Nutrient Budget

As a 50-acre landlocked lake with a minimal (159-acre) watershed area, Forest Lake is particularly vulnerable and sensitive to nutrient loadings. Studies indicate that aquatic plant growth in most Wisconsin lakes is limited by phosphorus. Algae utilize phosphorus from the water column, while aquatic macrophytes can also use nutrients from the bottom sediments. By identifying the sources of phosphorus, lake management practices can be designed to reduce phosphorus loadings and over time potentially reduce the growth of algae and some macrophytes.

Previous Phosphorus Budgets

The Wisconsin Department of Natural Resources (DNR) previously developed a phosphorus budget for Forest Lake in 1970, and the Forest Lake Improvement Association (FLIA) updated the budget in 1993. The 1970 budget estimated that the vast majority (73%) of the phosphorus was from failing septic systems. The total estimated 1970 phosphorus load to Forest Lake was 62 pounds per year.

The 1993 report reduced the estimated phosphorus load from septic systems because a 1985 sanitary survey found few failing systems. The estimated 1993 phosphorus budget was as follows:

Source	Phosphorus (lbs./yr)	% of Total
Residential Runoff	4.3	8
Septic Systems[a]	12.7	25
Forest and Open Land Runoff	8.3	16
Precipitation[b]	25.5	51
Total[c]	50.8	100

[a] Assumes the average property owner resides on Forest Lake for about three months a year
[b] Precipitation that falls on the lake itself
[c] Groundwater inflow loading assumed to be negligible

Primarily because of the lower phosphorus loadings from septic systems, the 1993 load of 51 pounds per year was 11 pounds lower than the 1970 estimate. The largest source of phosphorus (about one-half) was from precipitation that falls on the lake surface. Neither the 1970 nor 1993 budgets attempted to quantify the amount of phosphorus that may be released and recycled from the bottom sediments or groundwater resources.

2007 Phosphorus Budget

This report updates the previous phosphorus budgets using newer methodologies and tools. The watershed's land use characteristics have not changed substantially over the past 30 or 40 years.

The loadings from atmospheric sources (precipitation that falls directly on the lake surface) were calculated using procedures developed by the U.S. Geological Survey (USGS) for Wisconsin lakes (Robertson et al, 2005). USGS data indicate that precipitation in Wisconsin typically has a phosphorus concentration of about 7 ug/l. At this concentration, precipitation would contribute about 3 pounds of phosphorus per year to Forest Lake (only about one-tenth of the precipitation phosphorus load estimated in the 1993 report).

In a recent Wisconsin lake study, USGS calculated the impact of phosphorus from septic systems using the following equation:

$$M = Es \times \text{number of capita years} \times (1 - SR)$$

Where:
M= annual phosphorus load from septic systems to the lake
Es=export coefficient, which USGS assumed at 1.5 pounds of phosphorus per capita year
SR=soil retention coefficient, which USGS estimated at 0.85

The total number of capita years in the Forest Lake watershed was assumed to be:

- 11 year round residences @ 3 persons each
- 38 seasonal residences @ two months each @ 3 persons each

Note: Six residences have holding tanks, which do not discharge phosphorus to the lake

The total number of capita years was determined to be 51. Applying the USGS equation results in an estimated phosphorus load of 11.5 pounds per year. This estimate is slightly lower than the 1993 estimated septic system load of 12.7 pounds per year.

Two pollutant load models were evaluated to calculate the phosphorus load from land runoff:

1. The Watershed Treatment Model (WTM), developed by the Center for Watershed Protection in 2001 for USEPA.

2. The Source Loading and Management Model (SLAMM). Robert Pitt from the University of Alabama initially developed SLAMM. At the time Bob was an employee of DNR.

Both WTM and SLAMM are relatively simple models that calculate pollutant loadings as a product of flow and pollutant concentration. The models offer features that allow the users to test the effectiveness of various land management practices. Both models allow the user to separate impervious area (rooftop and roadway) loads from pervious area (vegetated area) loads.

For the 2007 Forest Lake phosphorus budget, SLAMM was selected because DNR recommends that Wisconsin municipalities utilize SLAMM to assess NR151 performance standards for NR216 municipal storm water permits. Many Wisconsin consultants and DNR staff are familiar with the SLAMM modeling procedures. Rather that actually apply SLAMM to the Forest Lake watershed, unit area loading rates (in

Nutrient Budget

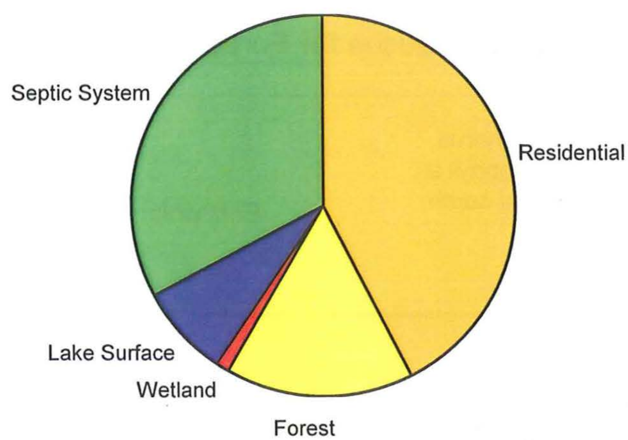
pounds per acre per year) were applied to the watershed land areas. The unit area loading rates were determined from SLAMM studies of the Milwaukee River watershed (which includes Forest Lake) conducted in 2006 by HNTB and Tetra Tech as part of the Milwaukee Metropolitan Sewerage District's 2020 facilities plan. The following phosphorus unit area loading rates were applied:

Residential (assume 10% impervious)
- Impervious: 1.6 pounds/acre/year
- Pervious (assume 50% lawn; 50% wooded): 0.25 pounds/acre/year

Forest and Wetland: 0.08 pounds/acre/year

The 2007 phosphorus budget for Forest Lake is presented below:

	Extent	Phosphorus Load (lbs/year)	% of Total
Residential Land			
• Impervious	4 acres	6.4	18.1
• Pervious	35 acres	8.8	24.9
Residential Subtotal	*39 acres*	*15.2*	*43.0*
Forest	69 acres	5.5	15.6
Wetland	1 acre	0.1	0.3
Lake Surface	50 acres	3.0	8.5
Septic Systems	49 systems	11.5	32.6
Total		35.3	100.0



The 2007 estimated phosphorus load from external sources is 30% lower than the load estimated in 1993 by the FLIA, and 43% lower than the load reported by DNR in 1970. Does this indicate that the phosphorus loading to Forest Lake has declined substantially over the past decades? Probably not. The reduced load is likely the result of the more accurate methodologies used to calculate the loading. The Trophic State Analysis described in the next section also does not suggest a long-term trend in lake water quality conditions.

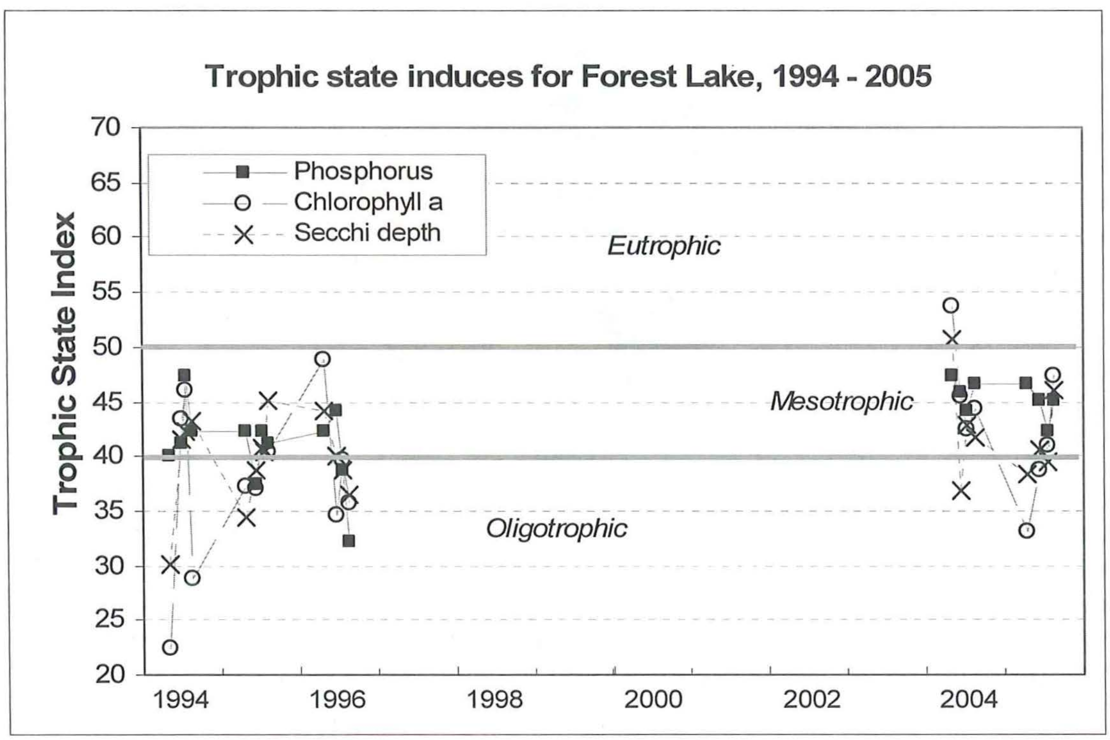
Trophic State Analysis

The trophic state is a measure of the biological productivity of a lake. A frequently used trophic state index is the Carlson (1977) trophic state index (TSI). The Carlson index is relatively simple to apply, it requires a minimal amount of data, and the results are easy to understand. The Carlson index uses algal biomass as the basis for trophic state classification. Three variables -- chlorophyll-a, water clarity (Secchi disk depth), and total phosphorus concentrations -- are used to reflect algal biomass.

The Carlson TSI ranges from zero to 100. The index values are categorized as follows:

TSI Value	Condition
>50	Eutrophic: High algal growth, poor water clarity, warmwater fishery; aquatic macrophyte problems likely
40-50	Mesotrophic: Moderate algal growth and water clarity; warmwater fishery; less potential for excessive macrophyte growth
<40	Oligotrophic: Low algal growth; excellent water clarity; coldwater fishery possible

Based on monitored phosphorus, chlorophyll-a, and Secchi disk levels in Forest Lake, the USGS calculated TSI values from 1994-1996 and 2004-2005. The results are shown below.



Trophic State Analysis

The results show that Forest Lake would be classified as a mesotrophic lake. The phosphorus TSI ratings tend to be highly mesotrophic (towards the eutrophic range). The water clarity TSI ratings generally lie near the bottom of the mesotrophic range (towards oligotrophic conditions). Based on the limited amount of data available, there did not appear to be any significant trends in productivity over the period of 1994-2005.

While the trophic state index represents the lake's productivity, it does not reflect the overall health of the lake. The TSI does not directly address important issues such as the health of fish and other aquatic life, invasive species, shoreline erosion, degraded habitat, or bacterial contamination.

Forest Lake Management Practices

The following lake management practices may help reduce nutrient loadings to Forest Lake. These practices do not address other resource-related issues that are not impacted by nutrient levels.

- Vegetation Management
  - Use phosphorus-free lawn and garden fertilizer or preferably do not fertilize at all
  - Do not apply fertilizer within 25 feet of the shoreline
  - Have your soil tested and use only the amount of fertilizer that is needed. Do not over-fertilize
  - Do not blow or rake clippings into the lake
  - Maintain a good vegetative cover on steep slopes, walkways, and other disturbed areas
  - Rake up and dispose of leaves in fall to prevent washing into the lake
  - Clean up pet waste deposited within 25 feet of the shoreline

- Shoreline Management
  - Maintain a buffer of natural vegetation to filter pollutants from storm water runoff
  - Control erosion and scouring of the shoreline
  - Do not burn leaves, grass clippings, or wood near the shoreline. Prevent ashes from washing into the lake.

- Household Management
  - Divert runoff from rooftops and paved areas away from the lake and towards flat vegetated areas, rain gardens, or rain barrels
  - Wash vehicles in areas that drain onto grassed areas away from the lake
  - Use non-toxic household cleaners and products

- Septic System Management
  - Regularly inspect septic systems and pump out the septic tanks at least once every 3 years
  - Use phosphorus-free detergents and soaps
  - Do not place grease, paint, pesticides or toxic substances into your system
  - Practice water conservancy and use water saving devices

KEYS TO FOREST LAKE WATERSHED MANAGEMENT

1. Maintain septic systems
2. Use environmentally-safe lawn practices
3. Absorb runoff from rooftops and driveways
4. Practice good shoreline management