2014 Augur Lake Experimental Milfoil Control Annual Report
Augur Lake (Essex County), New York
May 2015

prepared by

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I. Introduction:

Augur Lake is a mesoeutrophic body of water located in the Town of Chesterfield (***TOC***) in Essex County, in the northeastern region of New York State. The lake has a mean and maximum depth of 8 feet and 21 feet (the basin), respectively, and is roughly 360 surface acres in size. The outlets of three ponds (Butternut, Mud, and Clark) and a few smaller inlets contribute to Augur Lake's external hydrologic influence. Augur Lake has one outlet that is maintained by a concrete dam situated at the northern tip of the lake. This outlet flows into the Ausable River and eventually empties into Lake Champlain.

One of the primary problems facing the lake is the excessive growth of the invasive aquatic plant, Eurasian water milfoil (*Myriophyllum spicatum*). Eurasian water milfoil hereafter referred to as EWM, has been present in Augur Lake for at least the past several decades.

Studies performed as early as June of 1953 by the New York State Department of Environmental Conservation (***NYSDEC***) indicate that significant weed growth in the lake's various embayments existed. In 1998, an estimated 150+ acres of EWM was present in Augur Lake. Augur Lake is currently on the Priority Waterbodies List (PWL 2009) for the Lake Champlain drainage basin, with recreation listed as stressed due to excessive weed growth.

The Augur Lake Property Owner's Association (***ALPOA***), a group of riparian landowners has struggled with the control of EWM. Past management efforts have included the use of "homemade" mechanical harvesters to clear areas near docks of vegetation and to create boat pathways out into the deeper regions of the lake. While effective at temporarily opening up spaces for recreational use, the application of this technique did not result in any long-term reduction of the EWM population.

In October of 1998, under permit from the ***NYSDEC***, the ***ALPOA*** stocked 750 triploid grass carp into the lake. The permit allowed for a maximum stocking rate of 15 fish per weed acre or 2,500 carp, but desiring to proceed with caution, the ***ALPOA*** decided to stock at a rate of 5 fish per weed acre. A second stocking of carp occurred in October 1999, with an additional 750 fish being placed in the lake. The ***ALPOA***, using an estimate of 8% mortality of stocked fish per year, calculated that the 1999 stocking increased the number of carp in Augur Lake to 9.6 fish per weed acre.

Based on subjective reports from property owners, evidence of carp feeding became very apparent during the summer of 2000 "as holes began to appear in the milfoil beds." According to ***ALPOA*** officials, an estimated 40-50% decrease in EWM density had occurred by the summer of 2001. In 2002, however, a noticeable increase in EWM density was observed and property owners, fearing that a decrease in the number of carp per weed acre was the cause, decided to make plans for a third stocking in 2003.

During the process of preparing an application for stocking with the ***NYSDEC***, it was learned by the ***ALPOA*** that a permit from the Adirondack Park Agency (***APA***) would also be required. Discussions between the ***ALPOA*** and ***APA*** officials resulted in an agreement to allow for a stocking of carp during the summer of 2003 contingent on the performance of a monitoring program of both the lake's water quality and the aquatic plant community.

Consequently, the ***ALPOA*** contacted and retained the services of the lake management firm of Adirondack Ecologists, LLC (***AE***) of Crown Point to design and oversee an annual monitoring effort to assess the efficacy of the grass carp stocking and to deter-mine whether any perceivable water quality impacts occurred as a result of the stocking.

II. Methods:

Prior to stocking, six research sites were selected around Augur Lake by the ***ALPOA*** (see attached map in the *Appendix*). These sites were chosen for their representative nature of the general aquatic plant species assemblages present within the lake. In the middle of each site, a single cylindrical exclosure cage was placed. These cages, measuring roughly 4 feet in diameter and 4 feet in height and weighing about 40 pounds, were constructed of heavy gage 1" by 4" fencing wire. The same type of material was used to fabricate circular tops for each of the cages, and all of the cages were placed over aquatic vegetation in water depths ranging from between 6 and 7 feet (except for site #4). In order to minimize the chance of damage to the cages by boating, and thus reduce the chance of disruption of the monitoring program, each cage was placed in a manner as to allow for at least two feet of water over the top of the cages (except for site #4). No anchoring devices were required to keep the cages in place due to their weight, and a surface marker buoy was used at each location to help locate the individual cages.

The objective of the cages was to protect an isolated area within each monitoring site from the foraging activity of grass carp. Due to the sturdy nature of their construction, the cages were effective in preventing carp from feeding upon enclosed vegetation. This allowed the enclosed vegetation to grow under the same general environmental conditions as vegetation outside of the cages while affording it protection from foraging carp.

At each monitoring site, an aquatic macrophyte survey was performed within (the "protected area") and without (the "unprotected area") the exclosure cage. This type of analysis was performed via snorkeling or from the surface with the assistance of an aquascope, and it provided an opportunity for an unbiased assessment of the effects of grass carp feeding on native and exotic aquatic macrophytes in Augur Lake. In both areas at every site, each species of macrophyte present was identified and documented, and its percent (%) cover was estimated utilizing a modified Daubenmire percent cover rating system. Utilization of this relative abundance coding protocol allowed for a semi-

quantitative assessment of the aquatic vegetation present within the research sites during each monitoring trip. The following protocol was employed: abundant (>50% cover); common (25-50% cover); present (15-25% cover); occasional (5-15% cover); and rare (0-5% cover).

A trip was made to Augur Lake on July 2, 2003 to collect aquatic plant data at each of the research sites prior to the stocking of carp. On July 23, 750 12"-14" carp were stocked into the lake. Based on past stockings and the estimated annual carp mortality rate, this stocking presumably increased the number of carp per weed acre to roughly 11.9. Post-stocking monitoring trips were made on August 13 and September 26, 2003, July 13 and September 1, 2004, July 12 and September 6, 2005, August 19, 2006, August 7, 2007, September 12, 2008, August 11, 2009, August 19, 2010 and September 16, 2011.

Data obtained via the Citizen's Statewide Lake Assessment Program (***CSLAP***) from 1997 to 2001 and from 2003 to 2012 were utilized to help evaluate whether the stockings were responsible for any discernable changes in either the quality or clarity of Augur Lake's surface waters. *Figure 1* in *Appendix 1* of this report outlines secchi disk transparency data obtained during the 1997-2001 and 2003-2012 sampling seasons, and *Figure 2* is a pictorial illustration of seasonal changes in total phosphorus and chlorophyll a levels during this same timeframe. *Appendix 2* consists of a map of the six sites.

2014

Water samples were collected by ***AE*** during the spring of 2014 (April 25) from the lake basin testing station (Note: Both hypolimnetic and epilimnetic samples were obtained), the outlet, and the major tributaries to the lake (i.e., Cassidy Brook and McGuire Brook). The purpose for the water sampling during this time of the year was to gain information about the nature of the runoff into the lake from the inlets during a "spring flush" event and to attempt to determine the impact that this runoff might be having on the character of the lake water itself.

To obtain water samples characteristic of the inlets themselves, ***AE*** used a kayak to paddle up the two tributaries far enough to obtain a sample in a location that was not receiving any backflow from the lake. These samples and the samples from the basin and outlet were then immediately transported to the Darrin Fresh Water Institute (***DFWI***) for laboratory analysis.

Due to the proximity of I-87, there has always been a concern with the potential impacts that runoff from this major thoroughfare might have on the watersheds of both Butternut Pond (the Town of Chesterfield's water supply) and Augur Lake. Of particular concern has been the amount of de-icing agents (primarily chlorides) that may be leaching into the two lakes.

Thus, the water samples collected were analyzed for conductivity and chlorides, along with a variety of other parameters, to determine how much of these constituents were making it into the lake (see the *Augur Lake Spring Sampling* lab results in the *Appendix* section of this report). It was found that the chloride and conductivity levels of both of the inlet samples and the lake water samples were quite elevated. Cassidy and McGuire Brook possessed chloride levels of 28.8 and 23.3 mg Cl/L, respectively, while the epilimnetic lake water sample had a concentration of 21.5 mg Cl/L. Based on the results of the chloride and conductivity analyses, it is clear that Augur Lake is receiving a relatively heavy salt load from I-87 via the two tributaries, and that the volume of inlet water making it into the lake is increasing the lake chloride levels as well.

In addition, it was discovered that the calcium levels of both of the inlets and the lake were elevated and that McGuire Brook in particular possessed a very high calcium concentration. Augur Lake spring calcium levels were found to be higher than that observed in most Adirondack lakes and were high enough to support zebra mussel adults if they were ever to be introduced into this body of water. Calcium concentrations in McGuire Brook were actually high enough to support zebra mussel reproduction, and this poses a real potential, long-term concern for the lake.

As part of an ongoing effort to help control the growth and spread of EWM in Augur Lake, a supplemental stocking of 1,000 12" (+) grass carp was conducted on the morning of May 22. These fish were released off of Peter Gucker's property. The primary objective of the stocking was to increase the overall number of grass carp/weed-acre in the lake to improve the efficacy of their control on EWM. Refer to the *Appendix* to see photos of the stocking operation that were taken by ***AE***.

Unfortunately, Augur Lake was removed by the ***NYSDEC*** from the ***CSLAP*** testing in 2014 and the continuous database that had been maintained every year since 1997 (except for 2002) was interrupted. However, arrangements were made for Paul Knott, a representative of ***ALPOA*** to collect a one-time water sample from the lake basin testing station and to ship it to the ***CSLAP*** lab. This allowed for at least one data point for the summer of 2014 to exist. According to sources, the ***CSLAP*** will be reinstated for Augur Lake in 2015. Please refer to *Figure 1* and *Figure 2* in the *Appendix* for a pictorial illustration of ***CSLAP*** and ***AE***-obtained water clarity (secchi disk transparency) and chlorophyll a vs. total phosphorus levels, respectively, from 1997 to 2014.

Due to a serious injury, the principal investigator for the project, Steve LaMere, was unable to visit the lake during the summer of 2014. In addition, arrangements were made for a representative of the ***APA*** to visit the lake for the purpose of performing an on-site inspection to determine the extent of the EWM present. Reports from this representative (Leigh Walrath) and various subjective reports from local homeowners seem to indicate that the level of EWM growth was less in 2014 as opposed to that observed in 2013

IV. Conclusions (Summary):

Due to the late season stocking of grass carp in Augur Lake in 2003, and the fact that carp metabolism and feeding slows down considerably as the water temperature decreases, minimal carp foraging was documented in 2003. Information collected in 2004 and 2005 initially confirmed that carp were preferentially feeding in the area where **Site #3** is situated. As time has gone by, however, varying levels of grass carp herbivory have also been documented in **Sites #1**, **#4**, **#5**, and **#6**. It is still not known why the carp seem to concentrate most of their feeding in the northwestern region of the lake.

Some native species like *Elodea* were foraged extensively by carp during the first 3 years of the project. In 2006, however, it appeared that consumption of *Elodea* was less than that observed in previous years. In terms of estimated biomass consumed, EWM was overall the species most heavily affected by carp herbivory. It appears that the carp have avoided consumption of coontail to a large extent, and this explains why that by the summer of 2005 coontail had become the dominant species of aquatic plant present near

most of the Augur Lake research sites. Coontail continued to be the dominant aquatic plant species throughout 2006, but by 2007, EWM had once again become the dominant species. This was likely due to a decrease in the number of carp per weed acre as a result of natural mortality through the years.

The exclosures performed their job well for the research project in 2003. Plants contained within the cages seemed to grow normally and attained relatively the same height as those plants immediately outside the cage. Grass carp were unable to forage upon vegetation within the cages, and the weight of the cages prevented the carp from physically pushing them over to get at the plants contained within. In 2004, however, it appears that green filamentous algae growing attached to the cages in **Sites #3** and **#6** affected the growth and health of plants within the cages, and thus affected the study.

In 2005, it was theorized that heat energy absorbed by the metal cages from sunlight might have created an environment within the cages more conducive to plant growth than that found outside of the cages. This theory was not scientifically tested or proven. Even though water temperatures were, on average, higher than normal in 2005, it is not clear as to why this particular phenomenon was not observed to one extent or another in any of the years prior to or after 2005.

In 2003, a spike in the TP levels of Augur Lake's surface water was noted in mid- to late August, but this same type of seasonal increase has been observed in past years on this water body. Chlorophyll a levels increased gradually throughout the summer, and as indicated, a rather extensive "bloom" of green filamentous algae was present in the lake throughout much of August and early September. Water clarity started to decrease in early August and didn't level out until the end of August. After August, water clarity continued to rise until mid-October, when the last ***CSLAP*** sampling was performed.

In 2004, TP levels fluctuated, but chlorophyll a levels seemed to be much more stable than those levels observed in the previous year. Fluctuations in water clarity were evident throughout the summer of 2004, but overall it seemed to be better than that observed in past years. As would be expected during late summer lake turnover, the epilimnetic TP concentration of Augur Lake increased in mid-September, and this precipitated a predictable decrease in water clarity.

The same kind of limnological pattern was observed in 2005, with the exception that TP levels began to increase in July. These levels peaked in late August, and shortly thereafter (in early September after lake turnover) chlorophyll a levels increased and water transparency decreased.

In 2006, TP levels gradually increased from mid-June to mid-August. From mid-August to early September, surface water TP decreased, and then by September 22 these

levels had climbed back up again, presumably as a result of lake-turnover. Chlorophyll a concentrations seemed to correlate closely with the changing TP levels. Augur Lake SDT levels were somewhat depressed throughout the entire summer.

A similar pattern with TP and chlorophyll a levels was observed in 2007, but there seemed to be much less fluctuation in extremes. SDT readings progressively decreased throughout the sampling season and then stabilized in September. Historically, there have been minimal long-term changes observed in any of the Augur Lake trophic state indicators, but during the 2007 sampling season it was noted that the usual "peaks" and "troughs" in the dataset were not present.

Chlorophyll a and TP levels started out fairly high on July 5, 2008 and these levels remained relatively high throughout the entire 2008 ***CSLAP*** sampling season. SDT levels, which are normally high in the late spring and early summer, started out somewhat depressed on July 5 and remained fairly low (averaging about 2.5 meters) throughout the sampling season.

The milfoil population seemed to be at a manageable level by 2006, but there was some obvious indication that by 2007 this invasive species began rebounding. This perceived increase in EWM was likely a result of less grass carp being potentially available for milfoil control in the lake.

Based upon the 2008-2009 dataset, a 2010 stocking of grass carp seemed warranted at that time. It was recommended that discussions occur in order to arrive at a consensus of how best to achieve an overall stocking rate of 12 fish per weed acre. In addition, the importance of a functional fish barrier being installed at the location of the dam to prevent downstream migration of stocked carp was stressed by both the ***APA*** and ***AE***.

The installation of a fish barrier did not occur in 2010, and as a consequence the ***APA*** did not approve a carp stocking event for that year. In addition, since a noticeable decline in milfoil coverage and density was noted at many locations around the lake during the 2010 growing season, it seemed prudent to hold off stocking until further research into the cause of the decline could be performed.

Based on the results of the research, it does not appear that herbivorous insects had anything substantive to do with the milfoil decline of 2010. The milfoil clearly was affected by something. Currently, the only plausible theory that could explain this decline is that diminished water clarity early in the growing season might have minimized the amount of light available to plants (thus reducing photosynthetic productivity) to the extent that it depressed both the growth and fitness of the milfoil. Low growing, native species of aquatic plants did not seem to be affected by this phenomenon, if indeed this is what occurred.

The milfoil decline continued into the 2011 growing season and much less milfoil was present in the lake than ever observed before by ***AE***. Along with this decline, however, an obvious decrease in water clarity and an increase in both total phosphorus and chlorophyll a levels were documented. Unfortunately, it appears that not only did the EWM population rebound during the 2012 and 2013 growing seasons, but that some of the negative water quality changes observed in 2010 and 2011 also seemed to persist.

The results of recent monitoring efforts have exhibited some interesting (and potentially disturbing) trends. The increase in the prevalence of green filamentous algae present in Augur Lake (particularly in 2008) combined with subtle changes in some of the trophic parameters over the past several sampling seasons may be indicating that a shift in the water quality of the lake is occurring. It is not clear whether these are short-term changes or an indication of a long-term trend, but this phenomenon needs to be watched closely in order to discern the scope and duration of the change. In addition, phosphorus abatement strategies should be developed and followed.

Based on concerns for potential harmful algae blooms (HAB's), ***AE*** decided to evaluate the total nitrogen-total phosphorus ratio (TN:TP) of Augur Lake's surface waters in 2012 and 2013. This ratio can often be used as an indicator of what type of algae may become dominant in any given body of water at any given time. Since blue-green algae or cyanobacteria are capable of nitrogen fixation, these planktonic organisms tend to do well in lakes with low TN levels. Some research has indicated that TN:TP ratios of less than 30 favor blue-green and diatom production and ratios less than 15 tend to favor species like *Microcystis aeruginosa*, which can potentially produce anatoxins.

An analysis of the average TN and TP readings obtained through the ***CSLAP*** during the 2012 and 2013 field seasons indicated that a ratio (TN:TP) of about 18 and 21, respectively, existed. This suggests that blue-green algae may indeed have a competitive advantage over other forms of algae, in terms of production, in Augur Lake. This fact may predispose the lake to potentially problematic cyanobacteria blooms in the future.

The most recent interpretation of the dataset indicates that summer time TP levels have increased since 2010 and the current levels now place Augur Lake in the eutrophic category. A slight, long-term decrease in water clarity is noticeable, but it appears that chlorophyll a concentrations have been relatively stable over time. These findings illustrate the importance of continued monitoring in long-term management of the lake.

The stocking of grass carp into Augur Lake has clearly had some impact on the management of EWM. Caution and common sense, however, must be exercised in maintaining the right number of grass carp per weed acre to ensure continued control success without resulting in unwanted environmental impacts. In order to guide the ***TOC***

in future management decisions, continued monitoring of both the aquatic plant community and the water quality and clarity of the lake are both warranted and recommended.

In the future, continued research and more focused, regular testing will be a key to obtaining a better understanding of the dynamics of Augur Lake's limnological condition. A renewed initiative in gaining a better understanding of lake dynamics and what role disfuntional and/or inadequate septic systems could be playing in increasing nutrient loading to the lake would also be helpful.

Until a definitive determination can be made as to what exactly is causing the milfoil population fluctuations and the seemingly concurrent decrease in water clarity and quality, and if the two phenomena are even related, future stocking of carp should be handled very cautiously. It is important to ascertain whether there is a "cause and effect" relationship and for what duration the effect(s) may potentially last. Thus, it is imperative that annual monitoring of the lake continue and that a review of the stocking policy for the program be performed regularly by a lake manager and the appropriate state regulatory staff.

AE will be spending the next year working on a management plan for the lake in conjunction with the ***TOC*** and the ***ALPOA***. The eventual goal of the plan will be to: (1) provide a better understanding of the lake and its resources and problems; (2) gain consensus on how best to address those problems identified; and (3) outline a "blueprint" for the sound management and protection of this valuable water body.

Included in this document will be a discussion about the recent (spring 2014) water quality testing and the importance of the findings from that sampling.

APPENDIX

Figure 1. 1997-2014 Augur Lake Secchi Disk Transparency Levels (meters)

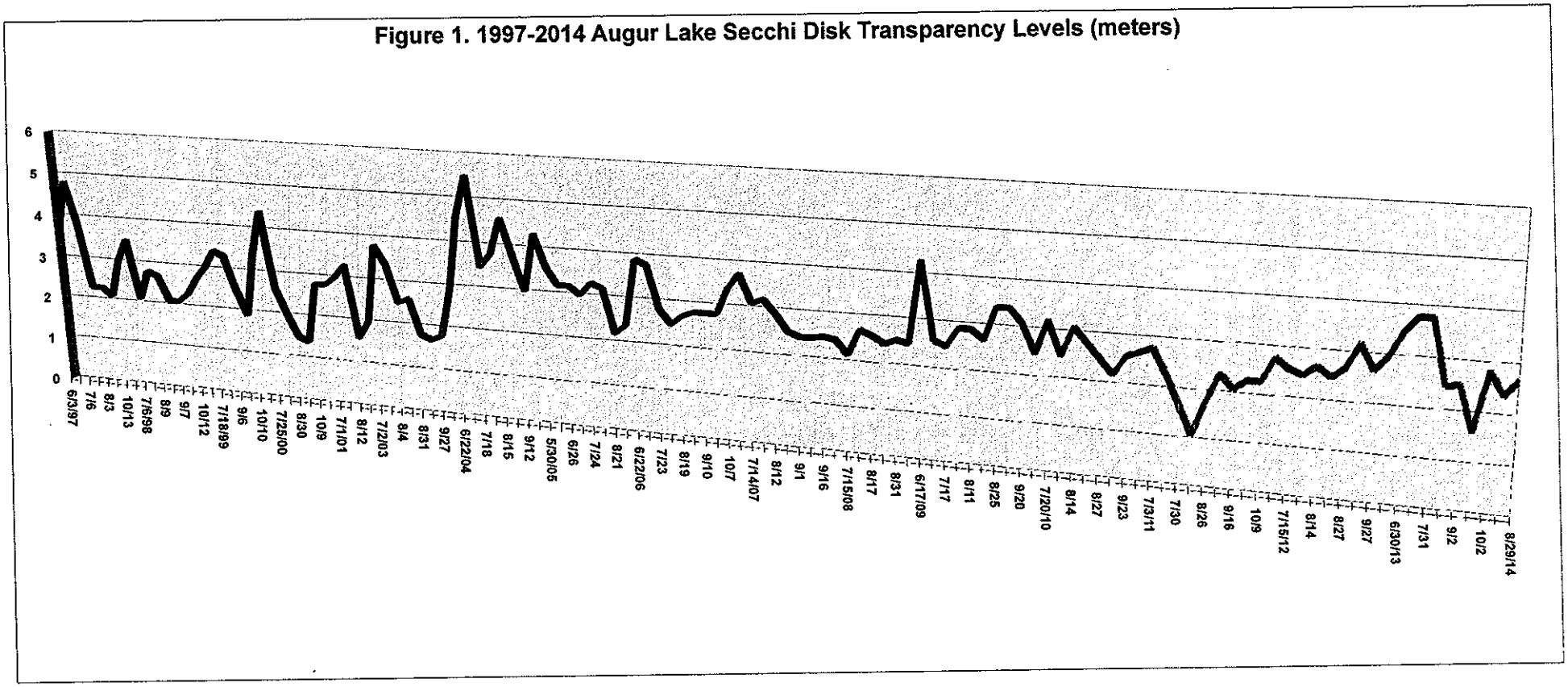
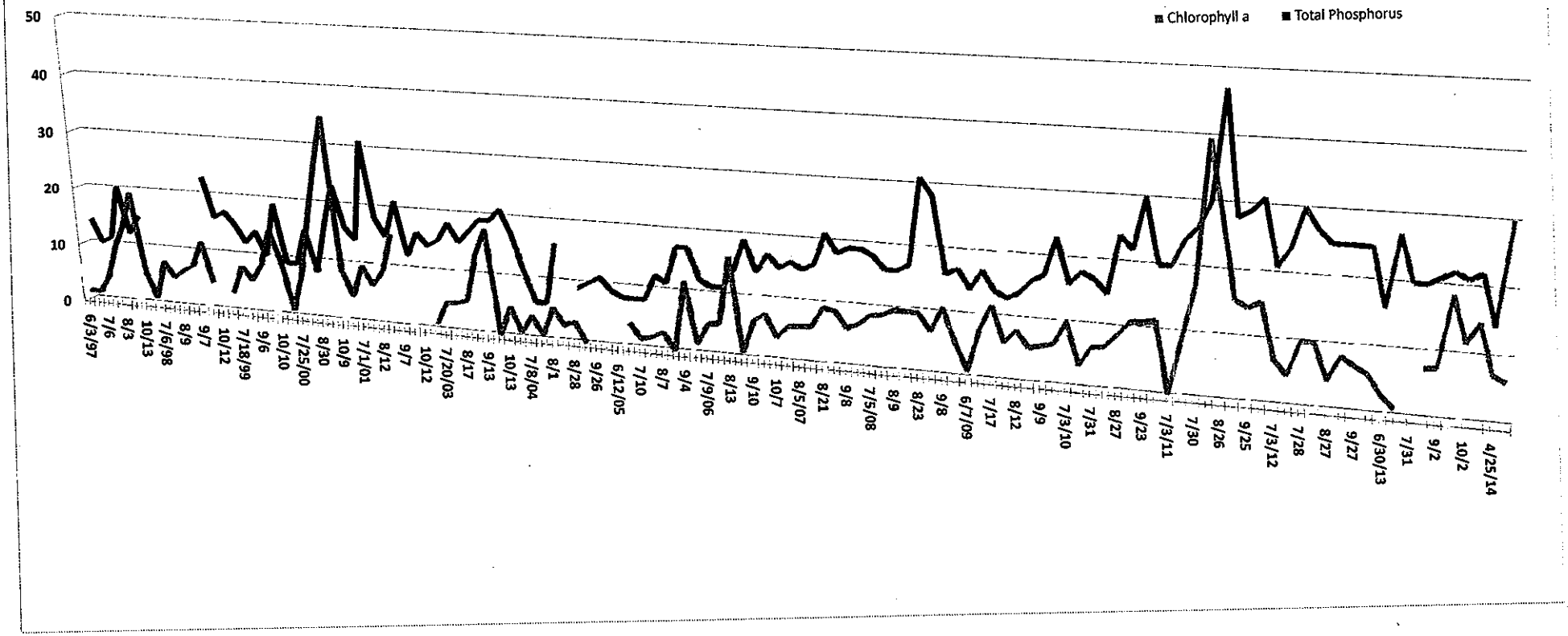


Figure 2. 1997-2014 Augur Lake Total Phosphorus (ppb) vs. Chlorophyll a levels (ppb)



Darrin Fresh Water Institute

A Research Center of Rensselaer Polytechnic Institute

Steve LaMere - Adirondack Ecologists **Augur Lake Spring sampling** **2014**

Date sampled: 25-Apr-14

	Site:	Outlet	Cassidy Brook	McGuire Brook	Lake Basin epi	Lake Basin hyp
	Sample ID:	LM 14-01	LM 14-02	LM 14-03	LM 14-04	LM 14-05
pH	**S.U.**	7.42	7.27	7.08	7.42	7.47
Alkalinity	**mg/l $CaCO_3$**	38.0	30.0	64.5	37.0	38.0
Spec Cond	**umhos/cm**	185.8	198.2	280.5	186.1	190.6
SRP	**ug P/l**	lt 1.0	lt 1.0	1.4	lt 1.0	lt 1.0
TP	**ug P/l**	11.7	11.9	7.0	14.4	16.4
TN	**mg N /l**	0.26	0.26	0.30	0.31	0.33
Cl	**mg Cl/l**	20.9	28.8	23.3	21.5	20.8
NO3	**mg N/l**	lt 0.01	lt 0.01	lt 0.01	lt 0.01	lt 0.01
Sulfate	**mg S/l**	```	```	```	```	1.04
Chla	**ug/l**	```	```	```	7.8	```
Calcium	**mg Ca /l**	14.6	12.9	32.8	13.7	14.6
Fe	**mg Fe /l**	```	```	```	```	0.08

Submitted by: Laurie Ahrens
Date: 22-May-14

lt = less than

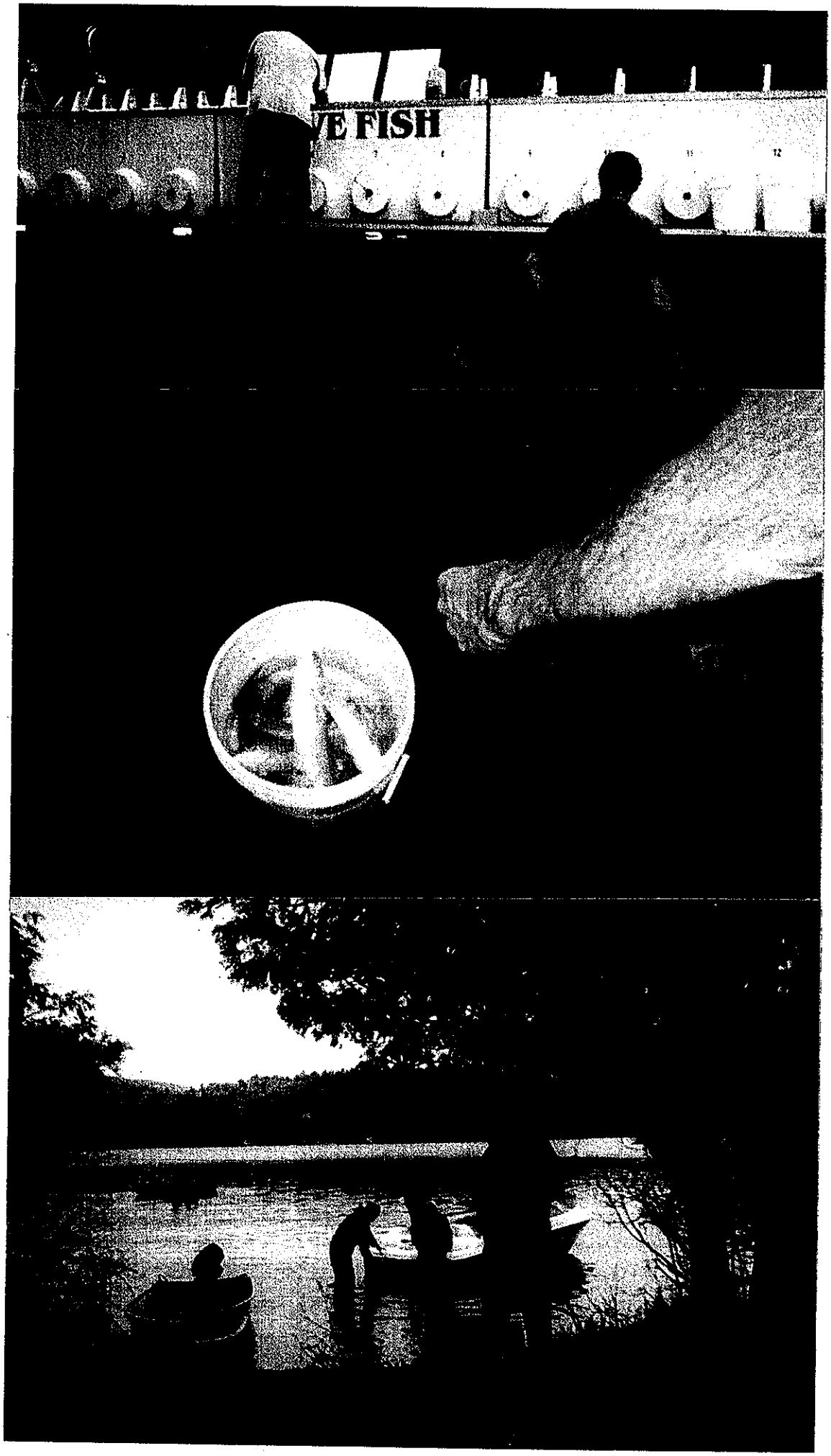
Methods:

Nitrate (NO3), Chloride (Cl), and Sulfate (SO4	Ion Chromatograph, EPA Method 300
Total Nitrogen (TN)	Persulfate Method, Standard Methods, 19th Ed., 4500-N D.
Total Phosphorus (TP)	Colorimetric- Persulfate Oxidation, Standard Methods, 19th Ed., 4500-P E.
Soluble Reactive Phosphorus (SRP)	Colorimetric, Standard Methods, 19th Ed., 4500-P E.
pH	Electrometric, Standard Methods, 19th Ed, 4500-H
Alkalinity	Titrimetric, pH 4.5. EPA Method 310.1
Calcium (Ca), and Iron (Fe)	Atomic Absorption Spectroscopy- Flame, Standard Methods 3111
Chlorophyll a (Chla)	Fluorometric, Standard Methods 10200

Revision 1.0

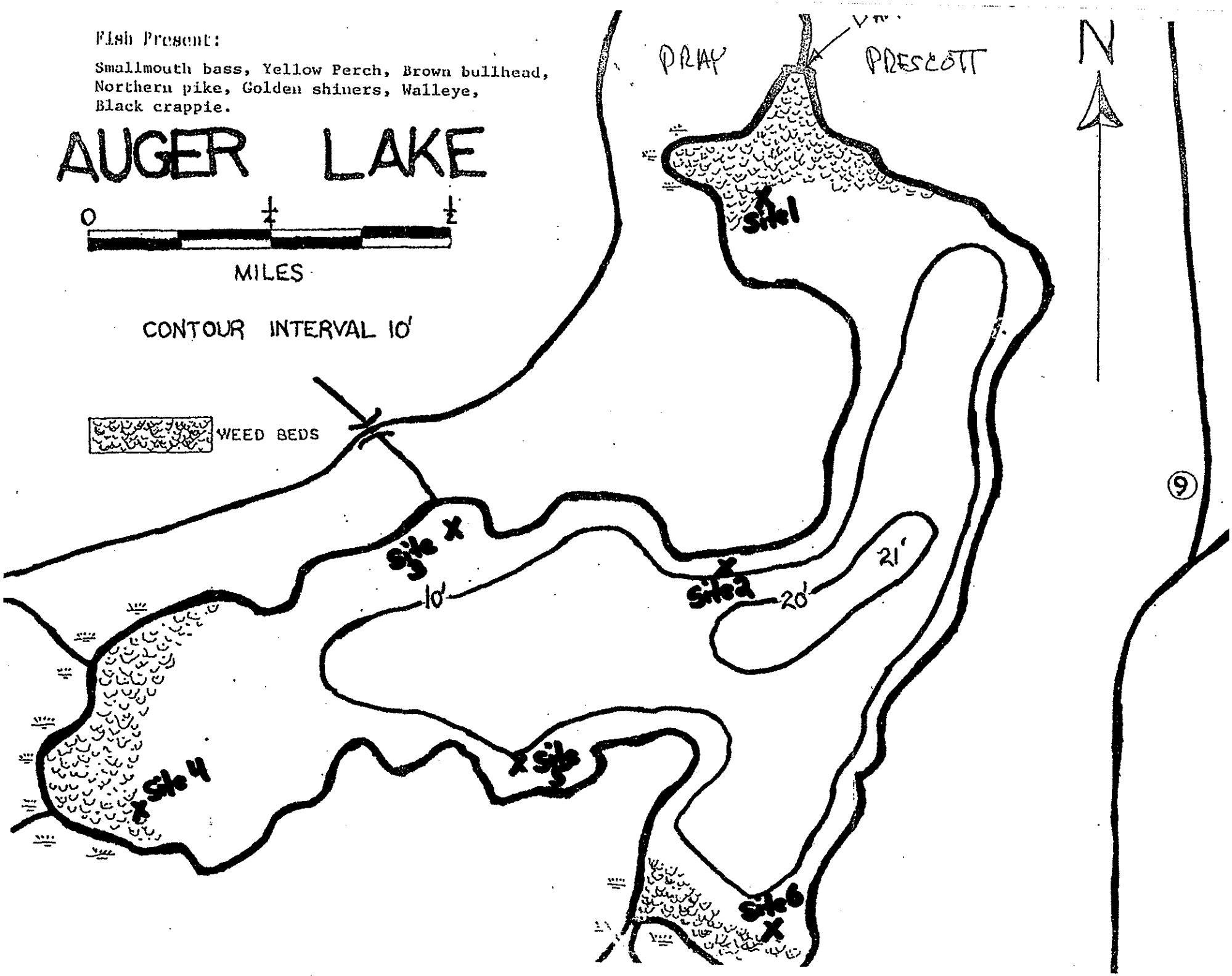
Lake Name	Date	Type	Tot.P	NO3	NH4	TDN	TN/TP	TColor	pH	Cond25	Ca	Chl.a	% BG	% Green	% Diatoms	% Crypto	% Yellow	Visual
Augur Lake	8/29/14	bottom											99%	0%	0%	1%	86%	Microcystis
Augur Lake	8/29/14	surface	0.030	0.01	0.10	0.45	33.52	13	7.09	217	12.3	6.80	0%	74%	22%	3%	2%	
Augur Lake	8/29/14	shoreline bloon	0.025															

NYSDEC - CSLAP 2014 Data (modified database)


E FISH

Fish Present:

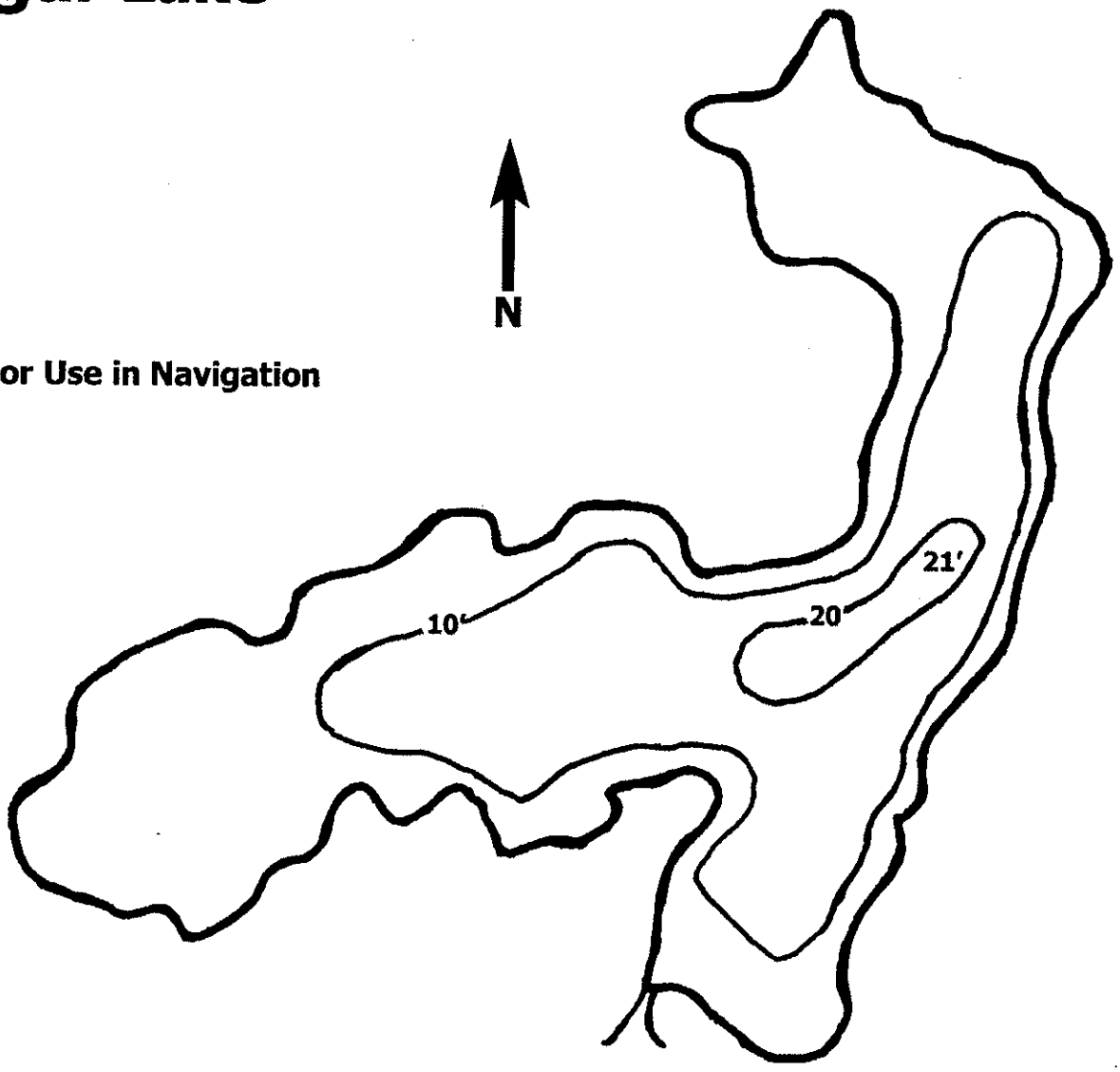
Smallmouth bass, Yellow Perch, Brown bullhead, Northern pike, Golden shiners, Walleye, Black crappie.



New York State Department of Environmental Conservation
Division of Fish, Wildlife and Marine Resources
Lake Map Series

Region 5

Augur Lake



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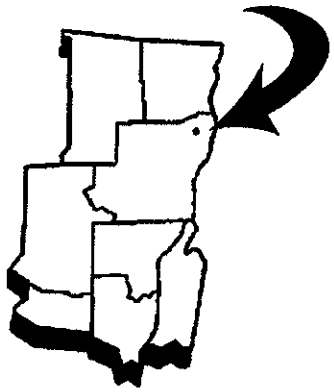

Augur Lake

County: Essex **Town: Chesterfield**

Size: 351 Acres

Fish Species Present: Smallmouth Bass, Northern Pike, Brown Bullhead, Yellow Perch, Golden Shiner, Walleye, Black Crappie

Scale: 0 1020 ft