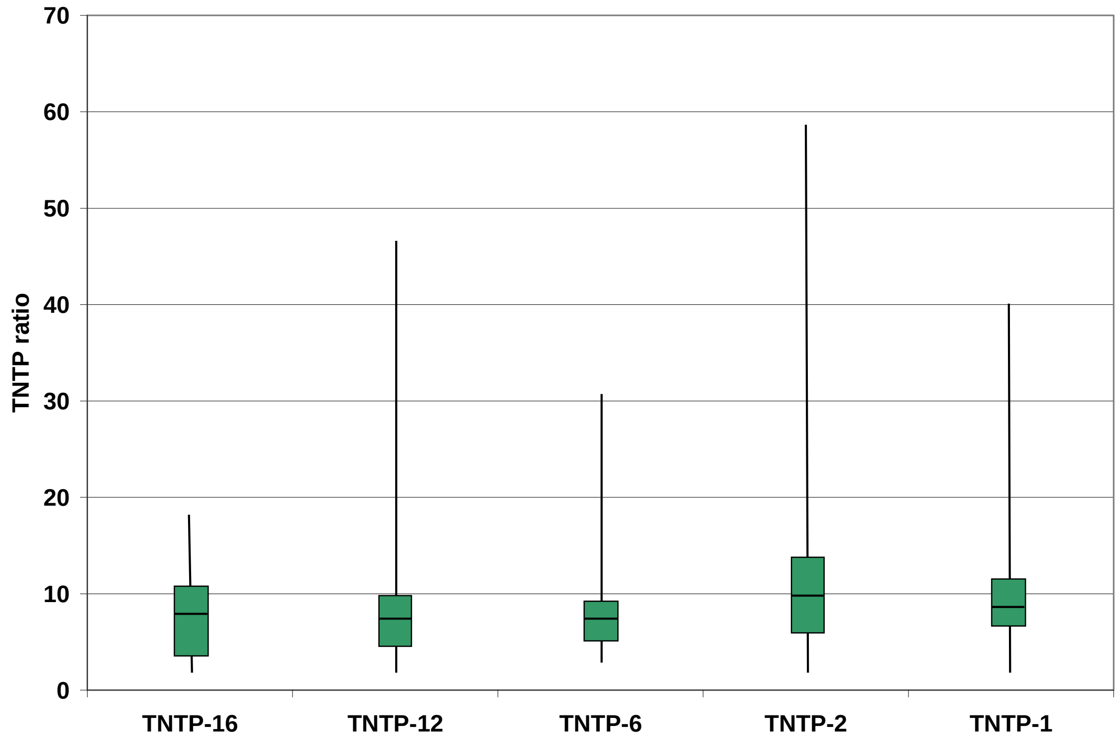

Figure 3.5. Box plots of total nitrogen : total phosphorus (TN:TP) by site from 1996 through 2006 at Clinton Lake.

Chlorophyll was measured monthly from June through August 2006 at all four lake sites. Mean monthly chlorophyll *a* concentration, which was at least 2x greater than during 2005, ranged from 35 – 53 ug/L; median lake concentrations are statistically lower in June than either July or August (Figure 3.6). Mean chlorophyll *a* by sample site and month are plotted in Figure 3.7. Site 2 (Tower) has the lowest mean summer chlorophyll *a* concentration (23.7 ug/L) and lowest monthly variability, while Site 6 (78.7 ug/L) has the highest mean summer chlorophyll *a* concentration (78.7 ug/l) and greatest monthly variability. Mean TSI values range from 61.6 (Site 2) to 73.2 (Site 6), which further classifies Clinton Lake as eutrophic.

Secchi depth was once again measured only during August. Increased algal concentrations during 2006 most likely reduced water clarity compared to 2005 (Figure 3.8). Water clarity was limited in both Deer Creek (Site 18 = 0.45 m) and the Wakarusa arm (Site 12 = 0.55 m), while the tower site was moderately clear (Site 2 = 0.9 m).

Atrazine samples were not collected during 2005. Between 1996 and 2004, median atrazine concentrations (1.3 – 1.7 ug/L) are less than the EPA drinking water maximum contaminant level of 3 ug/L (Figure 3.9). However, individual samples measured during that time period are significant enough to exceed the MCL. Figure 3.10 depicts the individual sample concentrations measured by date at Site 16 (Wakarusa River inflow site).

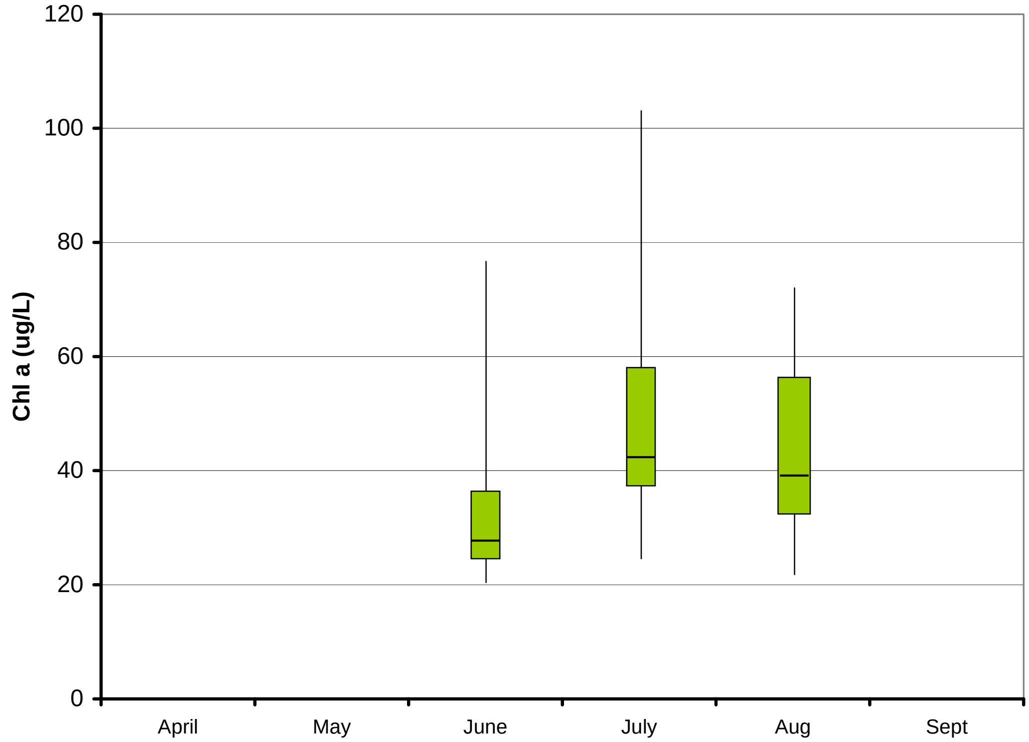

Figure 3.6. Box plots of chlorophyll *a* concentration by site samples collected during 2006 at Clinton Lake.

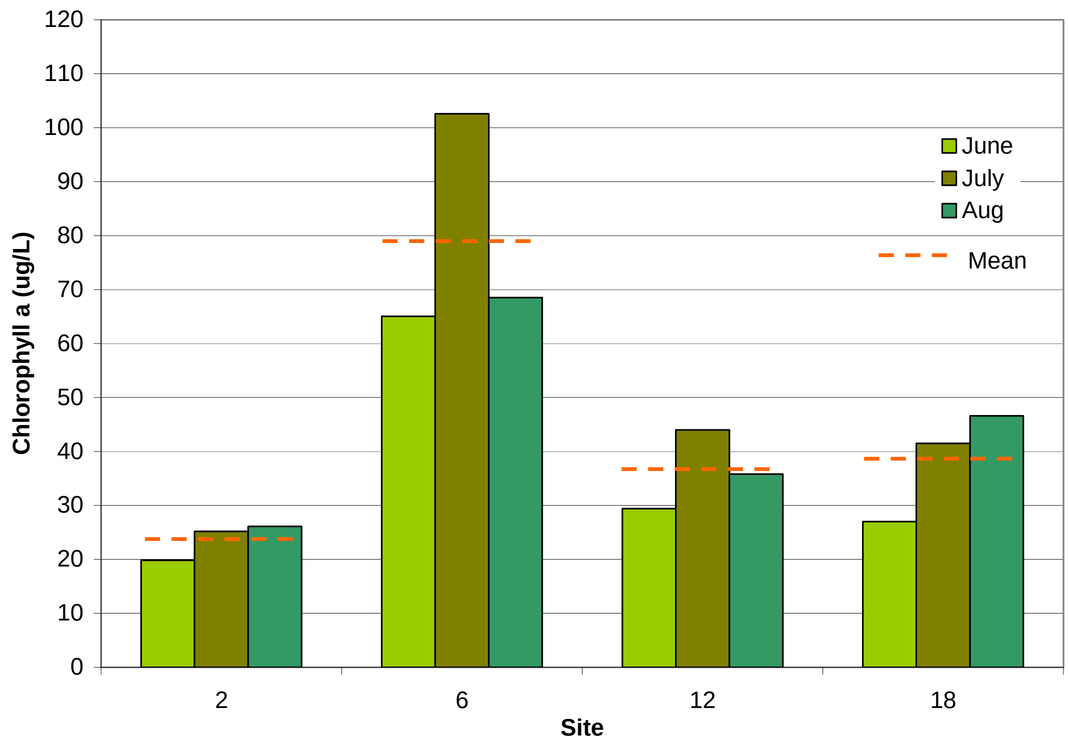

Figure 3.7. Monthly variability and mean chlorophyll *a* by sample site and month in Clinton Lake during 2006.

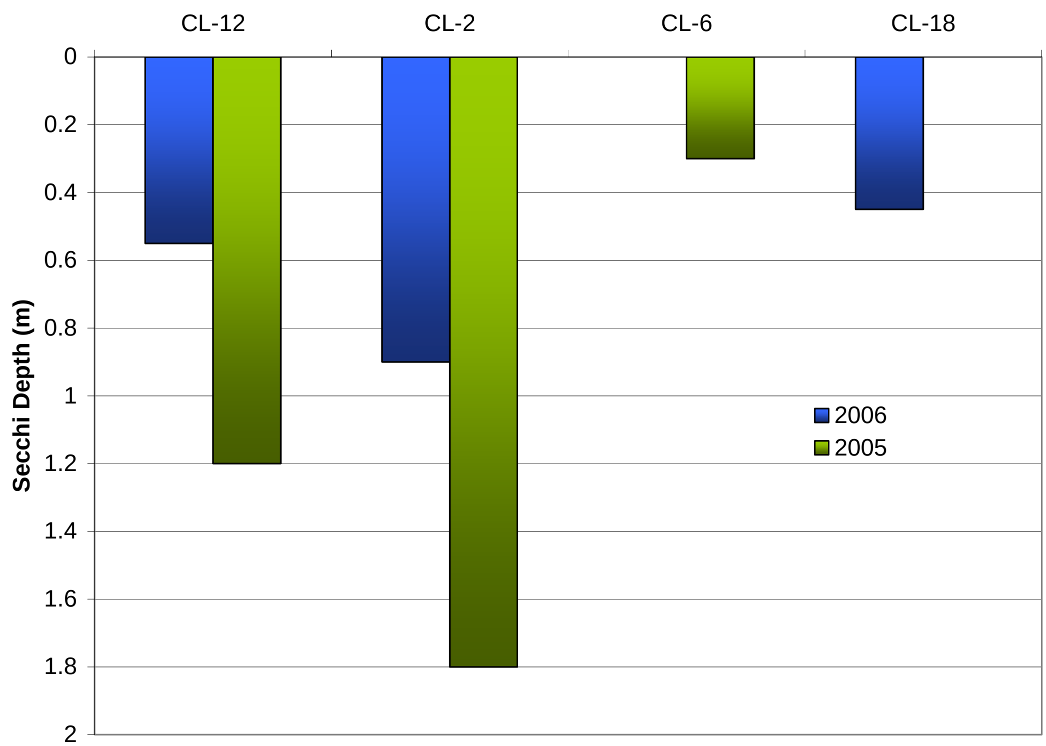

Figure 3.8. Comparative graph of secchi depth (m) measured during August by lake site in Clinton Lake during 2005 and 2006.

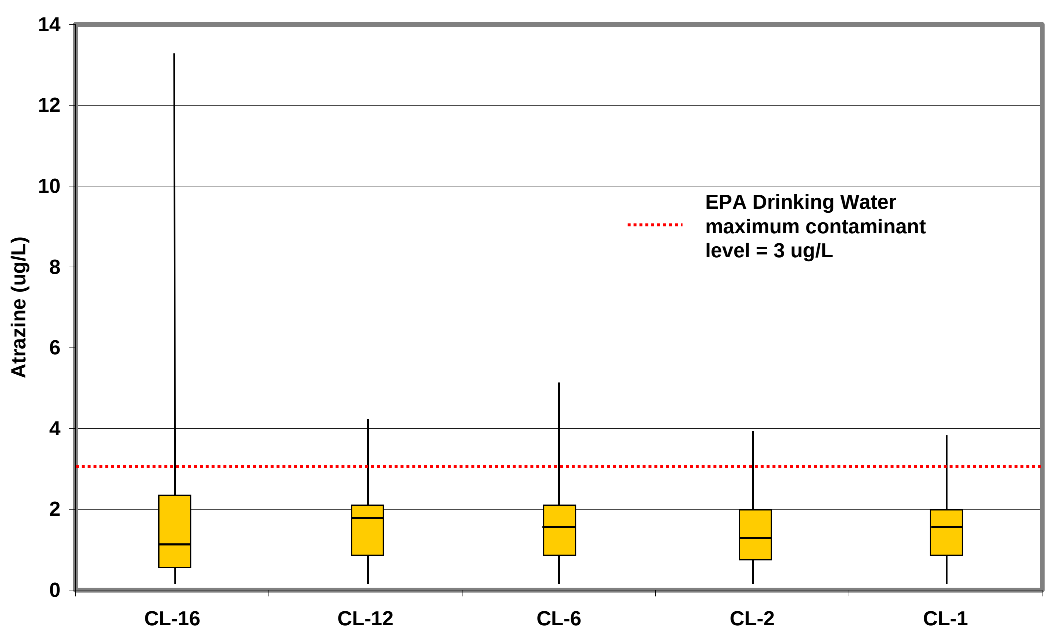

Figure 3.9. Box plots of surface water sample atrazine concentrations measured at lake sites from 1996 through 2004 at Clinton Lake.

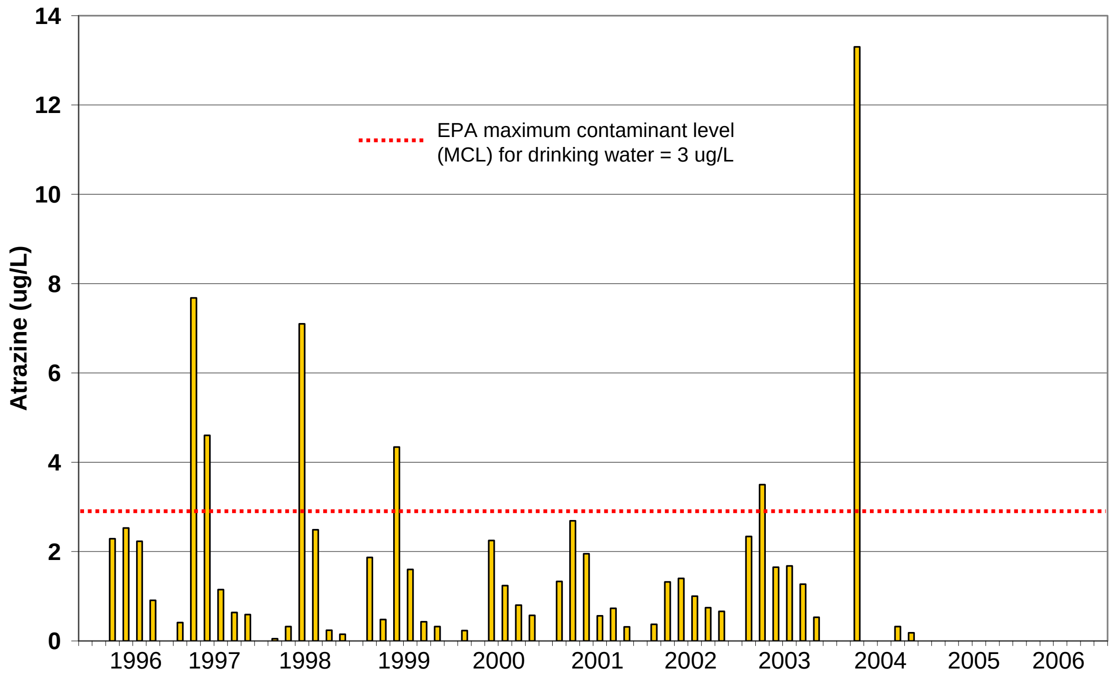

Figure 3.10. Atrazine concentrations by sample date collected at Site 16 (Wakarusa River) inflow to Clinton Lake from 1996 through 2004.

A single vertical profile was recorded at Site 2 (Tower) during the 22 August sampling trip. Parameters included temperature, dissolved oxygen, pH, conductivity, turbidity, chl a, and blue-green algae concentration. In spite of higher chlorophyll concentrations and reduced water clarity, the lake was not as strongly stratified during 2006 as in 2005 (Figure 3.11).

Fecal bacteria samples were collected from three locations at the Corps swimming beach prior to three major holidays (Memorial Day, July 4th, and Labor Day). Although elevated samples were evident prior to Labor Day, all samples were well within compliance limits of 732 colonies / 100 ml for a single sample (Figure 3.12).

3.3.3 Outflow

No outflow samples were from collected from Clinton Lake during 2006.

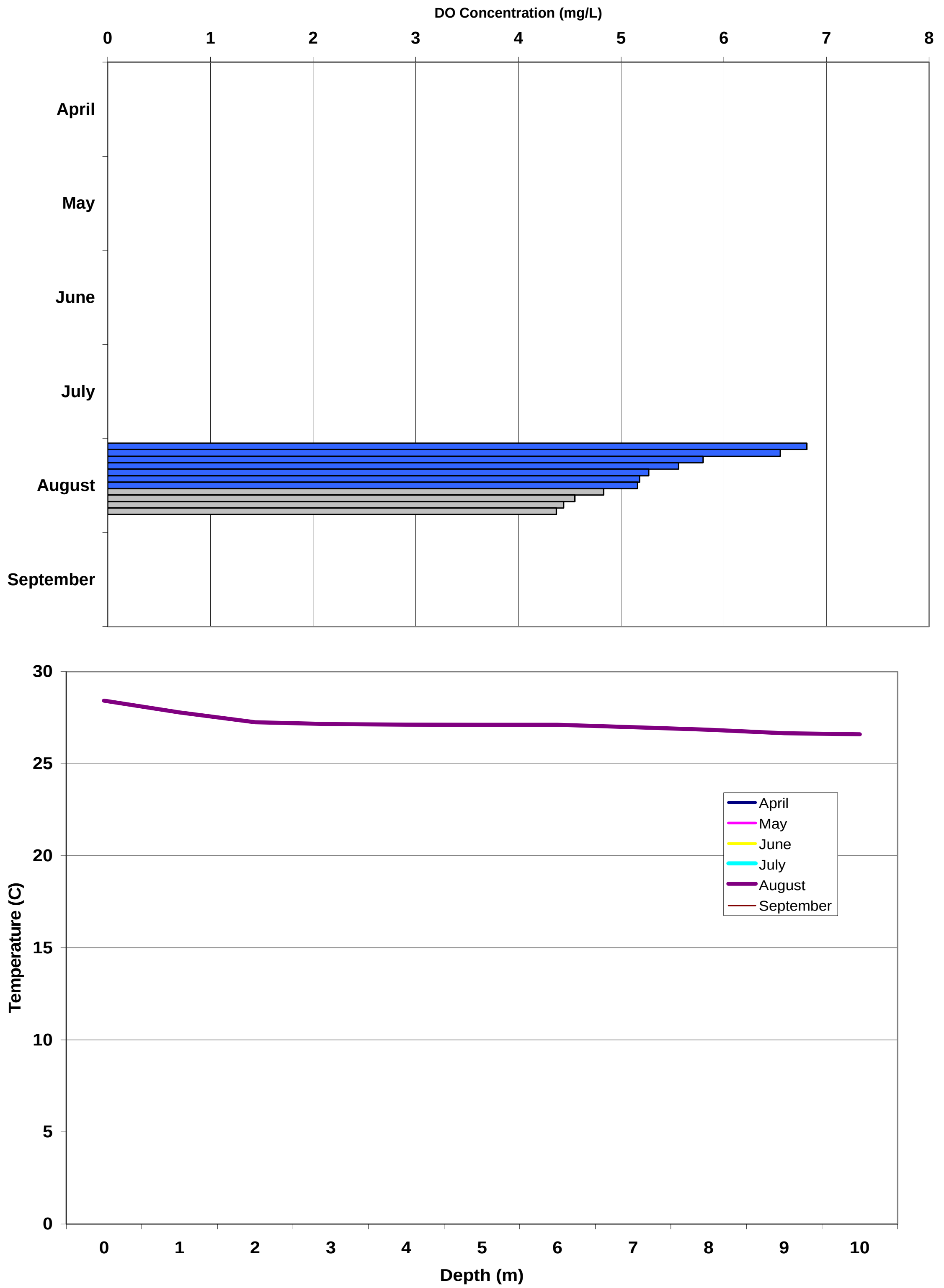

Figure 3.11. Dissolved oxygen concentration (mg/L) histogram and temperature (C) plots from a vertical profile recorded at Site 2 on 22 August 2006 at Clinton Lake.

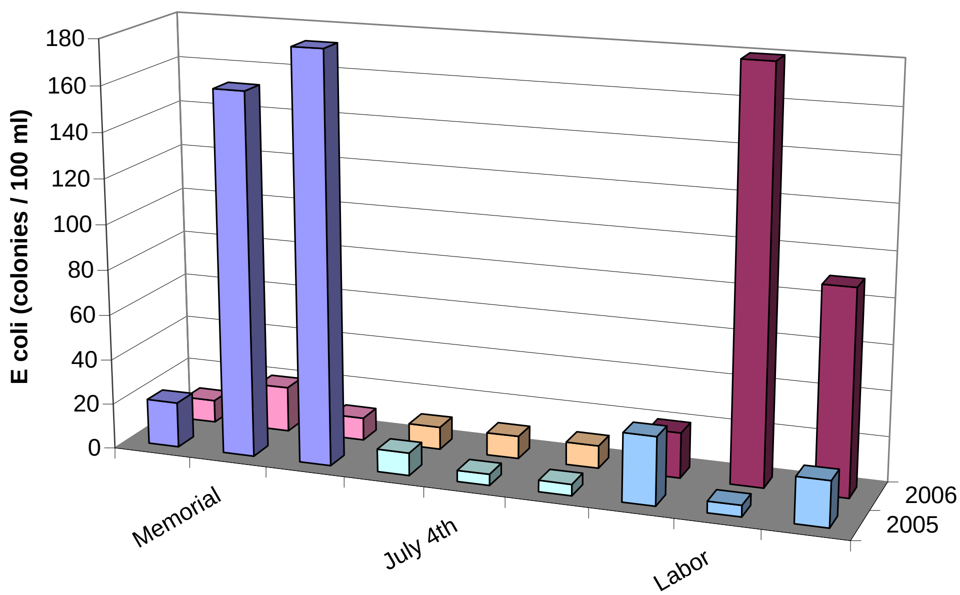

Figure 3.9. Fecal bacteria (E coli) colonies per 100 ml samples collected from three sites at the swimming beach prior to Memorial Day, July 4th, and Labor Day during 2005 and 2006 at Clinton Lake.

3.4 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 four lake sites, one inflow site, and one outflow site. Monthly vertical profiles will be recorded at each of the four lake sites. Due to concerns of bluegreen algal toxins, 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 metals will be examined during 2007 to provide a comparative point on potential resuspension sources. 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.