# **Division of Science, Research and Environmental Health**

# **Research Project Summary**

August 2016

# Nutrient Reference Conditions in New Jersey Lakes Based on Analysis of Sediment Cores

## Authors

Sonja Hausmann, Ph.D. and Donald F. Charles, Ph.D.<sup>1</sup>

# Prepared By

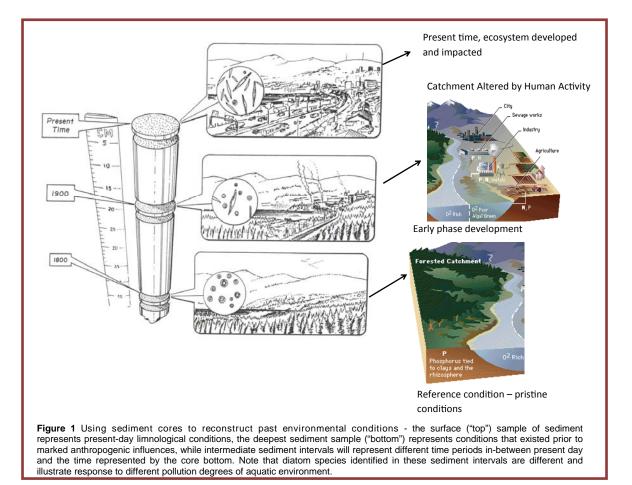
Mihaela Enache, Ph.D. (Project Manager)<sup>2</sup>

#### Abstract

This project was conducted to more accurately quantify reference water-quality conditions in New Jersey (NJ) lakes. An accurate quantification of reference conditions is required to support the development of numeric nutrient and other biological criteria needed in setting realistic targets for protection and restoration plans. This project provided data on historic lake nutrient conditions, including undisturbed natural conditions characteristic of the pre-European settlement period. The project had two main objectives: 1) quantify reference (pre-European settlement) trophic conditions and 2) assess the amount of change induced by anthropogenic activities on lake nutrient concentrations using diatom-based inference models. To reach these objectives, sediment cores have been collected and analyzed for diatom species present in the top core interval (present-day conditions) and bottom core interval (past lake conditions, could represent pre - or post-European). The field crew aimed to obtain 1-m long cores, which based on scientific literature should reach pre-European time in lakes from the northeastern USA. Two steps were used to determine if core bottom intervals represented the pre- European time period for each specific site: 1) pollen composition and relative abundance of Ambrosia pollen; and 2) radioisotope dating. Pb-210 radio isotope dates were used to determine if the core bottom intervals were older than ~100 years, which is the oldest age that Pb-210 can provide. Results suggest the core bottom sediments in most of the lakes were deposited at least 100 year ago; these core bottoms, may or may not reach pre-European time period. The Ambrosia pollen is a well-known chronomarker for the European settlement. Since settlement was marked by extensive forest clearing and replacement of clear-cut areas by Ambrosia plants, pollen counts of Ambrosia were used to determine if the bottom core was deposited before or after the European arrival. Bottom sediment samples from a few cores had Ambrosia pollen as high as 36 percent suggesting that they did not represent a time period prior to European settlement, while other bottom intervals had pollen assemblages atypical from today, without invasive species and with very low concentrations of Ambrosia pollen suggesting they represent the pre-European settlement time period . A total of 122 diatom samples were analyzed in top and bottom core intervals. Overall, top core sediment samples (representing current conditions) are rich in Fragilaria crotonensis, Asterionella formosa and Fragilaria capucina. These species are indicators of eutrophic conditions. Core bottom sediment samples are dominated by Cyclotella michiginana, a species indicative of low total phosphorus concentrations. The average diatom-inferred total-phosphorus concentration from all surface samples is 48  $\mu$ g/L. The historic average diatom-inferred total-phosphorus concentration determined from all core bottom samples is 24  $\mu$ g/L, just less than half of the current water quality standard for NJ. Total phosphorus estimates in bottom sediment samples were typically higher in impoundments than from natural lakes.

### Introduction

A paleolimnological investigation funded by the New Jersey Department of Environmental Protection's (NJDEP) Division of Science, Research and Environmental Health (DSREH) in 2008 produced a 33lake calibration set and historical total phosphorus (TP) reconstructions from sediment cores of 26 additional New Jersey lakes. The purpose of this new project was to supplement the calibration set with additional sites necessary to strengthen the predictive power of diatombased quantitative models (transfer functions) for nutrients (phosphorus and nitrogen). These models allow the



reconstruction of past nutrient concentrations from sediment cores used to define reference conditions in NJ lakes, prior to the European settlement.

This project used paleolimnological techniques based on the information preserved in lake sediment cores to estimate past conditions. Lakes gradually accumulate sediments layer by layer incorporating skeletal remains of micro- and macroorganisms, metals, and organic contaminants, among many other proxies. A sediment core collected from a lake can be sectioned stratum by stratum. Each stratum can be analyzed for preserved proxies providing ecological information that can be read like the pages of a history book when you have the right tool to interpret it. Each sediment interval mirrors the ecosystem characteristic of the time of deposition, going back in time from the surface interval (that represents the most recent, present-day conditions) to the core bottom that can go back for decades, centuries, or millennia, depending on the core length and sediment accumulation rates. Figure 1 illustrates how different sections of a core containing fossil remains (in this case diatoms, one of the most often used ecological and paleoecological indicators) can be used to reconstruct past environmental characteristics specific to the deposition times - e.g., 1800s, early industrial (1900s) and present impacted condition. Since diatom species that live in unimpaired environments are different from the ones that live in stressed (polluted) environments, the proportions of these species can be used as a surrogate of environmental

condition. The core can be sliced continuously to provide a continuum of data that reflects conditions before and after impacts of anthropogenic and natural factors, and quantify the direction and magnitude of change when instrumental records are absent.

# **Methods**

The main objective of this project was to quantify reference (pre-European settlement) trophic conditions in lakes from New Jersey and assess the amount of change induced by anthropogenic activities using diatom-based inference models. To reach this goal, the relationships between diatoms present in surface sediments ('modern samples') and measured water-chemistry parameters (calibration datasets) were first explored. Based on these relationships, quantitative models were developed to infer lake nutrients going back in time, since before the European settlement, representing reference or baseline conditions. Because the diatom-inferred nutrient values are directly comparable to current water chemistry samples, this information is valuable for developing lake management strategies.

Two diatom-based quantitative models were previously published by Enache et al. (2012) to reconstruct total phosphorus (TP) concentrations in the water column. One consisted of 278 lakes from the northeast US with a TP range of 0.9 to 323  $\mu$ g/L. The other consisted of 33 lakes located in New Jersey. Inference models based on these

regional datasets were used by Enache et al. (2012) to infer TP concentrations from fossil diatoms archived in sediments collected at the bottom of sediment cores from another 26 NJ lakes. The current project supplemented the existing NJ calibration set with additional cores originating from NJ lakes for a total of 69 lakes. The top sediment core samples were used to refine the inference models based on NJ specific sites, and the bottom core samples were used to infer past, historic lake water nutrient concentrations.

Efforts were made to collect sediment cores of about 1 meter in length in order to maximize the possibility of reaching the depositional layers from pre-European settlement. Information from the core bottom samples could therefore provide information on natural lake conditions. However, it was not always possible to obtain a core with this long of a depositional record. The lake dataset was comprised of natural lakes as well as manmade impoundments.

Two steps were used to determine if core bottom intervals represented the pre- European time period for each specific site: 1) radioisotope dating; and 2) pollen composition and relative abundance of Ambrosia pollen. Core bottom samples were measured for radioisotopes Pb -210 and Cs-137, and pollen analysis was performed to provide information on core age. The presence of Cs-137 indicates sedimentation after 1963, which was the end of atmospheric nuclear bomb testing. The Cs-137 activities must be interpreted with caution, as Cs is mobile in the sediment core. Pb-210 has a half-life of 22.3 years and cannot be measured after five half-lives. Thus, Pb-210 radio isotope can be used to determine if the core bottom intervals were older than ~100 years, which is the oldest age that Pb-210 can provide. Due to these limitations of radioisotopic analysis, an additional dating method is needed (Blais et al 1995) to determine if sediments were deposited prior to the European settlement and represent undisturbed environmental conditions. Pollen assemblages atypical from today likely indicate a deposition of sediments prior to the arrival of European-settlers who affected the vegetation by introducing invasive plants. Also, settlement was marked by extensive forest clearing and replacement of clear-cut areas by Ambrosia plants. Thus, a high percentage increase in Ambrosia pollen found in sediment cores constitutes a widely used chronomarker of European settlement in those lake watersheds.

# Results

# Radioisotope analyses

Radioisotope analyses for Pb-210 and Cs-137 were performed by Gary Krinke (Environmental Sciences for Wisconsin State Laboratory of Hygiene) and interpreted by Dr. Paul Garrison (Wisconsin Department of Natural Resources). According to the interpretation by Dr. Garrison, all bottom samples were deposited at least 100 years ago, as activities of Cs-137 and Pb-210 are below 1 pCi/gram. However, bottom samples of some lakes (e.g., Echo, Lefferts, Watchung, and Crystal Lakes) might be younger than 100 years as Cs-137 is mobile in lake sediments.

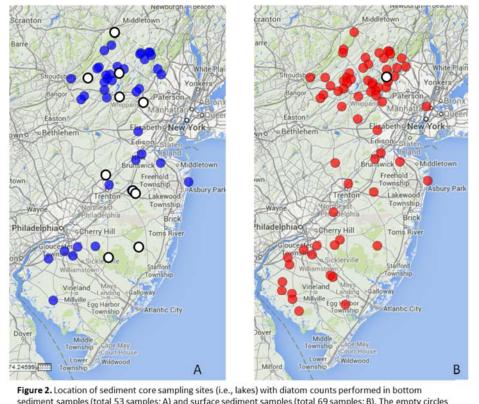


Figure 2. Location of sediment core sampling sites (i.e., lakes) with diatom counts performed in bottom sediment samples (total 53 samples; A) and surface sediment samples (total 69 samples; B). The empty circles indicate sites where diatoms were diluted by silt or charcoal and yielded low number of diatom valves or were impossible to count.

### Pollen Analysis

A high percentage of Ambrosia pollen is used to indicate disturbance from the European settlement. Dr. Ababneh (Cornell University) performed pollen analysis on 26 sediment samples. Ambrosia pollen percentages decreased significantly from the bottom to top sediments in the following lakes: Farrington (16 to 3%), Jeddys Pond (36 to 6%), Lefferts Lake (24 to 4%) suggesting these cores do not date back prior to colonization. Ambrosia pollen was found in the top sample in Echo Lake but not in the bottom sediments. In Stony Lake, the percentages are insignificant (less than 0.4% in top and bottom sediments). In Chesler Lake and Saginaw Lake there was not enough material to establish a reliable count of 300 pollen grains or more, and thus results cannot be provided based on the samples examined. Samples from another six sites had poor pollen preservation and counts were not possible.

#### **Diatom Analysis**

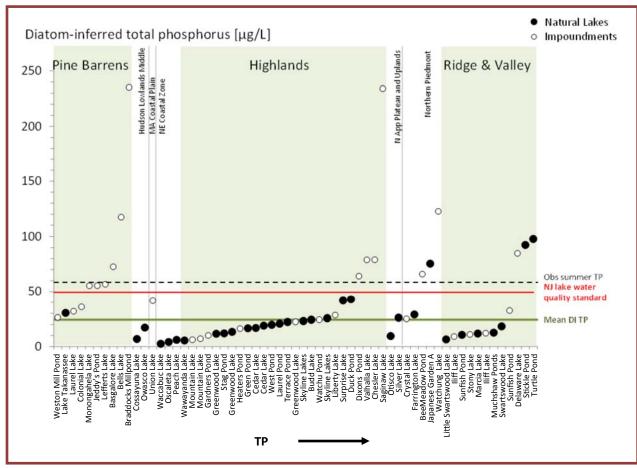
This report summarizes diatom analyses obtained through this project in addition to results from previous studies performed by the Academy of Natural Sciences. A total of 122 diatom samples (53 from sediment core bottoms and 69 from surface sediments) have been analyzed since 2008 (Fig. 2; Table 1 and 2). Thirty-seven bottom samples and 20 surface samples have been analyzed for diatoms in the funding period provided by this study (2011 to 2014). Some core bottom samples were difficult to count because of high silt content (e.g., Chesler Lake, Highlands ecoregion) or presence of charcoal (e.g., Decou Pond, Stone Tavern and Assunpink Lakes in the Atlantic Coastal Pine Barrens Ecoregion) (Fig. 2). Charcoal presence in these bottom samples may indicate natural fires, or controlled burn by the Lenape tribes to improve plant yields and hunting conditions (Stansfield 1998), or the production of bog iron, which was common in southern NJ during the revolutionary war period.

Site Name   Sample Depth   Collection Date   Latitude   Longitude   Ecosycian     Assunpic Lake-14   56.0   57.0   09/16/2012   39.742   74.735   Atlanic Coastal Pine Barrens     Basgalore Lake   47.0   40.80   672.2008   39.73   75.283   Atlanic Coastal Pine Barrens     Ber Meadow Pond   35.5   37.5   06/24.2008   40.834   74.410   Northem Piedmont     Ber Macdoxics Milpond-19   41.0   42.4   66.2   Atlanic Coastal Pine Barrens     Budd Lake   47.5   45.6   08/12/2013   40.812   74.452   Northem Appalachina and Atlanic Maritime Highlands     Coloral Lake-06   59.5   60.5   10/25/2011   40.052   74.442   Northem Appalachina and Atlanic Maritime Highlands     Coloral Lake-03   50.0   60/06/2013   39.815   74.442   Northem Piedmont     Decore Pond   47.5   75.5   11/2/2014   40.063   74.447   Northem Piedmont     Gardners Pond-2   41.0   42.5   67/02/2008   74.447   Northem Piedmont	Table 1: List of locations	s with diatom cou	unts from bottom	samples of	sediment co	res.
Atsion Lake-14   56.0   67.0   00/16/2012   39.742   -74.735   Attanic Coastal Pine Barrens     Bes Meadow Pond   35.5   37.5   06/24/2008   40.834   -74.410   Northern Piedmont     Bes Lake-18   40.0   -10.0   11/16/2011   39.73   -75.508   Attanic Coastal Pine Barrens     Bidd Lake   47.5   45.8   08/17/2013   39.822   -74.850   Attanic Coastal Pine Barrens     Codeat Lake-06   59.5   0.5   10/25/2011   40.912   -74.472   Northern Appalachian and Attanic Maritime Highlands     Colonial Lake   35.5   0.65   0.911/2012   40.256   -74.724   Attanic Coastal Pine Barrens     Dixons Pond   51.0   0.911/2012   40.256   -74.724   Attanic Coastal Pine Barrens     Dixons Pond   51.0   0.911/2013   40.05   -74.742   Northern Appalachian and Attanic Maritime Highlands     Gardners Pond   74.5   11/02/2011   40.03   -74.474   Northern Appalachian and Attanic Maritime Highlands     Gardners Pond   74.575   11/02/2011   40.3	Site Name	Sample Depth	Collection Date	Latitude	Longitude	Ecoregion
Basgalore Lake   47.0   40.0   06/23/2008   39.733   -75.283   Atlantic Costal Pine Barrens     Belk Lake-18   40.0   41.0   11/16/2011   39.753   -75.061   Atlantic Costal Pine Barrens     Bidd Lake   40.0   41.0   11/16/2011   39.753   -75.061   Atlantic Costal Pine Barrens     Budd Lake   47.5   45.0   08/19/2013   40.871   -74.475   Northern Appalachian and Atlantic Martime Highlands     Colonial Lake   42.0   43.0   10/20/2011   40.871   -74.422   Northern Appalachian and Atlantic Martime Highlands     Colonial Lake   55.0   00/17/2013   41.034   -74.422   Northern Appalachian and Atlantic Martime Highlands     Decou Pord   57.0   58.0   00/02/2014   41.067   -74.739   Northern Appalachian and Atlantic Martime Highlands     Greenwood Lake-03   59.0   60.0   11/03/2011   41.167   -74.335   Northern Appalachian and Atlantic Martime Highlands     Greenwood Lake-03   59.0   60.0   11/03/2011   41.167   -74.335   Northern Appalachian and Atlantic Martime Hig	Assunpink Lake	22.5 - 23.5	09/18/2013	40.216	-74.517	Atlantic Coastal Pine Barrens
Bea   Meadow Pond   36.5 - 37.5   06/24/2008   40.834   -74.410   Northern Predmont     Balts Lake-18   40.0 - 41.0   11/16/2011   33.822   -74.850   Atlantic Coastal Pine Barrens     Badd Lake   47.5 + 84.5   08/13/2013   38.822   -74.850   Northern Appalachian and Atlantic Maritime Highlands     Codat Lake-06   59.5 + 60.5   10/25/2011   40.917   -74.472   Northern Appalachian and Atlantic Maritime Highlands     Colonial Lake   35.5 - 36.5   09/11/2012   40.256   -74.724   Northern Appalachian and Atlantic Maritime Highlands     Colonial Lake   35.5 - 36.5   09/11/2012   40.256   -74.474   Northern Piedmont     Dixons Pond   41.5 - 42.5   00/01/2013   39.815   -74.446   Nathern Piedmont     Gardner Spend   74.5 - 75.5   11/02/2011   40.430   -74.477   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   42.5 - 43.5   07/02/2008   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Hill Lake-01   56.5 - 57.5   07/02/2008   34.037	Atsion Lake-14	56.0 - 57.0	09/16/2012			
Bells Lake-18   40.0 - 41.0   11/16/2011   39.753   -75.061   Atlantic Coastal Pine Barrens     Budd Lake   47.5 - 48.5   08/13/2013   40.871   -74.475   Northern Appalachian and Atlantic Maritime Highlands     Codar Lake   47.5 - 68.5   09/13/2013   40.871   -74.475   Northern Appalachian and Atlantic Maritime Highlands     Colonial Lake   35.5 - 58.5   09/11/2012   40.256   -74.472   Northern Appalachian and Atlantic Maritime Highlands     Colonial Lake   35.5 - 36.5   09/11/2013   40.381   -74.454   Northern Appalachian and Atlantic Maritime Highlands     Decou Pord   57.0 - 58.0   05/00/2013   39.815   -74.444   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   41.5 - 42.5   07/10/2008   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   42.5 - 43.5   07/02/2008   41.052   -74.7138   Northern Appalachian and Atlantic Maritime Highlands     Hilf Lake-01   60.0 - 67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Hilf Lake-01   60.0 - 67.0	Basgalore Lake	47.0 - 48.0	06/23/2008	39.733	-75.283	Atlantic Coastal Pine Barrens
Braddocks Milpond-19   41.0   42.0   08/13/2013   38.822   -74.850   Atlantic Coastal Pine Barrens     Budd Lake   47.5   48.5   08/11   47.472   Northem Appalachian and Atlantic Maritime Highlands     Chealer Lake-06   55.5   10/25/2011   40.871   -74.472   Northem Appalachian and Atlantic Maritime Highlands     Colonial Lake   35.5   36.5   09/11/2012   40.256   -74.724   Northem Appalachian and Atlantic Maritime Highlands     Crystal Lake-03   50.5   10/02/2011   40.395   -74.442   Northem Piedmont     Dixons Pond   41.5<-42.5	Bee Meadow Pond	36.5 - 37.5	06/24/2008	40.834	-74.410	Northern Piedmont
Budd Lake   47.5 - 48.5   08/19/2013   40.871   -74.745   Northern Appalachian and Atlantic Maritime Highlands     Credar Lake   42.0 - 43.0   10/22/2011   40.817   -74.422   Northern Appalachian and Atlantic Maritime Highlands     Colonial Lake-03   50.0 - 51.0   09/17/2013   41.034   -74.242   Northern Appalachian and Atlantic Maritime Highlands     Decou Pond   57.0 - 58.0   05/06/2013   38.15   -74.445   Northern Pedmont     Decou Pond   57.0 - 58.0   05/06/2013   38.15   -74.446   Northern Appalachian and Atlantic Maritime Highlands     Gardners Pond   41.5 - 42.5   07/10/2008   49.336   -74.447   Northern Appalachian and Atlantic Maritime Highlands     Gardners Pond   42.5 - 43.5   07/02/2008   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   0.5 -0.0   0.103/2011   41.032   -74.1715   Ridge and Valley     Hilf Lake-01   66.0 - 67.0   0.71/15/2013   41.032   -74.715   Ridge and Valley     Hilf Lake-01   50.5 -57.5   11.0   0.02/2013 <t< td=""><td>Bells Lake-18</td><td>40.0 - 41.0</td><td>11/16/2011</td><td>39.753</td><td>-75.061</td><td>Atlantic Coastal Pine Barrens</td></t<>	Bells Lake-18	40.0 - 41.0	11/16/2011	39.753	-75.061	Atlantic Coastal Pine Barrens
Codar Lake-06   59.5   60.5   10/25/2011   40.817   -74.472   Northern Appalachien and Atlantic Maritime Highlands     Colonial Lake   35.5   36.5   09/11/2012   40.256   -74.724   Atlantic Coastal Pine Barrens     Cystal Lake-03   50.0   57.0   58.0   05/06/2013   39.815   -74.424   Northern Appalachien and Atlantic Maritime Highlands     Datons Pond   41.5   42.5   07/10/2008   40.936   -74.444   Northern Appalachien and Atlantic Maritime Highlands     Greenwood Lake-03   42.5   53.5   07/10/2008   40.936   -74.447   Northern Appalachien and Atlantic Maritime Highlands     Greenwood Lake-03   54.5   55.5   11/21/2011   41.005   -74.738   Northern Appalachien and Atlantic Maritime Highlands     Iliff Lake-01   60.0   11/03/2011   41.167   -74.335   Northern Appalachien and Atlantic Maritime Highlands     Iliff Lake-01   60.0   67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Iliff Lake-01   60.0   67.0   06/15/2011   40.107   -74.358	Braddocks Millpond-19	41.0 - 42.0	08/13/2013	39.822	-74.850	Atlantic Coastal Pine Barrens
Chester Lake   42.0 + 43.0   10/202011   40.871   -74.829   Northern Appalachian and Atlantic Maritime Highlands     Convial Lake-03   50.0 + 51.0   09/11/2013   41.034   -74.242   Northern Piedmont     Decou Pond   57.0 + 58.0   05/06/2013   39.815   -74.442   Northern Piedmont     Gardners Pond   41.5 + 42.5   07/10/2006   40.936   -74.444   Northern Appalachian and Atlantic Maritime Highlands     Gardners Pond   44.5 + 43.5   07/10/2006   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   39.0 + 00.0   11/03/2011   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Hiff Lake-01   50.0 + 57.0   07/15/2013   41.032   -74.715   Ridge and Valley     Jaddy Pond   56.5 + 57.5   11/28/2011   34.33   -75.239   Atlantic Coastal Pine Barrens     Lawel Lake   46.0 + 47.0   06/24/2009   39.818   -76.014   Atlantic Coastal Pine Barrens     Lawel Lake   46.0 + 47.0   06/24/2009   39.818   -74.245   Northern Appal						
Colonial Lake   35.5   09/11/2012   40.256   -74.724   Attaintic Cossial Pine Barrens     Crystal Lake-03   50.0   51.0   09/17/2013   39.815   -74.424   Nonthern Piedmont     Decou Pond   57.0   58.0   05/06/2013   39.815   -74.444   Nonthern Appalachian and Atlantic Maritime Highlands     Gardners Pond   74.5   75.5   11/21/2011   41.005   -74.477   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   59.0   60.0   11/03/2011   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   59.0   60.0   11/03/2011   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Haters Pond-02   48.5   49.5   08/04/2009   41.032   -74.715   Ridge and Valley     Liff Lake-01   50.0   51.0   08/04/2009   40.27   -73.989   Atlantic Coastal Pine Barrens     Lake Takanasse   50.0   51.0   07/07/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Lakerel	Cedar Lake-06	59.5 - 60.5	10/25/2011	40.912		
Crystal Lake-03   50.0 - 51.0   09/17/2013   41.034   -74.242   Northern Pedmont     Decou Pond   57.0 - 58.0   06/06/2013   39.815   -74.464   Atlantic Coastal Pine Barrens     Dxons Pond   41.5 - 42.5   07/10/2008   40.936   -74.447   Northern Appalachian and Atlantic Maritime Highlands     Gardners Pond   74.5 - 75.5   07/02/2008   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   42.5 - 43.5   07/02/2008   41.027   -74.585   Northern Appalachian and Atlantic Maritime Highlands     Hitt Lake-01   60.0 - 67.0   07/16/2013   41.032   -74.715   Ridge and Valley     Jaddy S Pond   66.0 - 67.0   07/16/2013   41.032   -74.715   Ridge and Valley     Jaddy S Pond   66.0 - 67.0   07/07/2009   40.277   -73.989   Atlantic Coastal Pine Barrens     Lawel Lake   46.0 - 47.0   06/2/2009   98.18   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Lawel Lake   10/2/2013   41.014   -74.245   Atlantic Coastal Pine Barrens						
Decou Pond   57.0 - 58.0   05/06/2013   398.15   -74.46   Attanic Coastal Pine Barrens     Dixons Pond   41.5 - 42.5   07/10/2008   40.936   -74.444   Northern Appalachian and Atlantic Maritime Highlands     Gardners Pond   74.5 - 75.5   11/21/2011   41.005   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   59.0 - 60.0   11/03/2011   41.167   -74.335   Northern Appalachian and Atlantic Maritime Highlands     Heaters Pond-02   48.5 - 49.5   08/04/2009   41.032   -74.715   Ridge and Valley     Jilff Lake-01   60.0 - 67.0   08/04/2009   41.032   -74.715   Ridge and Valley     Jaddy's Pond   66.5 - 57.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lawer Lake   46.0 - 47.0   08/24/2009   39.818   -74.454   Matentic Coastal Pine Barrens     Lawer Lake   45.0 - 57.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lawer Lake   46.0 - 47.0   06/24/2009   39.818   -74.454   Matlantic Maritime Highland						
Dixons Pond   41.5 + 42.5   07/10/2008   40.936   -74.444   Northern Appalachian and Atlantic Martime Highlands     Farrington Lake-09   41.0 + 42.0   11/02/2011   40.430   -74.477   Northern Appalachian and Atlantic Martime Highlands     Greenwood Lake-03   42.5 + 43.5   07/02/2008   41.167   -74.335   Northern Appalachian and Atlantic Martime Highlands     Greenwood Lake-03   42.5 + 43.5   07/02/2008   41.167   -74.335   Northern Appalachian and Atlantic Martime Highlands     Hiff Lake-01   65.0 - 67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Jeddy's Pond   56.5 - 67.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lawer Level   40.0 - 47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Pond   55.5   10/07/2019   40.217   -73.889   Atlantic Coastal Pine Barrens     Laurel Pond   55.4   10/07/2009   41.81   -74.945   Atlantic Coastal Pine Barrens     Laurel Pond   55.4   10/07/2009   39.789   -75.136   Atlan						
Farrington Lake-09   41.0 + 42.0   11/02/2011   40.430   -74.739   Northem Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   52.0 + 43.5   07/02/2008   41.167   -74.335   Northem Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   52.0 + 60.0   11/03/2011   41.167   -74.335   Northem Appalachian and Atlantic Maritime Highlands     Heaters Pond-02   48.5 + 49.5   69.00   90.04/2009   41.072   -74.595   Northem Appalachian and Atlantic Maritime Highlands     Iliff Lake-01   65.0 - 67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Jaddy's Pond   56.5 - 67.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lawrel Lake   48.0 + 47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Lawrel Lake   32.5 + 33.5   10/17/2011   40.483   -74.454   Northem Appalachian and Atlantic Maritime Highlands     Little Swartswood Lake   0.2 + 5.4 + 5.4 + 5.5   05/15/2014   41.181   -74.456   Northem Appalachian and Atlantic Maritime Highlands     Littewartswood Lake						
Gardners Pond   74.5   11/21/2011   41.005   -74.335   Northem Appalachian and Atlantic Maritime Highlands     Greenwood Lake-03   42.5   -43.5   07/02/2008   41.167   -74.335   Northem Appalachian and Atlantic Maritime Highlands     Imil Lake-01   50.0   60.0   11/03/2011   41.167   -74.335   Northem Appalachian and Atlantic Maritime Highlands     Judge School   45.5   49.5   08/04/2009   41.032   -74.715   Ridge and Valley     Judge School   66.0   67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Judge School   50.0   51.0   07/07/2009   40.277   -73.989   Atlantic Coastal Pine Barrens     Laurel Pond   59.5   60.5   10/30/2013   41.181   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Learel Pond   59.5   60.5   10/30/2013   41.181   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Learel Pond   59.5   60.5   10/30/2013   41.381   -74.425   Northern Appalachian and Atlantic Maritime Highlands						
Greenwood Lake-03   42.5   43.5   Orthern Appalachian and Atlantic Martime Highlands     Greenwood Lake-03   59.0   60.0   11/03/2011   41.167   -74.335   Northern Appalachian and Atlantic Martime Highlands     Heaters Pond-02   48.5   49.5   08/04/2009   41.022   -74.715   Ridge and Valley     Illiff Lake-01   60.0   67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Jaddy's Pond   56.5   57.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lake Takanassee   50.0   51.0   07/07/2009   40.277   -73.989   Atlantic Coastal Pine Barrens     Laurel Lake   46.0   47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Lake   32.5   10/07/2011   40.418   -74.455   Northern Appalachian and Atlantic Martime Highlands     Little Swartswood Lake   67.0   60.0   60/5/5/20/2014   41.318   -74.456   Ridge and Valley     Monraia Lake-01   75.0   05/20/2014   41.318   -74.95						
Greenwood Lake-03   59.0   60.0   11/03/2011   41.167   -74.335   Northem Appalachian and Atlantic Maritime Highlands     Heaters Pond-02   48.5 - 49.5   08/04/2009   41.032   -74.715   Ridge and Valley     Iliff Lake-01   66.0   67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Jaddy S Pond   66.5   57.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lake Takanassee   50.0   51.0   07/07/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Lake   60.0   67.0   06/24/2009   38.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Lake   67.0   0.68.0   06/15/2014   41.085   -74.815   Ridge and Valley     Marcia Lake-01   73.5   74.5   07/01/2008   39.789   -74.815   Ridge and Valley     Moongahela Lake-01   73.5   74.5   05/02/2014   41.318   -74.815   Ridge and Valley     Moontain Lake-01   75.0   76.0   09/04/2013   40						
Heaters Pond-02   48.5   98/04/2009   41.072   -74.585   Northern Appalachian and Atlantic Maritime Highlands     Iliff Lake-01   50.0   51.0   08/02/2008   41.032   -74.715   Ridge and Valley     Jaddy's Pond   56.5   57.5   11/12/8/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lake Takanassee   50.0   51.0   07/07/5/2013   41.1032   -74.745     Lake Takanassee   60.0   47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Lake   46.0   47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Liberty Lake   32.5   11/01/2011   40.410   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Little Swartwood Lake   67.0   68.0   05/15/2014   41.085   -74.945   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   75.0   07/07/2010   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   75.0   09/04/2013						
Iliff Lake-01   50.0   51.0   08/26/2008   41.032   -74.715   Ridge and Valley     Iliff Lake-01   66.0   67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Jaddy S Pond   56.5   57.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lawel Lake   46.0   47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Lake   46.0   -70.06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Lake   15.5   52.5   10/17/2014   40.410   -74.245   Northem Appalachian and Atlantic Maritime Highlands     Liberty Lake   23.5   33.5   10/17/2014   41.085   -74.815   Ridge and Valley     Marcia Lake-01   75.0   76.0   05/02/2014   41.181   -74.667   Ridge and Valley     Mountain Lake-01   42.5   43.5   07/01/2008   39.789   -75.136   Atlantic Coastal Pine Barrens     Mountain Lake-01   75.0   66/03/2013   40.30   -74.747						
Iliff Lake-01   66.0   67.0   07/15/2013   41.032   -74.715   Ridge and Valley     Jaddy's Pond   56.5   57.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lake Takanassee   60.0   47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Lake   46.0   47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Pond   59.5   60.5   11/01/2011   40.410   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Liberty Lake   32.5   33.5   10/17/2014   40.883   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Marcia Lake-01   73.5   74.5   05/20/2014   41.318   -74.667   Ridge and Valley     Mountain Lake-01   75.0   76.0   09/04/2013   40.859   -74.944   Northern Appalachian and Atlantic Maritime Highlands     Saddie Bag   63.5   65.5   05/03/2013   40.302   -74.763   Northern Appalachian and Atlantic Maritime Highlands <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td></t<>						
Jeddy's Pond   56.5 - 57.5   11/28/2011   39.433   -75.239   Atlantic Coastal Pine Barrens     Lake Takanassee   50.0 - 51.0   07/07/2009   40.277   -73.989   Atlantic Coastal Pine Barrens     Laurel Lake   46.0 - 47.0   06/24/2009   39.81   -75.014   Atlantic Coastal Pine Barrens     Laurel Pond   59.5 - 60.5   10/30/2013   41.181   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Lefferts Lake-12   51.5 - 52.5   11/01/12011   40.883   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Marcia Lake-01   73.5 74.5   05/20/2014   41.181   -74.467   Ridge and Valley     Monongahela Lake   42.5 - 43.5   07/01/2008   39.789   -75.136   Atlantic Coastal Pine Barrens     Mountain Lake-01   48.0 - 49.0   07/28/2008   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Saddle Bog   65.5   66/26/2013   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lake-03   43.5 - 44.5   08/27/2008   41.072   -74.272<						<b>o</b> ,
Lake   50.0   51.0   07/07/2009   40.277   -73.989   Atlantic Coastal Pine Barrens     Laurel Lake   46.0   47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Pond   59.5   60.5   10/30/2013   41.181   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Liberty Lake   32.5   33.5   10/17/2011   40.883   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Little Swartswood Lake   67.0   68.0   05/15/2014   41.085   -74.815   Ridge and Valley     Monogahela Lake-01   73.5   74.5   05/20/2014   41.085   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   75.0   76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Saddle Bog   65.5   66.5   06/26/2013   41.236   -74.703   Ridge and Valley     Saginaw Lake-02   24.5   25.5   11/22/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands						
Laurel Lake   46.0 - 47.0   06/24/2009   39.818   -75.014   Atlantic Coastal Pine Barrens     Laurel Pond   59.5 e0.5   10/30/2013   41.81   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Lefferts Lake-12   51.5 e5.2   11/01/2011   40.883   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Little Swartswood Lake   67.0 - 68.0   05/15/2014   41.085   -74.815   Ridge and Valley     Marcia Lake-01   73.5 - 74.5   05/20/2014   41.318   -74.966   Ridge and Valley     Monongahela Lake   42.5 - 43.5   07/01/2008   39.789   -75.136   Atlantic Coastal Pine Barrens     Mountain Lake-01   48.0 - 49.0   07/28/2008   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Rosedale lake   72.5 - 73.5   05/03/2013   40.330   -74.756   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.022   -74.222   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.						
Laurel Pond   59.5 e 60.5   10/30/2013   41.181   -74.425   Northern Appalachian and Atlantic Maritime Highlands     Lefferts Lake-12   51.5 e 52.5   11/01/2011   40.410   -74.425   Atlantic Coastal Pine Barrens     Liberty Lake   32.5 e 33.5   10/17/2011   40.480   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Libterty Lake   32.5 e -74.5   05/20/2014   41.085   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Monongahela Lake   67.0 e 68.0   05/15/2014   41.085   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   78.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Rosedale lake   72.5 - 73.5   05/03/2013   40.330   -74.756   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/04/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td></td<>						
Lefferts Lake-12   51.5 - 52.5   11/01/2011   40.410   -74.245   Atlantic Coastal Pine Barrens     Liberty Lake   32.5 - 33.5   10/17/2011   40.883   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Little Swartswood Lake   67.0 - 680   05/15/2014   41.085   -74.815   Ridge and Valley     Mancia Lake-01   73.5 - 74.5   05/20/2014   41.318   -74.667   Ridge and Valley     Mountain Lake-01   48.0 + 09   07/28/2008   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   75.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Saddle Bog   65.5   065/02/013   40.330   -74.756   Northern Piedmont     Sadgle Bog   65.5   061/2/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   43.5 - 44.5   08/27/2008   41.072   -74.7470   Ridge and Valley     Stagl Pond   48.0 - 49.0   08/19/2009   40.993   -74.7435   Ridge and Valley						
Liberty Lake   32.5 - 33.5   10/17/2011   40.883   -74.954   Northern Appalachian and Atlantic Maritime Highlands     Little Swartswood Lake   67.0 - 68.0   05/15/2014   41.085   -74.815   Ridge and Valley     Marcia Lake-01   73.5 - 74.5   05/20/2014   41.085   -74.816   Ridge and Valley     Monongahela Lake   42.5 - 43.5   07/01/2008   39.789   -75.136   Atlantic Coastal Pine Barrens     Mountain Lake-01   75.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Rosedale lake   72.5 - 73.5   05/03/2013   40.320   -74.703   Ridge and Valley     Saginaw Lake-02   24.5 - 25.5   11/22/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.874   Northern Appalachian and Atlantic Maritime Highlands     Storke Pond   93.0 - 9/18/2013   40.197   -74.4272						
Little Swartswood Lake   67.0 - 68.0   05/15/2014   41.085   -74.815   Ridge and Valley     Marcia Lake-01   73.5 - 74.5   05/20/2014   41.318   -74.667   Ridge and Valley     Monongahela Lake   42.5 - 43.5   07/01/2008   39.789   -75.136   Atlantic Coastal Pine Barrens     Mountain Lake-01   75.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Saddle Bog   65.5 - 66.5   06/20/2013   41.236   -74.756   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-02   24.5 - 25.5   11/22/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   33.5 - 44.5   08/27/2008   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.675   Ridge and Valley     Stag Pond   30.0 94.0   05/21/2014   41.028   -74.753   Ridge and Valley     Storp Lake-01   31.0 - 32.0   11/30/2011   41.200   -74.770   Ridge and						
Marcia Lake-01   73.5 - 74.5   05/20/2014   41.318   -74.667   Ridge and Valley     Monongahela Lake   42.5 - 43.5   07/01/2008   39.789   -75.136   Atlantic Coastal Pine Barrens     Mountain Lake-01   48.0 - 49.0   07/28/2008   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   75.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Saginaw Lake-02   24.5 - 25.5   05/03/2013   40.330   -74.756   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   43.5 - 44.5   08/27/2008   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   06/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stokle Pond   93.0 - 94.0   05/21/2014   41.028   -74.753   Ridge and Valley     Stone Tavern-11   76.5 - 77.5   09/18/2013	-					
Monongahela Lake   42.5 - 43.5   07/01/2008   39.789   -75.136   Atlantic Coastal Pine Barrens     Mountain Lake-01   48.0 - 49.0   07/28/2008   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   75.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Rosedale lake   72.5 - 73.5   05/03/2013   40.330   -74.756   Northern Piedmont     Saddle Bog   65.5 - 66.5   06/26/2013   41.236   -74.703   Ridge and Valley     Saginaw Lake-02   24.5 - 25.5   11/22/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   43.5 - 44.5   08/27/2008   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stokle Pond   93.0 - 94.0   05/21/2014   41.028   -74.753   Ridge and Valley     Stone Tavern-11   76.5 - 77.5   09/18/2013   40.197   -74.485   Atlantic Coastal Pine Barrens     Stony Lake-01   31.0 - 32.0   11/30/2011   41.020   -74.770						
Mountain Lake-01   48.0 - 49.0   07/28/2008   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Mountain Lake-01   75.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Rosedale lake   72.5 - 73.5   05/03/2013   40.330   -74.756   Northern Piedmont     Saddle Bog   65.5 - 66.5   06/26/2013   41.236   -74.703   Ridge and Valley     Saginaw Lake-02   24.5 - 25.5   11/22/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stickle Pond   93.0 - 94.0   05/21/2014   41.028   -74.753   Ridge and Valley     Storp Lake-01   31.0 - 32.0   11/30/2011   41.020   -74.770   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073						<b>o</b> ,
Mountain Lake-01   75.0 - 76.0   09/04/2013   40.859   -74.984   Northern Appalachian and Atlantic Maritime Highlands     Rosedale lake   72.5 - 73.5   05/03/2013   40.330   -74.756   Northern Piedmont     Sadilae Bog   65.5 - 66.5   06/26/2013   41.236   -74.763   Ridge and Valley     Saginaw Lake-02   24.5 - 25.5   11/22/2014   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   43.5 - 44.5   08/27/2008   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   93.0 - 94.0   06/21/2014   41.028   -74.753   Ridge and Valley     Stone Tavern-11   76.5 - 77.5   09/18/2013   40.197   -74.485   Atlantic Coastal Pine Barrens     Stony Lake-01   31.0 - 32.0   11/30/2011   41.200   -74.770   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>						
Rosedale lake   72.5 - 73.5   05/03/2013   40.330   -74.756   Northern Piedmont     Saddle Bog   65.5 - 66.5   06/26/2013   41.236   -74.703   Ridge and Valley     Saginaw Lake-02   24.5 - 25.5   11/22/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   43.5 - 44.5   08/27/2008   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.197   -74.485   Atlantic Coastal Pine Barrens     Store Tavern-11   76.5 - 77.5   09/18/2013   41.003   -75.073   Ridge and Valley     Sunfish Pond   37.5 - 38.5   08/12/2008   41.003   -75.073   Ridge and Valley     Surprise Lake   74.0 - 75.5   06/19/2013   41.186   -74.347   Northern Appalachian						
Saddle Bog   65.5 - 66.5   06/26/2013   41.236   -74.703   Ridge and Valley     Saginaw Lake-02   24.5 - 25.5   11/22/2011   41.022   -74.624   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   43.5 - 44.5   08/27/2008   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   93.0 - 94.0   05/21/2014   41.028   -74.773   Ridge and Valley     Stone Tavern-11   76.5 - 77.5   09/18/2013   40.197   -74.485   Atlantic Coastal Pine Barrens     Stony Lake-01   31.0 - 32.0   11/30/2013   41.003   -75.073   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Surprise Lake   74.0 - 75.5   06/19/2013   41.186   -74.347   Northern Appalachian						
Saginaw Lake-02 24.5 - 25.5 11/22/2011 41.022 -74.624 Northern Appalachian and Atlantic Maritime Highlands   Skyline Lakes-03 43.5 - 44.5 08/27/2008 41.072 -74.272 Northern Appalachian and Atlantic Maritime Highlands   Skyline Lakes-03 74.0 - 75.0 09/16/2013 41.072 -74.272 Northern Appalachian and Atlantic Maritime Highlands   Stag Pond 48.0 - 49.0 08/19/2009 40.993 -74.697 Northern Appalachian and Atlantic Maritime Highlands   Stickle Pond 93.0 - 94.0 05/21/2014 41.028 -74.753 Ridge and Valley   Storp Lake-01 31.0 - 32.0 11/30/2011 41.200 -74.770 Ridge and Valley   Sunfish Pond 37.5 - 38.5 08/12/2008 41.003 -75.073 Ridge and Valley   Sunfish Pond 65.5 - 66.5 09/25/2013 41.003 -76.073 Ridge and Valley   Surprise Lake 74.0 - 75.5 06/19/2013 41.186 -74.347 Northern Appalachian and Atlantic Maritime Highlands   Swartswood Lake 63.5 - 64.5 05/23/2014 41.074 -74.835 Ridge and Valley   Turtle Pond 61.5 - 62.5 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td></t<>						
Skyline Lakes-03   43.5 - 44.5   08/27/2008   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stickle Pond   93.0 - 94.0   05/21/2014   41.028   -74.753   Ridge and Valley     Stone Tavern-11   76.5 - 77.5   09/18/2013   40.197   -74.485   Atlantic Coastal Pine Barrens     Stony Lake-01   31.0 - 32.0   11/30/2011   41.003   -75.073   Ridge and Valley     Sunfish Pond   37.5 - 38.5   08/12/2008   41.003   -75.073   Ridge and Valley     Surprise Lake   74.0 - 75.5   06/19/2013   41.186   -74.347   Northern Appalachian and Atlantic Maritime Highlands     Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.769   Ridge and Valley<						
Skyline Lakes-03   74.0 - 75.0   09/16/2013   41.072   -74.272   Northern Appalachian and Atlantic Maritime Highlands     Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stickle Pond   93.0 - 94.0   05/21/2014   41.028   -74.753   Ridge and Valley     Stone Tavern-11   76.5 - 77.5   09/18/2013   40.197   -74.485   Atlantic Coastal Pine Barrens     Stony Lake-01   31.0 - 32.0   11/30/2011   41.200   -75.073   Ridge and Valley     Sunfish Pond   37.5 - 38.5   08/12/2008   41.003   -75.073   Ridge and Valley     Surfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Surfish Pond   65.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Surfish Pond   61.5 - 62.5   08/19/2008   40.981   -74.347   Northern Appalachian and Atlantic Maritime Highlands     Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Turt	0					
Stag Pond   48.0 - 49.0   08/19/2009   40.993   -74.697   Northern Appalachian and Atlantic Maritime Highlands     Stickle Pond   93.0 - 94.0   05/21/2014   41.028   -74.753   Ridge and Valley     Stone Tavern-11   76.5 - 77.5   09/18/2013   40.197   -74.485   Atlantic Coastal Pine Barrens     Stony Lake-01   31.0 - 32.0   11/30/2011   41.200   -74.770   Ridge and Valley     Sunfish Pond   37.5 - 38.5   08/12/2008   41.003   -75.073   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Sunfish Pond   65.5 - 64.5   05/23/2014   41.003   -74.347   Northern Appalachian and Atlantic Maritime Highlands     Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Terrace Pond   41.0 - 42.5   06/06/2013   41.139   -74.394   Northern Appalachian and Atlantic Maritime Highlands     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands	,					
Stickle Pond 93.0 - 94.0 05/21/2014 41.028 -74.753 Ridge and Valley   Stone Tavern-11 76.5 - 77.5 09/18/2013 40.197 -74.485 Atlantic Coastal Pine Barrens   Stony Lake-01 31.0 - 32.0 11/30/2011 41.200 -74.770 Ridge and Valley   Sunfish Pond 37.5 - 38.5 08/12/2008 41.003 -75.073 Ridge and Valley   Sunfish Pond 65.5 - 66.5 09/25/2013 41.003 -75.073 Ridge and Valley   Surprise Lake 74.0 - 75.5 06/19/2013 41.186 -74.347 Northern Appalachian and Atlantic Maritime Highlands   Swartswood Lake 63.5 - 64.5 05/23/2014 41.074 -74.835 Ridge and Valley   Terrace Pond 41.0 - 42.5 06/06/2013 41.139 -74.394 Northern Appalachian and Atlantic Maritime Highlands   Turtle Pond 61.5 - 62.5 08/19/2008 40.981 -74.769 Ridge and Valley   Watchu Pond  08/11/2010 40.928 -74.770 Northern Appalachian and Atlantic Maritime Highlands   Watchung Lake-09 47.5 - 48.5 11/18/2011 40.636 -74.454						
Stone Tavem-11   76.5 - 77.5   09/18/2013   40.197   -74.485   Atlantic Coastal Pine Barrens     Stony Lake-01   31.0 - 32.0   11/30/2011   41.200   -74.770   Ridge and Valley     Sunfish Pond   37.5 - 38.5   08/12/2008   41.003   -75.073   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Surprise Lake   74.0 - 75.5   06/19/2013   41.186   -74.347   Northern Appalachian and Atlantic Maritime Highlands     Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Terrace Pond   41.0 - 42.5   06/06/2013   41.139   -74.394   Northern Appalachian and Atlantic Maritime Highlands     Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchup Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Appalachian and Atlantic Maritime Highlands <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>						
Stony Lake-01   31.0 - 32.0   11/30/2011   41.200   -74.770   Ridge and Valley     Sunfish Pond   37.5 - 38.5   08/12/2008   41.003   -75.073   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Surprise Lake   74.0 - 75.5   06/19/2013   41.186   -74.347   Northern Appalachian and Atlantic Maritime Highlands     Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Terrace Pond   41.0 - 42.5   06/06/2013   41.139   -74.394   Northern Appalachian and Atlantic Maritime Highlands     Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Appalachian and Atlantic Maritime Highlands     Wasyanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.438   Nor						0,
Sunfish Pond   37.5 - 38.5   08/12/2008   41.003   -75.073   Ridge and Valley     Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Surprise Lake   74.0 - 75.5   06/19/2013   41.186   -74.347   Northern Appalachian and Atlantic Maritime Highlands     Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Terrace Pond   41.0 - 42.5   06/06/2013   41.139   -74.394   Northern Appalachian and Atlantic Maritime Highlands     Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.769   Ridge and Valley     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Appalachian and Atlantic Maritime Highlands     Wasyanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.438   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Norther						
Sunfish Pond   65.5 - 66.5   09/25/2013   41.003   -75.073   Ridge and Valley     Surprise Lake   74.0 - 75.5   06/19/2013   41.186   -74.347   Northern Appalachian and Atlantic Maritime Highlands     Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Terrace Pond   41.0 - 42.5   06/06/2013   41.139   -74.394   Northern Appalachian and Atlantic Maritime Highlands     Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.769   Ridge and Valley     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.474   Northern Appalachian and Atlantic Maritime Highlands     Waawayanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.438   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471						
Swartswood Lake   63.5 - 64.5   05/23/2014   41.074   -74.835   Ridge and Valley     Terrace Pond   41.0 - 42.5   06/06/2013   41.139   -74.394   Northern Appalachian and Atlantic Maritime Highlands     Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.769   Ridge and Valley     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Appalachian and Atlantic Maritime Highlands     Waxayanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.454   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.419   Atlantic Coastal Pine Barrens     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	Sunfish Pond	65.5 - 66.5	09/25/2013	41.003	-75.073	Ridge and Valley
Terrace Pond   41.0 - 42.5   06/06/2013   41.139   -74.394   Northern Appalachian and Atlantic Maritime Highlands     Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.769   Ridge and Valley     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Piedmont     Wawayanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.354   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     West Pond   52.0 - 53.0   08/29/2013   40.471   -74.454   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.454   Northern Appalachian and Atlantic Maritime Highlands     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	Surprise Lake	74.0 - 75.5	06/19/2013	41.186	-74.347	
Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.769   Ridge and Valley     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Piedmont     Wawayanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.438   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.419   Atlantic Coastal Pine Barrens     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	Swartswood Lake	63.5 - 64.5	05/23/2014	41.074	-74.835	Ridge and Valley
Turtle Pond   61.5 - 62.5   08/19/2008   40.981   -74.769   Ridge and Valley     Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Piedmont     Wawayanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.438   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.419   Atlantic Coastal Pine Barrens     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley		41.0 - 42.5	06/06/2013	41.139	-74.394	
Watchu Pond    08/11/2010   40.928   -74.770   Northern Appalachian and Atlantic Maritime Highlands     Watchung Lake-09   47.5 - 48.5   11/18/2011   40.636   -74.454   Northern Piedmont     Wawayanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.438   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.419   Atlantic Coastal Pine Barrens     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	Turtle Pond	61.5 - 62.5	08/19/2008	40.981	-74.769	
Wawayanda Lake-02   45.0 - 46.0   08/25/2009   41.176   -74.438   Northern Appalachian and Atlantic Maritime Highlands     West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.419   Atlantic Coastal Pine Barrens     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	Watchu Pond		08/11/2010	40.928	-74.770	Northern Appalachian and Atlantic Maritime Highlands
West Pond   83.0 - 84.0   10/03/2013   41.185   -74.354   Northern Appalachian and Atlantic Maritime Highlands     Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.419   Atlantic Coastal Pine Barrens     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	Watchung Lake-09	47.5 - 48.5	11/18/2011	40.636	-74.454	Northern Piedmont
Weston Mill Pond   52.0 - 53.0   08/29/2013   40.471   -74.419   Atlantic Coastal Pine Barrens     White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	Wawayanda Lake-02	45.0 - 46.0	08/25/2009	41.176	-74.438	Northern Appalachian and Atlantic Maritime Highlands
White Lake-Sparta   73.5 - 74.5   09/26/2013   41.088   -74.649   Ridge and Valley	West Pond	83.0 - 84.0	10/03/2013	41.185	-74.354	Northern Appalachian and Atlantic Maritime Highlands
	Weston Mill Pond	52.0 - 53.0	08/29/2013	40.471	-74.419	
White Lake-Hardwick 55.0 - 56.5 05/12/2014 41.000 -74.914 Ridge and Valley						
	White Lake-Hardwick	55.0 - 56.5	05/12/2014	41.000	-74.914	Ridge and Valley

Site Name	Sample	Collection	Latitude	-	sediment cores. Ecoregion
	Depth	Date		-	-
Algonquian Waters Lake	0.0 - 0.5	08/14/2009		-74.368	Northern Appalachian and Atlantic Maritime Highlands
Allamuchy Pond	0.0 - 0.5	07/15/2009		-74.817	Northern Appalachian and Atlantic Maritime Highlands
Ames Lake-06	0.0 - 0.5	07/30/2009		-74.501	Northern Appalachian and Atlantic Maritime Highlands
Amwell Lake-10	0.0 - 0.5	07/20/2009		-74.842	Northern Piedmont
Basgalore Lake	0.0 - 0.5	05/23/2008		-75.283	Atlantic Coastal Pine Barrens
Bee Meadow Pond	0.0 - 0.5	05/24/2008		-74.410	Northern Piedmont
Bells Lake-18	0.0 - 0.5	11/15/2011		-75.051	Atlantic Coastal Pine Barrens
Braddocks Mill Pond-19	0.0 - 0.5	08/13/2013		-74.850	Atlantic Coastal Pine Barrens
Braddocks Mill Pond-19	0.5 - 1.0	08/13/2013		-74.850	Atlantic Coastal Pine Barrens
Cedar Lake-06	0.0 - 0.5	10/25/2011		-74.472	Northern Appalachian and Atlantic Maritime Highlands
Chesler Lake	0.0 - 0.5	10/20/2011		-74.629	Northern Appalachian and Atlantic Maritime Highlands
Colonial Lake	0.0 - 0.5	09/11/2012		-74.724	Atlantic Coastal Pine Barrens
Culvers Lake-01	0.0 - 0.5	08/20/2009		-74.771	Ridge and Valley
Decou Pond	0.0 - 0.5	05/05/2013		-74.456	Atlantic Coastal Pine Barrens
Dixons Pond	0.0 - 0.5	07/10/2008		-74.444	Northern Appalachian and Atlantic Maritime Highlands
East Lake	0.0 - 0.5	08/18/2008		-74.356	Northern Appalachian and Atlantic Maritime Highlands
arrington Lake-09	0.0 - 0.5	11/02/2011		-74.477	Northern Piedmont
oxs Pond-06	0.0 - 0.5	07/15/2008		-74.517	Northern Appalachian and Atlantic Maritime Highlands
Gardners Pond	0.0 - 0.5	11/21/2011		-74.739	Northern Appalachian and Atlantic Maritime Highlands
George Lake	0.0 - 0.5	07/15/2009		-74.785	Northern Appalachian and Atlantic Maritime Highlands
Girl Scout Pond	0.0 - 0.5	07/23/2009		-74.496	Northern Appalachian and Atlantic Maritime Highlands
Glovers Pond	0.0 - 0.5	07/29/2009		-74.890	Ridge and Valley
Greenwood Lake-03	0.0 - 0.5	07/02/2008		-74.335	Northern Appalachian and Atlantic Maritime Highlands
Greenwood Lake-03	0.0 - 0.5	11/03/2011		-74.335	Northern Appalachian and Atlantic Maritime Highlands
Harrisonville Lake-18	0.0 - 0.5	07/05/2009	39.682	-75.265	Atlantic Coastal Pine Barrens
Heaters Pond-02	0.0 - 0.5	08/04/2009	41.072	-74.585	Northern Appalachian and Atlantic Maritime Highlands
Heritage Lakes-02	0.0 - 0.5	08/05/2009	41.143	-74.564	Ridge and Valley
Hospitality Lake	0.0 - 0.5	07/01/2009	39.604	-74.888	Atlantic Coastal Pine Barrens
liff Lake-01	0.0 - 0.5	08/25/2008	41.032	-74.715	Ridge and Valley
Jeddy's Pond	0.0 - 0.5	11/28/2011	39.433	-75.239	Atlantic Coastal Pine Barrens
_ake Takanassee	0.0 - 0.5	07/07/2009	40.277	-73.989	Atlantic Coastal Pine Barrens
Laurel Lake	0.0 - 0.5	05/24/2009	39.818	-75.014	Atlantic Coastal Pine Barrens
Lefferts Lake-12	0.0 - 0.5	11/01/2011		-74.245	Atlantic Coastal Pine Barrens
Liberty Lake	0.0 - 0.5	10/17/2011		-74.954	Northern Appalachian and Atlantic Maritime Highlands
Longwood Lake	0.0 - 0.5	07/29/2008		-74.540	Northern Appalachian and Atlantic Maritime Highlands
Lower Aetna Lake-19	0.0 - 0.5	07/08/2008		-74.802	Atlantic Coastal Pine Barrens
Lower Aetna Lake-19	0.0 - 0.5	09/24/2008		-74.802	Atlantic Coastal Pine Barrens
Lower Sylvan Lake-20	0.0 - 0.5	05/29/2009	40.054	-74.860	Atlantic Coastal Pine Barrens
Lower Twin Lake	0.0 - 0.5	08/05/2008		-74.297	Northern Appalachian and Atlantic Maritime Highlands
Lummis Mill Pond	0.0 - 0.5	05/30/2009		-75.182	Atlantic Coastal Pine Barrens
Varcia Lake-01	0.0 - 0.5	05/20/2003		-74.667	Ridge and Valley
Monongahela Lake	0.0 - 0.5	07/01/2008		-75.136	Atlantic Coastal Pine Barrens
Vountain Lake-01	0.0 - 0.5	07/28/2008		-74.984	Northern Appalachian and Atlantic Maritime Highlands
North Hudson Parklake-05	0.0 - 0.5	07/09/2009		-73.999	Northern Piedmont
Panther Lake-01	0.0 - 0.5 0.0 - 0.5	07/09/2009		-73.999 -74.736	Northern Appalachian and Atlantic Maritime Highlands
Rainbow Lakes-06	0.0 - 0.5	08/25/2009		-74.730	Northern Appalachian and Atlantic Maritime Highlands
Ravine Lake-08	0.0 - 0.5	05/15/2009		-74.403	Northern Appalachian and Atlantic Maritime Highlands
Rhodo Lake	0.0 - 0.5	05/17/2009		-75.339	Atlantic Coastal Pine Barrens
Scarlet Oak Pond	0.0 - 0.5	08/11/2009		-74.191	Northern Piedmont
Sheppard Pond-03	0.0 - 0.5	08/12/2009		-74.228	Northern Appalachian and Atlantic Maritime Highlands
Silver Lake	0.0 - 0.5	05/10/2009		-75.248	Atlantic Coastal Pine Barrens
Skyline Lakes-03	0.0 - 0.5	08/27/2008		-74.272	Northern Appalachian and Atlantic Maritime Highlands
Spring Valley Lake	0.0 - 0.5	08/07/2008		-74.940	Ridge and Valley
Stag Pond	0.0 - 0.5	08/19/2009		-74.697	Northern Appalachian and Atlantic Maritime Highlands
Stephen Lake	0.0 - 0.5	05/19/2008		-74.750	Atlantic Coastal Pine Barrens
Stone Tavern-11	0.0 - 0.5	09/01/2008		-74.485	Atlantic Coastal Pine Barrens
Stony Lake-01	0.0 - 0.5	11/30/2011		-74.770	Ridge and Valley
Sunfish Pond	0.0 - 0.5	08/12/2008		-75.073	Ridge and Valley
Surprise Lake	0.0 - 0.5	06/19/2013		-74.347	Northern Appalachian and Atlantic Maritime Highlands
Sycamore Lake	0.0 - 0.5	06/18/2008		-75.335	Atlantic Coastal Pine Barrens
Tamarack Lake-02	0.0 - 0.5	07/28/2009		-74.538	Northern Appalachian and Atlantic Maritime Highlands
Terrace Pond	0.0 - 0.5	06/06/2013	41.139	-74.394	Northern Appalachian and Atlantic Maritime Highlands
Turtle Pond	0.0 - 0.5	08/19/2008	40.981	-74.769	Ridge and Valley
Watchu Pond	0.0 - 0.5	08/11/2010	40.928	-74.770	Northern Appalachian and Atlantic Maritime Highlands
Watchung Lake-09	0.0 - 0.5	11/18/2011	40.636	-74.454	Northern Piedmont
Wawayanda Lake-02	0.0 - 0.5	08/25/2009	41.176	-74.438	Northern Appalachian and Atlantic Maritime Highlands
West Pond	0.0 - 0.5	10/03/2013		-74.354	Northern Appalachian and Atlantic Maritime Highlands
Weston Mill Pond	0.0 - 0.5	07/09/2008		-74.419	Atlantic Coastal Pine Barrens
				-	

Overall, top core sediment samples (representing current conditions) are rich in *Fragilaria crotonensis*, *Asterionella formosa* and *Fragilaria capucina*. These species are indicators of eutrophic conditions. Core bottom sediment

samples are dominated by *Cyclotella michiginana*, a species indicative of low TP concentrations. *Aulacoseira ambigua* and *Achnanthidium minutissimum* were found dominant in both top and bottom samples. The mean observed summer TP from all



NJ panel lakes (measured by the Bureau of Freshwater Monitoring, between 2005 - 2011) is 58  $\mu$ g/L. The water quality standard for lakes in NJ is 50  $\mu$ g/L. The mean of all diatom-inferred surface samples is 48  $\mu$ g/L. The average diatom- estimated historic TP for all core bottom samples is 24  $\mu$ g/L, just less than half of the current water quality standard for NJ (**Fig. 3**). Total phosphorus estimates in bottom sediment samples were typically higher from impoundments than from natural lakes. This difference might reflect trophic upsurge after impoundment.

# Conclusions

This project represents a continuing effort, started in 2008, to estimate historic water quality and lake reference nutrient concentrations inferred from diatoms preserved in lake sediments. Sampling was initiated for this phase of the effort in 2011. During this study, 37 bottom samples and 20 surface samples were analyzed for diatom species. Reconstructions of total phosphorus (TP) in core bottom samples revealed that the mean TP was 24  $\mu$ g/L, which is less than half of the current water quality standard for NJ of 50  $\mu$ g/L.

#### References

Blais J. M., J. Kalff, R. J. Cornett and R. D. Evans. 1995. Evaluation of 210-Pb dating in lake sediments using stable Pb, Ambrosia pollen, and 137Cs. Journal of Paleolimnology 1 13: 169 -178.

Enache, D.M., D.F. Charles, T.J. Belton, and C.W. Callinan. 2012. Total phosphorus changes in New York and New Jersey lakes (USA) inferred from sediment cores. Lake and Reservoir Management 28 (4): 293-310.

Stansfield, C. (1998). A geography of New Jersey: The city in the garden. Rutgers University Press.

# Acknowledgements:

Funding was provided by the Division of Science, Research and Environmental Health, contract SR12-005. This study was continued through funding from the Bureau of Freshwater & Biological Monitoring to provide additional lakes to refine the diatom-nutrient models, perform radioisotope and pollen dating on all core samples, and reconstruct historical reference conditions of total phosphorus and nitrogen in these sites.

# **PRINCIPAL INVESTIGATORS:**

<sup>1</sup> Academy of Natural Sciences of Drexel University, Patrick Center for Environmental Research, Philadelphia, PA

# PREPARED BY:

<sup>2</sup>New Jersey Department of Environmental Protection, Division of Science, Research and Environmental Health

# **RESEARCH PROJECT SUMMARY**

Please send comments or requests to: Division of Science, Research and Environmental Health Mail code 428-01, P.O. Box 420 Trenton, NJ 08625

Phone: (609) 984-6070 Visit the Division of Science, Research & Environmental Health web site @ www.state.nj.us/dep/dsr/

**Division of Science, Research & Environmental Health** *Dr. Gary Buchanan, Director*  State of New Jersey Chris Christie, Governor Department of Environmental Protection Bob Martin, Commissioner