Water Quality Data Analysis

In New Hampshire, designated uses and the water quality to protect those uses are regulated through the Water Quality Standards, which include RSA 485-A:8 - the Classification of Water, and Env-Wq 1700 - the Surface Water Quality Regulations. RSA 485-A:8 establishes that all New Hampshire surface waters are classified as either Class A or Class B waters, and specifies certain minimum surface water quality criteria for each classification. The Surface Water Quality Regulations further protect and maintain New Hampshire's waters through the identification of designated uses, antidegradation provisions, and additional numeric and narrative water quality criteria. The designated uses for New Hampshire waters are:

1. Aquatic Life
2. Fish and shellfish consumption
3. Drinking water supply
4. Primary and secondary contact recreation (swimming and boating)
5. Wildlife

The State of New Hampshire has set water quality standards for nutrients based on the aquatic life designated use of the waterbody (Table 1).

Table 1. Total Phosphorus (TP) and Chlorophyll-*a* (Chl-*a)* Criteria for Aquatic Life Designated Use

Trophic State	TP (µg L^{-1})	Chl-*a*(µg L^{-1})
Oligotrophic	< 8.0	< 3.3
Mesotrophic	<= 12.0	<= 5.0
Eutrophic	<= 28	<= 11

Assessment Units (AU) are the basic unit of record for water quality assessments that use all available data to report whether or not a waterbody is meeting standards. Rivers and streams, lakes and ponds, wetlands, and segments or sections thereof, each have individual assessment unit IDs. Water quality is tracked by assessment unit for the purpose of reporting to the public.

Currently**, Lake Waukewan** is classified as **oligotrophic** and **Winona Lake** as **mesotrophic**.

An analysis of the existing water quality data available for the last ten years (2004-2013) for Lake Waukewan and Winona Lake was performed to determine the median total phosphorus (TP), mean chlorophyll-*a* (Chl-*a*) values, and mean secchi disk depths for each lake to determine if the waters of each lake meet the Tier 2 High Quality Water criteria set by the NH Department of Environmental Services (NHDES).

The major source of the water quality data comes from measurements and samples collected by volunteers under the NHDES Volunteer Lake Assessment Program (VLAP). Winona Lake has one deep water site, WINNWHD; sampling frequency varies year to year, from a minimum of one to a maximum of three samples collected June through September. Two deep water sites are monitored on Lake Waukewan, WAUMERMD – Mayo Station N, WAUMERWD – Winona Station S; approximately three samples are collected each season, monthly from July through September. There is also a shallow site WAUMERP-Perkins Cove on Lake Waukewan that is sampled; however data from shallow lake sites is not included in the Assimilative Capacity analyses.

Phosphorus and chlorophyll-*a* data collected from the epilimnion (upper surface layer) between May 24 and September 15 are used to determine the summer median TP and mean Chl-*a* values for each waterbody.

The median and mean values for each water quality parameter (TP, Chl-*a*, Secchi depth) for Lake Waukewan (Table 2) were arrived at by first determining the median or mean value of each water quality parameter for each site sampled during 2004 to 2013; the median or mean of the two sites is then used to represent the overall lake value for the parameter.

Table 2: Summary of water quality data for 10 year period (2004-2013) for Lakes Waukewan and Winona.

Water Quality Analysis (Time Period: 5/24-9/15)	**Waukewan** 2004 - 2013	**Winona**
Total Phosphorus (μg L^{-1})		
Median	5.6	7.2
# samples (n)	(41)	(11)
Chl_*a* (μg L^{-1})		
Mean	2.5	4.3
# samples (n)	(57)	(14)
Secchi disk (m)		
Mean	7.0	5.6
# samples (n)	(59)	(13)

Assimilative Capacity Analysis

The assimilative capacity of a water body describes the amount of pollutant that can be added to that water body without causing a violation of the water quality criteria. The water quality nutrient criterion for phosphorus has been set at 8μg L^{-1} for an oligotrophic waterbody (high quality water) and <=12 μg L^{-1} for a mesotrophic waterbody. The NHDES requires 10% of the state standard to be kept in reserve; therefore phosphorus levels must remain below 7.2 μg L^{-1} for oligotrophic and < 10.8 for mesotrophic waterbodies to be in the Tier 2 High Quality Water category. An example of the calculations for an oligotrophic classed waterbody is shown below.

Assimilative Capacity (AC) for Total Phosphorus (TP)

- Total AC = Water Quality Standard (8 µg L^{-1} TP) – Best Possible WQ (0 µg L^{-1} TP) = 8.0 µg L^{-1} TP
- Reserve assimilative capacity = 0.10 x Total AC = 0.8 µg L^{-1} TP
- Remaining assimilative capacity = 7.2 µg L^{-1} – Existing WQ

An analysis of a waterbody's assimilative capacity is used to determine the total assimilative capacity, the reserve assimilative capacity, and the remaining assimilative capacity of each water quality parameter being considered. This information is then used to determine water quality goals and actions necessary to achieve those goals. The assimilative capacity analysis is conducted in accordance with the Standard Operating Procedure for Assimilative Capacity Analysis for New Hampshire Waters.

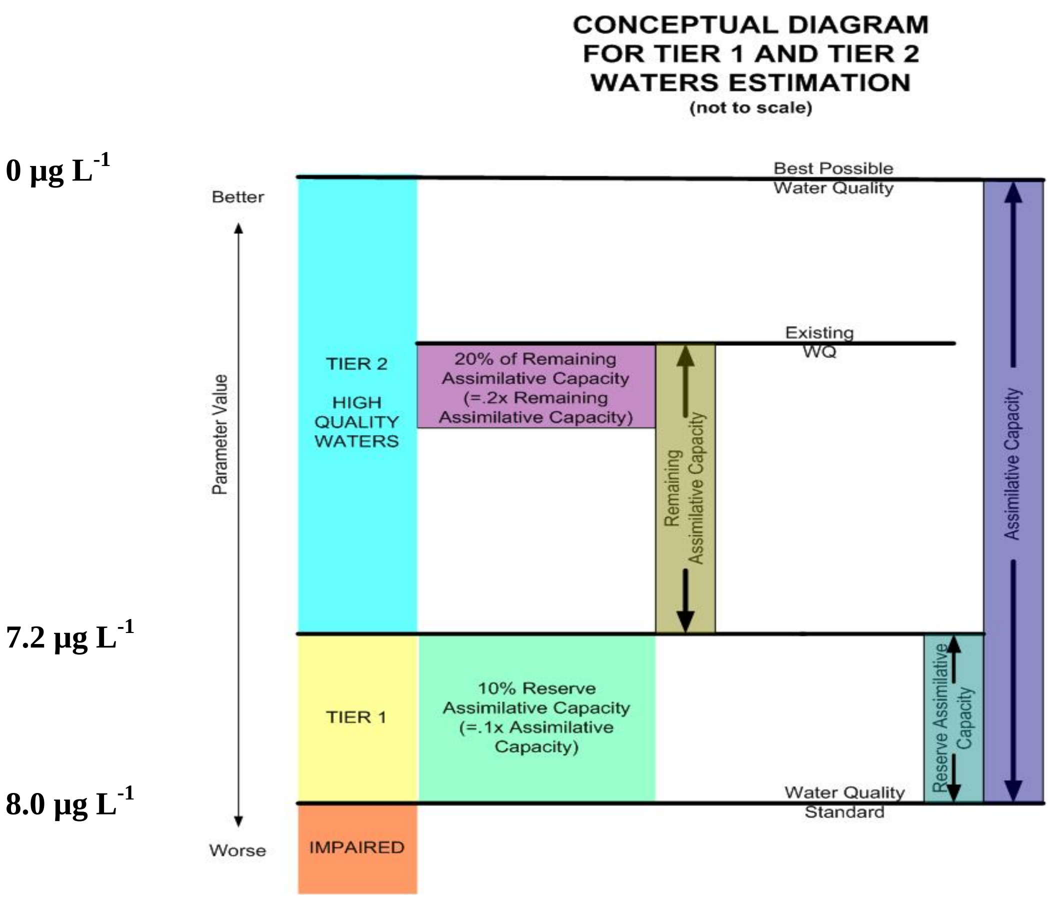

Figure 1. Conceptual diagram for the determination of Assimilative Capacity for a waterbody.

Results of Assimilative Capacity Analysis

Winona Lake

The existing median TP value for Winona Lake of 7.2 µg L^{-1} results in a remaining assimilative capacity of 3.6 µg L^{-1}, which qualifies Winona Lake in Tier 2 for a mesotrophic waterbody. The existing Chl-*a* mean value of 4.3 µg L^{-1} is also below the NH State Nutrient Criterion of <=5.0 µg L^{-1} for the aquatic life designated use set for a mesotrophic water body.

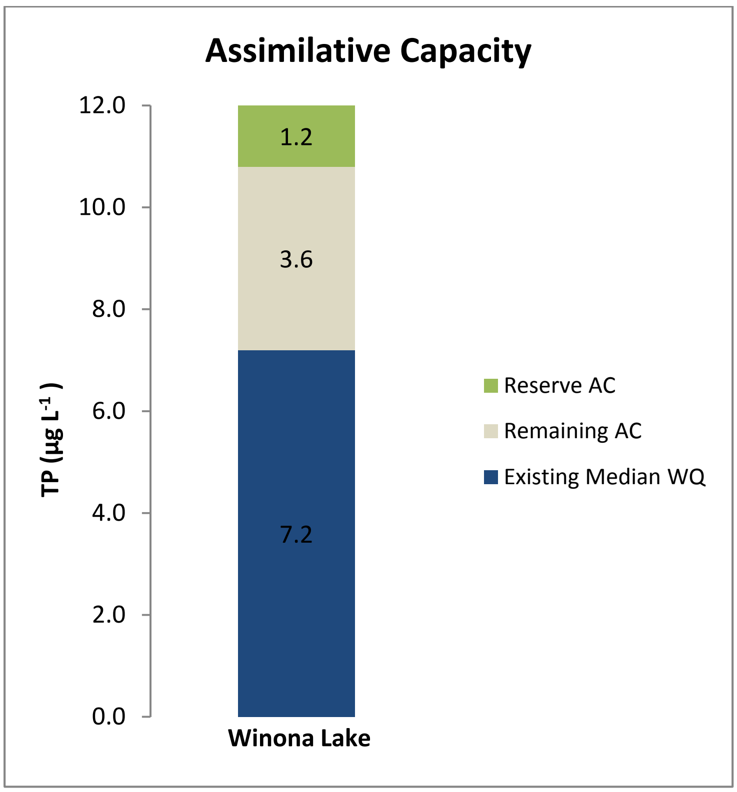

Figure 2. Graph depicting the results of the Assimilative Capacity analysis for total phosphorus for Winona Lake

Lake Waukewan

The existing median TP value for Lake Waukewan of 5.6 µg L^{-1} results in a remaining assimilative capacity of 1.6 µg L^{-1}, which qualifies Lake Waukewan in Tier 2 for an oligotrophic waterbody. The existing Chl-*a* mean value of 2.5 µg L^{-1} is also below the NH State Nutrient Criterion of <3.3 µg L^{-1} for the aquatic life designated use set for the oligotrophic classification; therefore the water quality data and assimilative capacity analyses support Lake Waukewan's designation as a high quality water and oligotrophic classification.

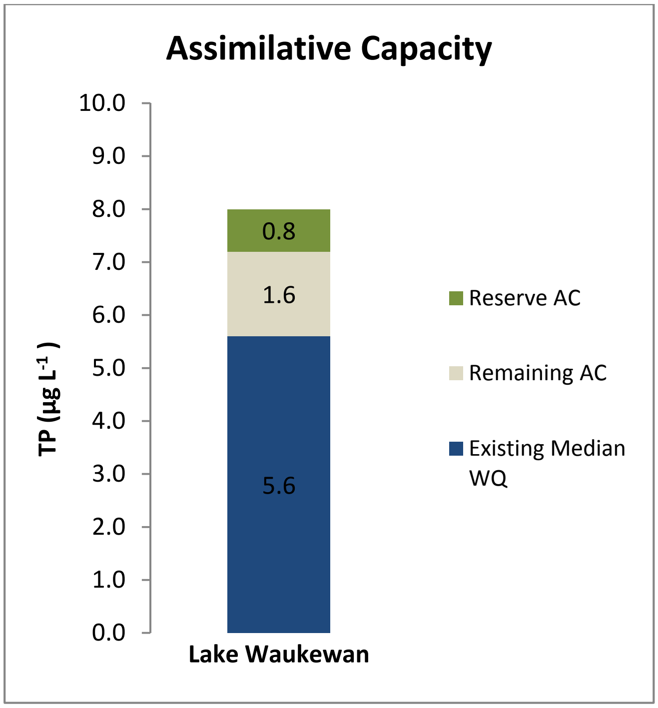

Figure 3. Graph depicting the results of the Assimilative Capacity analysis for total phosphorus for Lake Waukewan.

Selecting a Water Quality Goal

Lake quality is impacted by the amount of nutrients that enter the waterbody. Nutrients are delivered in several ways; through atmospheric deposition (rainfall), groundwater, point sources, watershed loading (land use), septic systems, and internal loading. Phosphorus is the limiting nutrient of concern for NH's freshwater lakes; therefore setting a water quality goal for total phosphorus (TP) and preventing or limiting increases in phosphorus loading to both Lake Waukewan and Winona Lake is critical for protecting lake health.

Setting the water quality goal is of central importance to the Plan because it will dictate the level and scope of watershed restoration efforts necessary to reduce phosphorus loads by the determined amount.

A local water quality goal for phosphorus for Lake Waukewan and Winona Lake should either meet or exceed the State Standard in order to protect the health of the waterbody and Lake Winnipesaukee for the long term. In general, local water quality goals may be set to:

- result in no increase in in-lake TP concentration,
- no increase that would violate state water quality criteria,
- attain a decrease in existing in-lake TP levels.

To guide the Waukewan Winona Lake Study Advisory Committee in choosing water quality targets for Lakes Waukewan and Winona, staff from LWWA, FB Environmental Associates and NHDES held a conference call to review the water quality data, assimilative capacity and pollutant loading analyses and recommend a water quality goal.

NH lakes have a greater Chl-*a* response to TP loadings than many other lakes due to their excellent water clarity. As the in-lake TP levels near 8-10 µg L^{-1}, an increased response in cyanobacteria is often seen. Because of this low tipping point for many NH lakes (8-10 µg L^{-1} threshold), it is important to prevent increases in in-lake TP concentrations as it may not be possible to return to lower levels (J. Schloss, personal communication, August 8, 2013).

Evaluation of options for selection of a WQ goal

Estimate in-lake Phosphorus and Chlorophyll-*a* Concentrations

The ability to run various scenarios that will predict in-lake response to nutrient load is important to the setting of the local water quality goal. FB Environmental Associates used the Lake Loading Response Model (LLRM) to predict in-lake phosphorus and chlorophyll-*a* for each lake based on estimates of current nutrient loading. Predictions of in-lake phosphorus and chlorophyll-*a* are important to the loading model because they allow for calibration of model inputs. Values predicted in the LLRM are compared to actual field data to ensure the accuracy of data used to build the model, and the validity of the results that the model provides (Table 3).

Table 3. In-lake concentrations of Phosphorus and Chlorophyll-*a*, compared to actual observed field data (median values for previous 10 years)

Parameter		**Waukewan**	**Winona**
Total Phosphorus (µg/L)	Actual (10-year Median)	5.6	7.2
	Predicted (LLRM)	5.9	7.2
Chlorophyll-*a* (µg/L)	Actual (10-year Median)	2.5	4.3
	Predicted (NH Chl-*a* Model)	2.8	2.9

Three possible water quality goals are presented below (Table 4). The first goal is set to attain the in-lake phosphorus value that is the threshold for each lake's trophic class, as designated by NHDES. Lake Waukewan is currently designated as Oligotrophic, and Lake Winona as Mesotrophic. The corresponding TP concentrations for these designations (8.0 and 12.0 µg/L, respectively) are used in the calculations below. Although Lake Winona's TP is within the Oligotrophic threshold for NH lakes, several parameters are considered to determine trophic class, including summer bottom Dissolved Oxygen, secchi disk transparency, aquatic vascular plant abundance, and summer epilimnetic chl-*a*.

The second scenario uses a goal of the NHDES threshold minus 10% of that value, in order to provide the lake with reserve assimilative capacity that will keep it below the threshold, accounting for year to year variation. The third goal uses a target value of predicted in-lake phosphorus concentrations minus 10% of that value, in order to set water quality goals that will quantify reductions in phosphorus loading to the lakes.

Since both lakes have current phosphorus concentrations below the NHDES thresholds, the "Change in P loading" values for these goals are expressed as a positive percentage value. These values represent an allowable increase in phosphorus loading before the threshold target is reached. In the third scenario in Table 4 (Predicted concentration – 10%), the percent change is expressed as a negative number, indicating the amount of decreased phosphorus load necessary to meet the target concentrations.

Table 4. Lake data and possible water quality goals, with phosphorus reduction estimates.

Current Values

Lake	Current NHDES Trophic Class Phosphorus Threshold (µg/L)	Current TP Concentration (µg/L)	Predicted Concentration (µg/L P)	Current Phosphorus Load (kg/yr)
Waukewan	8.0	5.6	5.9	307
Winona	12.0	7.2	7.2	103

Water Quality Goal: Meet Current NHDES Thresholds for Trophic Class

Lake	Predicted TP Concentration (µg/L)	Target TP (µg/L)	Current Phosphorus Load (kg/yr)	Phosphorus Load to meet target TP (kg/yr)	Change in P loading (kg/yr) to achieve target concentration
Waukewan	5.9	8.0	307	421	37.1%
Winona	7.2	12.0	103	172	67%
Water Quality Goal: Meet Current NHDES Thresholds for Trophic Class, with 10% reserve assim. capacity					
Waukewan	5.8	7.2	307	375	22.1%
Winona	7.2	10.8	103	155	50.5%
Water Quality Goal: 10% Decrease from predicted in-lake phosphorus concentrations					
Waukewan	5.8	5.2	307	271	-11.7%
Winona	7.2	6.5	103	93	-9.8%