Toronto Lake:
Water Quality Status Fact Sheet

Location
Toronto Lake is a 2,800 acre lake, located in the scenic Flint Hills region of Kansas with a maximum depth of approximately 5.5 m and a mean depth of 2.1 m. Construction was completed by the Tulsa District Corps of Engineers in 1960 by damming the Verdigris River and Walnut Creek to control flooding.

Land Use
Toronto Lake lies within a 690-sq. mile watershed that is predominantly grassland (70%). Pasture/hay occupies 15% of the watershed, while forest accounts for 5% and cropland 4% of the total land area within the watershed.

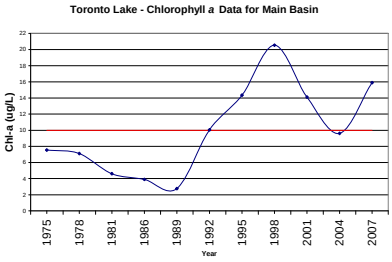
Water Quality's Decline
Toronto Lake is a Class A primary contact recreational water for public swimming. Other designated uses include aquatic life support, food procurement, drinking water, ground water recharge, industrial water supply, irrigation use and livestock watering use.

KDHE water quality data collected from 1992 to 2007 revealed that Toronto Lake ranks as the ninth highest for total phosphorus (TP) concentration of the 24 federal reservoirs in the state. TP concentrations range between 55-108 µg/L, with an average concentration of 81 µg/L, which is ~4 times greater than the statewide benchmark of 23 µg/L.

The total suspended solids (TSS) concentration, indicative of turbid conditions, is high and averages about 30 mg/L, third highest among the federal reservoirs. Because of the appearance of high turbidity values, the lake has low water clarity with an average secchi depth value of 35 cm. Eutrophication along with siltation and dissolved oxygen deficiencies encompass the primary water-quality problems in Toronto Lake.

Eutrophication
Though eutrophication occurs naturally, it can be accelerated through an anthropogenic process that causes reservoirs to become more productive or eutrophic due to excessive nutrient additions from their associated watersheds.

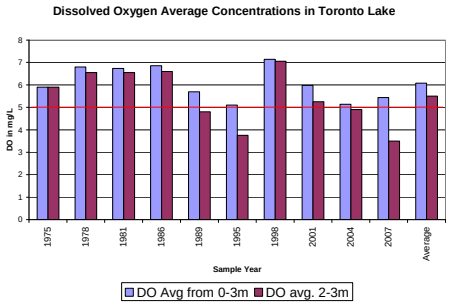
The chlorophyll *a* (Chla) concentration has been used as a general trophic indicator of a waterbody. Toronto Lake averages 14.9 µg/L of Chla, which ranks as the 13th highest in the state among the federal reservoirs. The occurrence of low Chla concentrations is closely associated with low water clarity (or high turbidity) conditions. High turbidity, caused by suspended particles, negatively affects phytoplankton communities and light penetration.



The average total nitrogen concentration within Toronto Lake is 0.64 mg/L. Toronto Lake is generally limited by light and nitrogen. However, during the years with the higher chlorophyll *a* concentrations (1995, 1998, and 2007) the lake was co-limited by light, nitrogen and phosphorus.

Siltation
Toronto Lake has high inorganic turbidity and high levels of siltation. The lake is shallow and sediment is re-suspended easily due to wind, motorboat traffic, and moderate to high inflow events. Siltation is aggravated during large runoff events when releases from Toronto Lake are minimized to accommodate flood control along the Verdigris River, which causes large silt deposits within the lake and the inflowing river channels. Subsequent runoff events of moderate duration then facilitate the transport of that deposited sediment into the lake where it may settle out.

Dissolved Oxygen
Dissolved Oxygen concentrations significantly drop around the 4-meter depth range in Toronto Lake. Temperature readings are generally stable throughout the water column, indicating that the lake is not stratified. Low dissolved oxygen concentrations are likely prevalent when the lake is turbid and temperatures are warmer. The decomposition of plant material has lowered the dissolved oxygen concentrations toward the lake bottom.



Fish Community
Toronto Lake offers sports-fishing opportunities throughout the year and is known for having "an abundance of some of the largest white bass in the world" (USACE). According to the Kansas Department of Wildlife

and Parks fish survey, the number of adult fish Captured Per Unit Time Effort (CPUE) shows that white bass have been increasing, largemouth bass fluctuate from year to year and white crappie have remained somewhat stable. Bottom feeding fish are dominated by variable gizzard shad populations and channel catfish have been stable.

Runoff Potential

Runoff plays an important role in transporting nutrients and sediment to the lake. It occurs as precipitation is greater than soil permeability. According to the Natural Resources Conservation Service's soil database (STATSGO), the soils in the watershed have low permeability values. Eighty-one percent of the soils have permeability $\leq$ 0.56″/hr. The watershed-average soil permeability is 0.43″/hr.

Restoration of Toronto Lake

Based on the Clean Water Act, a waterbody that does not meet water quality standards is considered "impaired". The Clean Water Act requires states to develop a clean-up plan for all impairments. The clean-up plan and the process used to develop it is the Total Maximum Daily Load (TMDL). A TMDL for Toronto Lake was developed to address eutrophication, siltation, and dissolved oxygen in 2007.

The TMDL provides allocations for phosphorus (TP), nitrogen, and total suspended solids (TSS) loads. A lake model (BATHTUB) was utilized to determine phosphorus and nitrogen allocations to the lake. In order to improve the trophic condition of Toronto Lake from its fully eutrophic status, the desired endpoint of the TMDL is to maintain the summer chlorophyll *a* concentration below 10 µg/L. In order to improve the clarity of the water column and the siltation impairment, the endpoint should also result in an increase in the average transparency of the lake to 0.7 meters, as measured by the secchi disk depth within the main basin of the lake. In addition dissolved oxygen should exceed 5 mg/L for the entire water column of the lake. The model results concluded that the total phosphorus and total nitrogen concentrations entering the lake from both Walnut Creek and the Verdigris River must be reduced by 30% to achieve the necessary load reductions for the lake.

Parameter	Current Avg. Condition	TMDL	Percent Reduction
TP Annual Load (lbs/year)	71,686	50,585	29.4%
TP Daily Load (lbs/day)*	373.2	263.3	29.4%
TN Annual Load (lbs/year)	691,437	490,450	29.1%
TN Daily Load (lbs/day)*	5077	3601	29.1%
TP Main Basin (µg/L)	73.0	52.4	28%
TN Main Basin (µg/L)	636.0	492.3	23%
Secchi Depth (m)	0.4	> 0.70	75% Increase

Sources

Nonpoint sources are the main contributor for the nutrient input and impairment in Toronto Lake. Runoff transporting nutrient loads associated with animal wastes and cultivated crops where fertilizer has been applied contribute to the eutrophic condition of the lake. Load allocations within the TMDL resulting from nonpoint sources for phosphorus and nitrogen are 43,913 lbs/year and 419,868 lbs/year respectively. Wasteload allocations associated with point sources total 1,383 lbs/year and 6,289 lbs/year for phosphorus and nitrogen respectively. Point sources attribute to less than 3% of the total allocations for phosphorus and nitrogen. The discharging point sources in the watershed include the Cities of Toronto, Hamilton, and Madison.

Siltation loading comes predominantly from nonpoint source pollution as well. Overland runoff can easily carry sediment to the stream segments and eventually to the lake. The level of the siltation impairment can be measured through secchi depth readings, which can be improved through setting allocations and reductions for total suspended solids (TSS) for Toronto Lake. The TMDL calculated the current sedimentation rate at 96,300 tons/year of TSS (sediment) accumulating on the bottom of the lake each year and the TMDL for TSS is set at 55,854 tons/year based on a regression calculation. Therefore a 42% TSS reduction is necessary to achieve a secchi depth of 0.7 m.

Priorities

In general the areas that should be targeted for implementation include the HUC12 subwatersheds along the main stem of Walnut Creek, and the Verdigris River in addition to the subwatersheds adjacent to the lake

TSS Load	TSS tons/year	TSS tons/day*
Wasteload Allocation	21	0.1
Load Allocation	50248	261.5
Margin of Safety	5585	29.1
TSS TMDL	***55854***	***290.7***

Implementation of Watershed Management in Reducing Phosphorus Entering the Lake

To abate excessive phosphorus and sediment, here are several recommended agricultural practices: (1) Apply nutrient best management practices (BMPs) to reduce nutrient additions from excess fertilization; (2) Promote and adopt continuous no-till cultivation to minimize soil erosion and nutrient transports; (3) Install grass buffer strips along streams; (4) Reduce activities within riparian areas; (5) Setback both confined and non-confined animal feeding operation sites; and (6) Construct ponds/detention basins, erosion control structures and/or wetlands to reduce soil erosion and to trap sediment and lower peak runoff rates.