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New Hampshire Volunteer Lake Assessment Program

2011
White Mountain Region
Regional Report

Province Lake, Effingham, NH

NHDES

Celebrating 1987 25 Years 2012

New Hampshire Volunteer Lake Assessment Program 2011 White Mountain Regional Report

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Introduction and History

New Hampshire is home to approximately 900 lakes and ponds, and thousands of river miles. Protecting our lakes and rivers is critical to sustaining New Hampshire's drinking water resources, aquatic and natural environments, recreational and tourism industries.

The New Hampshire Department of Environmental Services (DES) recognizes the importance of these waterbodies in maintaining a healthy ecosystem for our current and future generations. Protecting high quality waters and restoring those that are impaired requires coordination and partnership between federal, state and local governments, non-profits, regional commissions, lake associations, and watershed residents.

To help citizens assess the health of New Hampshire's lakes and ponds, DES established the Volunteer Lake Assessment Program (VLAP) in 1985. The program is a volunteer-driven cooperative effort between the State and local governments, lake associations and lake residents. VLAP trains citizen volunteer monitors to collect water quality data at lakes and their associated tributaries on a monthly basis during the summer. VLAP compiles, interprets and reports the data back to state, federal and local governments, lake associations, and lake residents.

VLAP volunteer monitors are invaluable stewards for New Hampshire's lakes. Volunteer monitoring allows DES to establish a strong set of baseline chemical and biological data, determine long-term water quality trends and identify emerging water quality issues. DES acts on these findings through its funding and regulatory programs. Volunteers use this information to educate lake and watershed residents, businesses and local governments on best management practices to keep New Hampshire's lakes and ponds clean. They have been, and will continue to be, a key element in protecting the integrity of New Hampshire's lakes.

Program Overview

VLAP is a cooperative program between DES and lake residents and associations. Currently, approximately 500 volunteers monitor water quality at 180 lakes throughout New Hampshire. Interest in the program has grown drastically in the past ten years as citizens have become more aware of the connections between land use activities and water quality. Volunteer monitors continually collect high quality data on their local waterbodies and educate watershed residents.

Volunteer monitors are trained by DES to use monitoring equipment to collect lake water quality data, survey the surrounding watershed, and sample the streams and rivers that are tributaries to the lake. Each of the participating lakes must be visited by a DES biologist on a bi-annual basis. This visit is a valuable event in which the volunteer monitors have an opportunity to discuss water quality and watershed concerns and receive recommendations on potential remediation activities. Also, the event allows DES biologists to perform a field sampling techniques audit to evaluate volunteer monitor's ability to collect quality data, and to collect information on additional water quality parameters as necessary. Volunteers then sample on their own for the remaining summer months.

To further encourage volunteer monitoring, DES, established partnerships with the Lake Sunapee Protective Association (LSPA), Colby Sawyer College (CSC) in New London, NH, and Plymouth State University (PSU) in Plymouth, NH to operate VLAP satellite laboratories. These satellite laboratories serve as a convenient location for volunteers to borrow sampling equipment and deliver water samples for analysis. These strategic locations serve the Dartmouth Lake Sunapee, North Country and White Mountain regions.

The data gathered by the volunteers are reviewed by DES Quality Assurance Officers and Satellite Laboratory Managers and imported into DES' Environmental Monitoring Database (EMD). During the winter, DES biologists review and interpret the water quality data, perform trend analyses, and compile the results into annual reports. The high quality data gathered through VLAP also helps DES to conduct statewide surface water quality assessments. Assessment results and methodology are published and submitted to the Environmental Protection Agency (EPA) by DES every two years as a requirement of the Clean Water Act.

Once the volunteer monitors receive the data and the annual report for their lake, DES encourages the volunteers to relay that information to their respective associations, organizations, businesses, and local governments. Volunteers are also kept informed of the latest in lake management and water quality issues through an annual newsletter, technical and educational materials, regional workshops, and information on important legislation. In addition, DES biologists give presentations at lake association meetings and participate in youth education events. Educational initiatives, such as those mentioned above, allow volunteers to recognize potential water quality or shoreland violations around the lake and report their findings to DES. Volunteer monitors are dedicated, proactive lake stewards who are concerned for the well-being of their lakes.

MONITORING AND PARAMETER SUMMARY

VLAP encourages the collection of comprehensive data sets on key water quality parameters from participating lakes to determine overall health of the system. The lake and tributaries are sampled several times each year over a period of years. This establishes baseline water quality data and allows for the discernment of long-term water quality trends. These trends depict lake health and provide invaluable information to DES' mission to protect New Hampshire's lakes. The sampling efforts of the volunteer monitors supplement the environmental monitoring efforts of DES. Only through the assistance of volunteer monitors can such a high volume of sampling be accomplished throughout the state.

DES recognizes the importance of collecting data sets that are representative of varying conditions. VLAP has an EPA approved Quality Assurance Project Plan

(QAPP). The QAPP identifies specific responsibilities of DES and volunteers, sampling rationale, training procedures, and data management and quality control. DES and volunteers adhere to the QAPP regime to ensure high quality and representative data sets are collected.

Volunteers collect samples once per month in June, July and August, with some lakes monitored more or less frequently. Samples are collected at approximately the same location each month at each deep spot thermal layer, major tributaries (those flowing year round) and seasonal tributaries during spring run-off. The samples are analyzed for a variety of chemical and biological parameters including: pH, alkalinity, conductivity, chloride, turbidity, total phosphorus, and *E. coli* (optional). Additional in-lake data are also collected at the deep spot including lake transparency (with and without a viewscope), chlorophyll-a, phytoplankton, and dissolved oxygen and temperature profiles. Volunteer monitors are also trained to identify and collect samples of suspicious aquatic plants and cyanobacteria.

Environmental outcomes are measured by making comparisons to established New Hampshire averages and ranges of lake water quality, and state water quality standards. If analytical results for a particular sampling station frequently exceed state water quality averages or standards, then additional sampling to identify potential pollution sources is necessary. Volunteers often conduct storm event sampling, tributary bracket sampling, and spring run-off sampling to better assess watershed health and provide additional data to guide lake management decisions.

Appendix A includes a summary of each monitoring parameter and Appendix B includes recommended best management practices to remediate pollution sources.

WHITE MOUNTAIN REGIONAL SUMMARY

The White Mountain region (WM) consists of towns located in the central to northern portion of Carroll County, and central to northern portion of Grafton County (Figure 1). Bordering portions of the Connecticut River and Vermont, and the Saco River and Maine, this region is home to the infamous Mount Washington, White Mountain National Forest and a variety of scenic and recreational activities.

Freshwater resources in the WM region provide valuable drinking water and recreational opportunities and play an important role in the regional economy. Freshwater recreation, including boating, fishing and swimming, in the WM region generate approximately $67 million dollars in sales, $23 million in household income, and 1,078 jobs annually (Nordstrom, 2007). A perceived decline in water quality as measured by water clarity, levels, flows, aesthetic beauty, or overuse could result in approximately $28 million dollars in lost revenue, $10 million dollars in lost household income and 447 lost jobs (Nordstrom, 2007).

Similarly, a decline in water clarity alone can result in a decrease in New Hampshire lakefront property values. A one meter decrease in water clarity can lead to an average decrease in property values of between 0.9 and 6.0 percent in New Hampshire (Gibbs, Halstead, Boyle& Huang, 2002). This may negatively impact property tax revenues, especially in a state where there are approximately 64,000 vacation homes concentrated around the Lakes Region (lakes), Seacoast (ocean) and North Country (skiing) (Loder, 2011). According to a 1999 publication of the Society for the

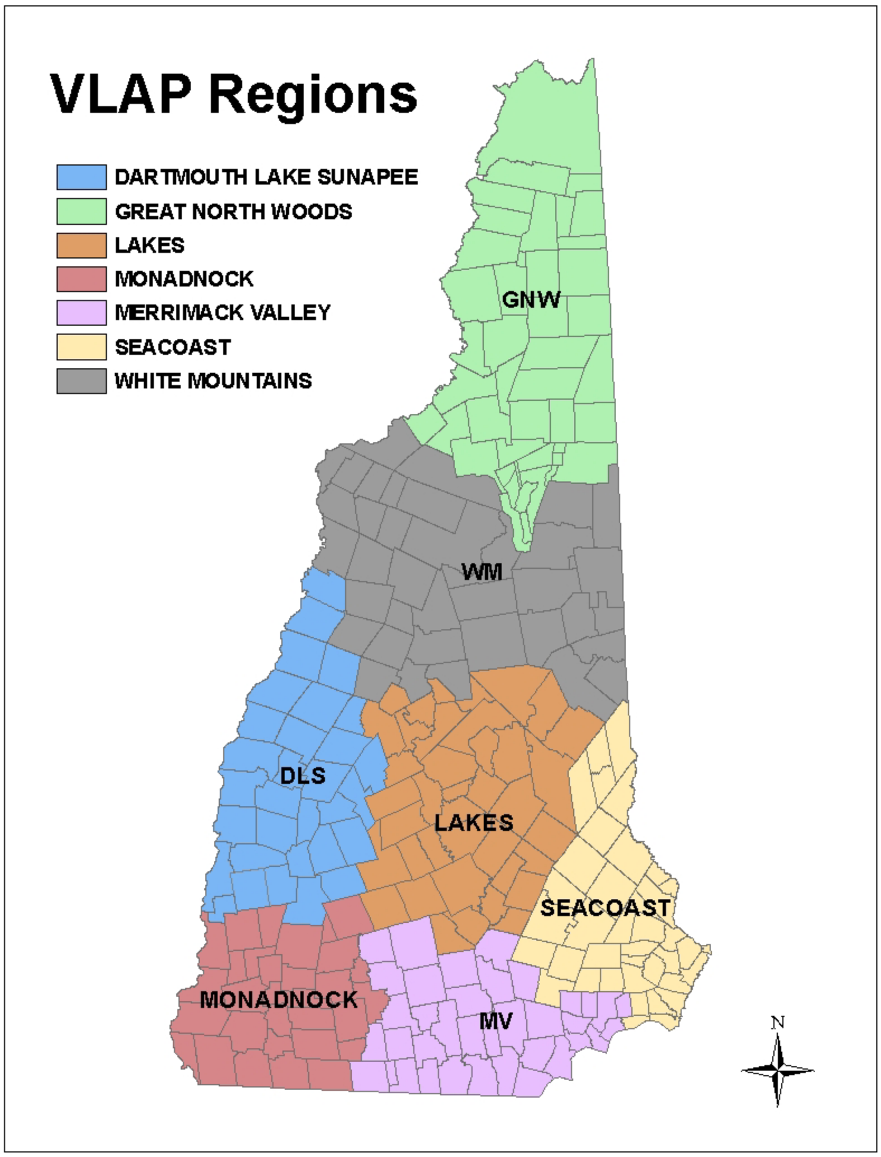


Figure 1. VLAP Regions

Protection of New Hampshire Forests, "The Economic Impact of Open Space in New Hampshire", vacation homes contribute approximately $286 million to state and local tax revenues (note: open space includes lakes). For a town with a large number of lakefront homes (vacation or residential), a decline in water clarity can cause decreased property values and local tax revenue.

The WM region encompasses the Level 8 Hydrologic Unit Code (HUC) Watersheds of the Connecticut-Johns River to Waits River, Pemigewasset River and Saco River. The HUC boundary defines a specific drainage basin of a major river or series of smaller rivers. There are 18 HUC 8 watersheds in New Hampshire. There are seven VLAP regions (Figure 1). VLAP lakes in the WM region include:

Lake Name	Town
Gardner Lake	Bath
Province Lake	Effingham
Berry Bay	Freedom
Lower Danforth Pond	Freedom
Mountain Lake, North	Haverhill
Mountain Lake, South	Haverhill
White Oak Pond	Holderness
Partridge Lake	Littleton
Dodge Pond	Lyman
Round Pond	Lyman
Big Pea Porridge Pond	Madison
Middle Pea Porridge Pond	Madison
Broad Bay	Ossipee
Conner Pond	Ossipee
Leavitt Bay	Ossipee
Loon Lake	Plymouth
Stinson Lake	Rumney
Bearcamp Pond	Sandwich
Moores Pond	Tamworth

LAND USE AND POPULATION GROWTH

According to the 2010 update of the Society for the Protection of New Hampshire Forests' publication "New Hampshire's Changing Landscape 2010", New Hampshire's population is expected to increase by 180,000 through 2030 (Figure 2). Almost 70 percent of that growth will occur in the Southeastern part of the state, particularly in Merrimack, Hillsborough and Rockingham counties.

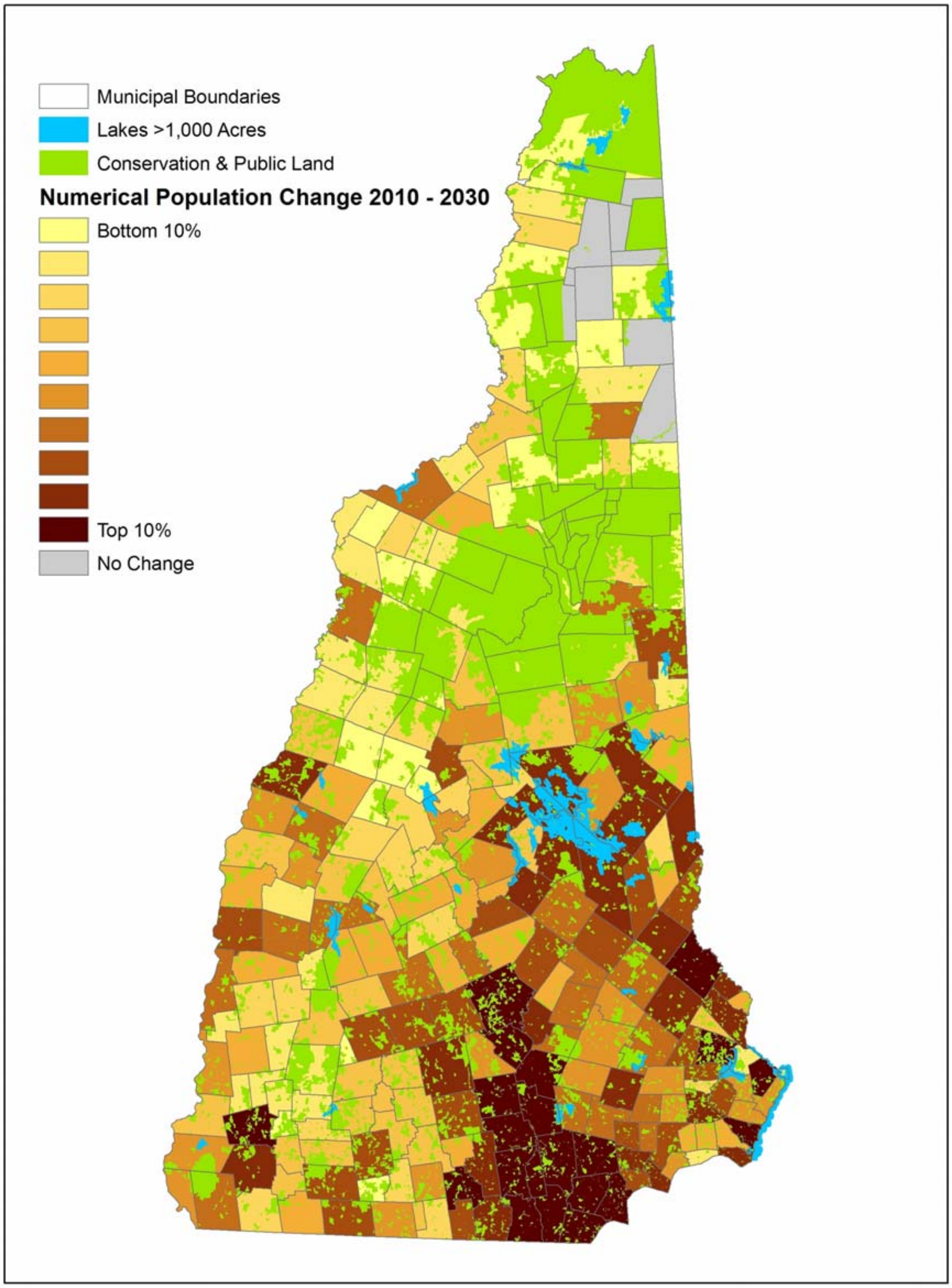
The population is anticipated to grow by approximately 20,000 people in Carroll and Grafton counties by 2030. The majority of growth is estimated to follow main road corridors and urbanizing areas and is anticipated to be greatest in the towns of Littleton, Haverhill, Plymouth, Campton, Conway, Madison, Tamworth, Ossipee, Effingham, and Freedom.

The WM region is home to over 25,000 acres of water (lakes, river, and wetlands). Forty-eight percent of this water is located in Grafton County and 52 percent is located in Carroll County. Over 13,000 acres of water occurs in the towns predicted to experience the heaviest population growth in these two counties, representing approximately 53 percent of the total waterbody acreage in the WM region.

Major land use categories in the WM region are agriculture, forest, wetland, and residential. Population growth and land use change go hand in hand. Growing populations necessitate land clearing to accommodate new homes, housing complexes, roadways, and commercial businesses. Developed land corresponds to more impervious surfaces such as roadways, driveways, and rooftops. It also corresponds to the loss of tree canopy coverage, unstable sediments, wildlife habitat loss, and vegetative buffer loss. Consequences of development can negatively affect our waterbodies through increases in stormwater runoff, water temperatures, erosion, turbidity and nutrients, as well as shifts in aquatic life, aquatic plant, algae and cyanobacteria growth.

Overall, population growth in WM region could greatly impact a large portion of its waterbodies. Efforts should be made to evaluate current land use activities, infrastructure, and regional water quality. This information should facilitate a plan to accommodate projected population growth while conserving and protecting valuable land and water resources.

Figure 2. NH Population Growth per Town 2010-2030



EXOTIC SPECIES

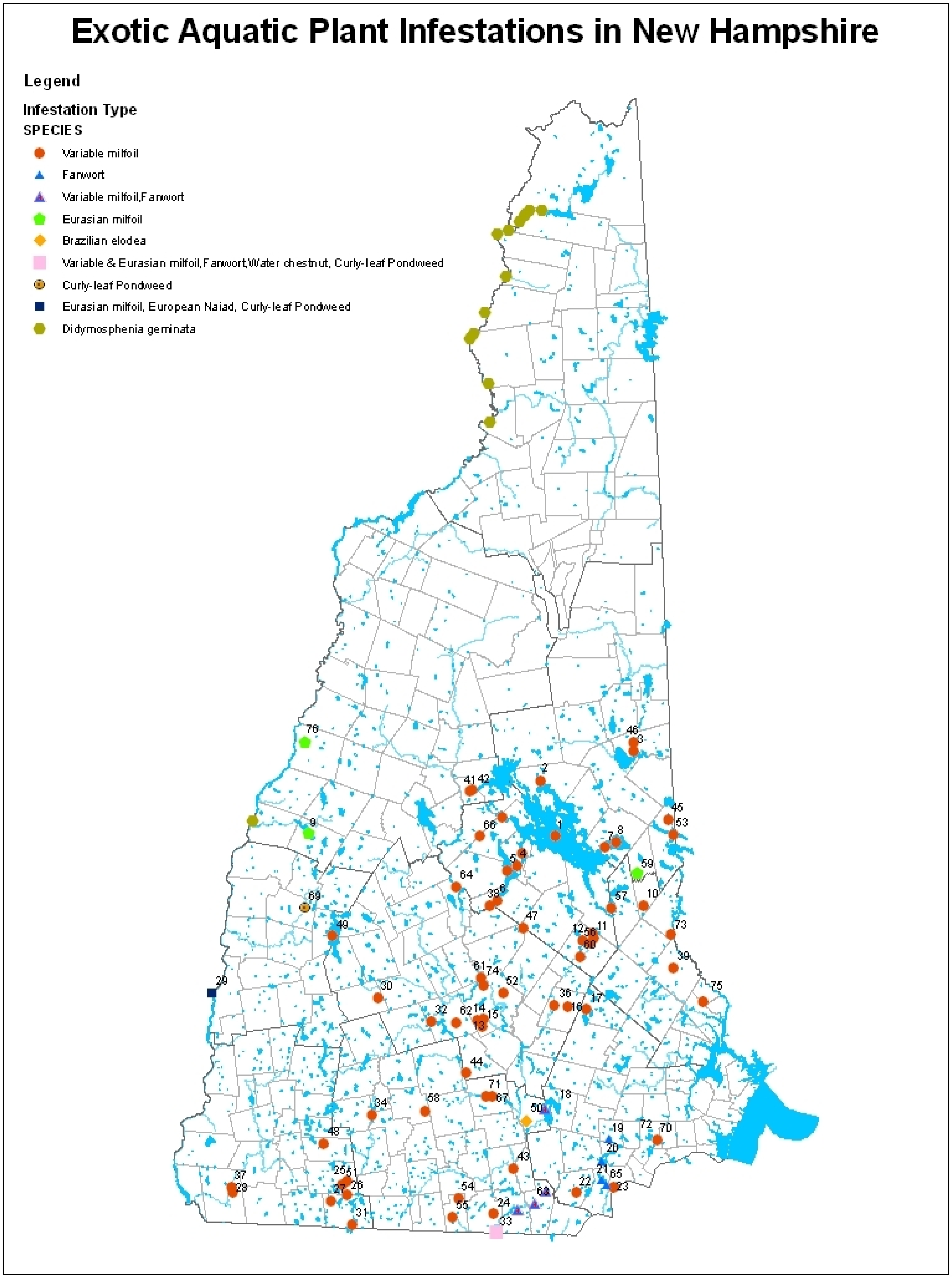
Exotic aquatic species are those plants and animals not native to New Hampshire's waterbodies, such as Variable milfoil and Zebra mussels. Many of these species are invasive and quickly spread throughout the aquatic system, altering habitat and the ecology of the system, often to the detriment of native species. They are a serious threat to the health of New Hampshire's aquatic ecosystem, recreation and tourism industries.

New Hampshire has 85 exotic plant infestations in 76 waterbodies. Those include Variable milfoil, Eurasian milfoil, Brazilian Elodea, Water chestnut, Curly-leaf Pondweed, Fanwort, European Naiad, and Didymo ("Rock Snot"). Variable milfoil inhabits the majority of infested waterbodies, and Didymo, an invasive alga, has now infested 54 river miles in the North Country. Currently, three waterbodies in the WM region are infested with an exotic species. Broad Bay, Lower Danforth Pond and Squam Lake have Variable milfoil infestations.

The low number of waterbodies with an exotic species infestation is great news for the WM region, however the unique nature and invasive tendencies of these exotic species heighten the need to prevent new infestations, manage current infestations and engage watershed residents. The newest infestations of Eurasian milfoil occurred in 2010, and public education is integral in preventing further infestations. One program that educates the public and engages watershed residents is the DES Weed Watchers Program. The Weed Watchers program has approximately 750 volunteers dedicated to monitoring lakes and ponds for the presence of exotic aquatic plants. Volunteers are trained to survey their lake or pond once a month from May through September. To survey, volunteers slowly boat, or sometimes snorkel, around the perimeter of the waterbody and its islands. Using the materials provided in the Weed Watcher kit, volunteers look for suspicious aquatic plant species. After a trip or two around the waterbody, volunteers have a good knowledge of its plant community and immediately notice even the most subtle change. If a suspicious plant is found, the volunteers send a specimen to DES for identification, either in the form of a live specimen mailed to DES, or as a photograph emailed to the Exotic Species Program Coordinator. Upon positive identification, a biologist visits the site to determine the extent of infestation, initiates a rapid response management technique where possible, and formulates a long-term management plan to control the nuisance infestation.

Another program dedicated to public education and engaging watershed residents is the Lake Host™ program. The Lake Host™ Program is funded through DES and Federal grants. The program was developed in 2002 by NH LAKES and DES to educate and prevent boaters from spreading exotic aquatic plants to waterbodies in New Hampshire. Since then, the number of participating waterbodies has doubled, the number of volunteers involved and boats inspected has quadrupled, and the number of "saves" (exotic plants discovered) has consistently increased. The program is invaluable in educating boaters, preventing recreational hazards, avoiding property value and aquatic ecosystem decline, addressing aesthetic issues, and saving costly remediation efforts.

Figure 3. NH Exotic Aquatic Plant Infestations



GEOMORPHOLOGY AND CLIMATE

Chemical, physical and biological properties of lakes often reflect how they were formed. Lake formation can occur in a variety of ways. In New Hampshire, most lakes were formed during the last ice age as glaciers retreated. Lakes were also formed from rivers (oxbow), and were man and animal made (impoundments, dams and beavers). These formations create distinct lake morphology, such as length, width, area and volume that affect the lake's ability to adapt to shifts in climate and land use.

Along with morphological characteristics of lakes, the bedrock and sediment geology is also important in understanding lake properties. Underlying geological properties can affect the pH and acid neutralizing capacity (ANC) of our surface and groundwater. New Hampshire is typically referred to as the "Granite State" because the bedrock geology consists of variations of Igneous Rock high in granite content and typically contributes to a lower pH and less capacity to buffer acidic inputs such as acid rain. Metamorphic rocks make up the remainder of bedrock geology and consist of slate, schist, quartzite and carbonate rocks which tend to contribute to a more neutral pH and better buffering capacity.

Along with bedrock geology, climate also drives multiple processes in lake systems. Lakes respond to shifting weather conditions such as sunlight, rainfall, air temperature, and wind and wave action in various ways. This variability is reflected in the types and number of biological communities present, and chemical and physical properties of the lake system. It is essential that we understand how these factors influence water quality data collected at individual lake systems. Therefore, volunteers record pertinent weather data, rain and storm event totals on field data sheets while sampling.

To summarize WM region climate conditions in 2011, the sampling season was slightly warmer and wetter based on air and rainfall data recorded in North Conway, NH and surface water temperatures recorded by VLAP (Table 1). Average air temperatures in May, July, and September were warmer than historical averages, while June and August were slightly below average. Overall, the 2011 average summer air temperature was 0.8° warmer than the historical average. Surface water temperatures were above average in June and July, and 2011 surface temperatures were 1.3° warmer than the historical regional average.

Table 1. Current Year and Historical Average Temperature and Precipitation Data for WM Region

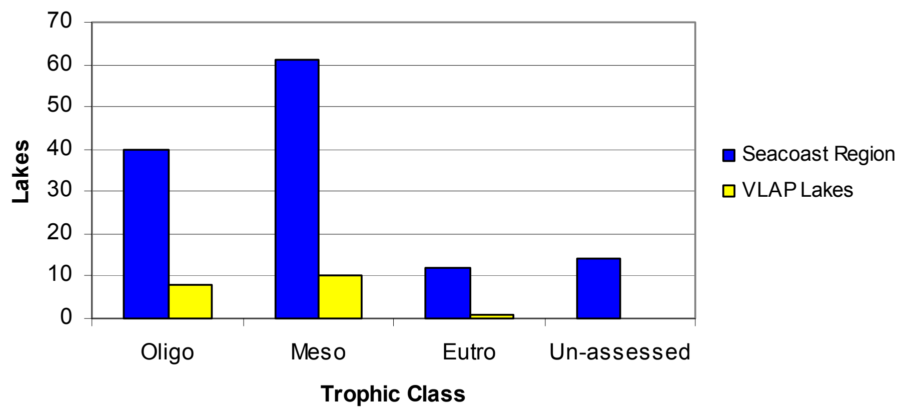
	May	June	July	August	September	Summer
2011 Average Air Temperature (°F)	55.4	63.0	70.2	66.4	61.2	63.2
Annual Average Air Temperature (°F)	54.0	64.0	69.0	67.0	58.0	62.4
2011 Average Surface Water Temperature (°F)	-------	71.9	79.2	73.0	--------	74.7
Annual Average Surface Water Temperature (°F)	-------	70.9	74.8	74.5	--------	73.4
2011 Precipitation (in.)	4.31	3.59	1.69	10.31	4.87	4.95
Annual Average (in.)	3.92	4.36	4.35	4.46	3.63	4.14

The 2011 monthly summer rainfall amounts were above average in June, August and September. The end of the summer season was marked by Tropical Storm Irene, which dumped over 10 inches of rainfall in higher elevations throughout the region. Tropical Storm Irene also caused severe flooding and damage in the WM region of New Hampshire. The above average rainfall likely let to an increase in lake turbidity, decrease in water clarity, and an increase in phosphorus and algal growth.

MONITORING AND ASSESSMENT

New Hampshire considers a public water to be a great pond or artificial impoundment greater than 10 acres in size, public rivers, streams and tidal waters. The WM region consists of 127 lakes, or great ponds, and 19 of those lakes participate in VLAP. Data on the remaining 85 percent of lakes are sparse, being only occasionally sampled through the DES Lake Survey Program.

Figure 4. Trophic Classification of WM Region Lakes



The DES Lake Survey Program monitors NH's lakes on a rotating basis, with the goal of conducting a comprehensive lake survey every 10 to 15 years. The surveys compile chemical, biological and morphological data. The data are used to assign a lake trophic class to each waterbody. The trophic class provides an assessment on how "aged" a lake is and can provide information on how population growth and human activities may be accelerating the aging process, also know as lake eutrophication.

Three trophic classes are used to assess a lake's overall health, Oligotrophic, Mesotrophic and Eutrophic. Oligotrophic lakes have high dissolved oxygen levels (> 5 mg/L), high transparency (> 12 ft.), low chlorophyll-a concentrations (< 4 mg/L), low phosphorus concentrations (< 10 ug/L), and sparse aquatic plant growth. Eutrophic lakes have low levels of dissolved oxygen (< 2 mg/L), low transparency (< 6 ft.), high chlorophyll-a concentrations (> 15 mg/L), high phosphorus concentrations (> 20 ug/L), and abundant aquatic plant growth. Mesotrophic lakes have characteristics that fall in between those of Oligotrophic and Eutrophic lakes for the parameters listed.

The trophic class breakdown of WM region lakes is shown in Figure 4. Forty lakes are Oligtrophic, 61 Mesotrophic, 12 Eutrophic, and 14 are un-assessed for trophic classification due to lack of data. Eight Oligotrophic and 10 Mesotrophic and one Eutrophic lake participate in VLAP. Approximately 80 percent of the WM lakes are classified as Oligotrophic and Mesotrophic; however over 75 percent of those lakes do not participate in VLAP or a similar monitoring program. As human activities in watersheds accelerate lake aging, it is imperative to keep a close eye on the health of those lakes in the Oligotrophic and Mesotrophic classes. Efforts should also be made to gather data on the un-assessed waterbodies. Protecting a lake and preventing lake aging is much more cost-effective than restoring a damaged lake.

VLAP WATER QUALITY DATA INTERPRETATION

The WM region is home to 19 lakes and ponds that participate in VLAP. Volunteer monitors at each lake collect comprehensive data sets at the deepest spot of the lake and from streams entering or exiting the lake. Deep spot sample collection is representative of overall lake quality conditions and provides information into how the lake responds to localized events such as stormwater and drought. Deep spot data are used to establish long term water quality trends and to provide insight into the overall health of the waterbody. Stream sample collection is representative of what flows into the lake from the surrounding watershed. Stream data are used to identify potential watershed pollution problems so that remediation actions occur before they negatively impact the overall health of the waterbody.

The following section provides a summary of the VLAP monitoring parameters, long-term water quality trends, and an analysis of the current year and historical data for the VLAP lakes and ponds in the WM region compared with regional and state medians. The deep spot data for the epilimnion, or surface water layer, is compared to the New Hampshire median to provide an understanding of how the quality of your lake deep spot compares to other New Hampshire lake deep spots. Similarly, the epilimnion data are compared to the regional median to provide an understanding of how the quality of your lake deep spot compares with other local lakes. Median values were utilized to represent historical state and regional conditions as the value tends to better represent the actual middle number while minimizing the effects of outlier values. Average annual lake and regional values are then compared to the historical medians.

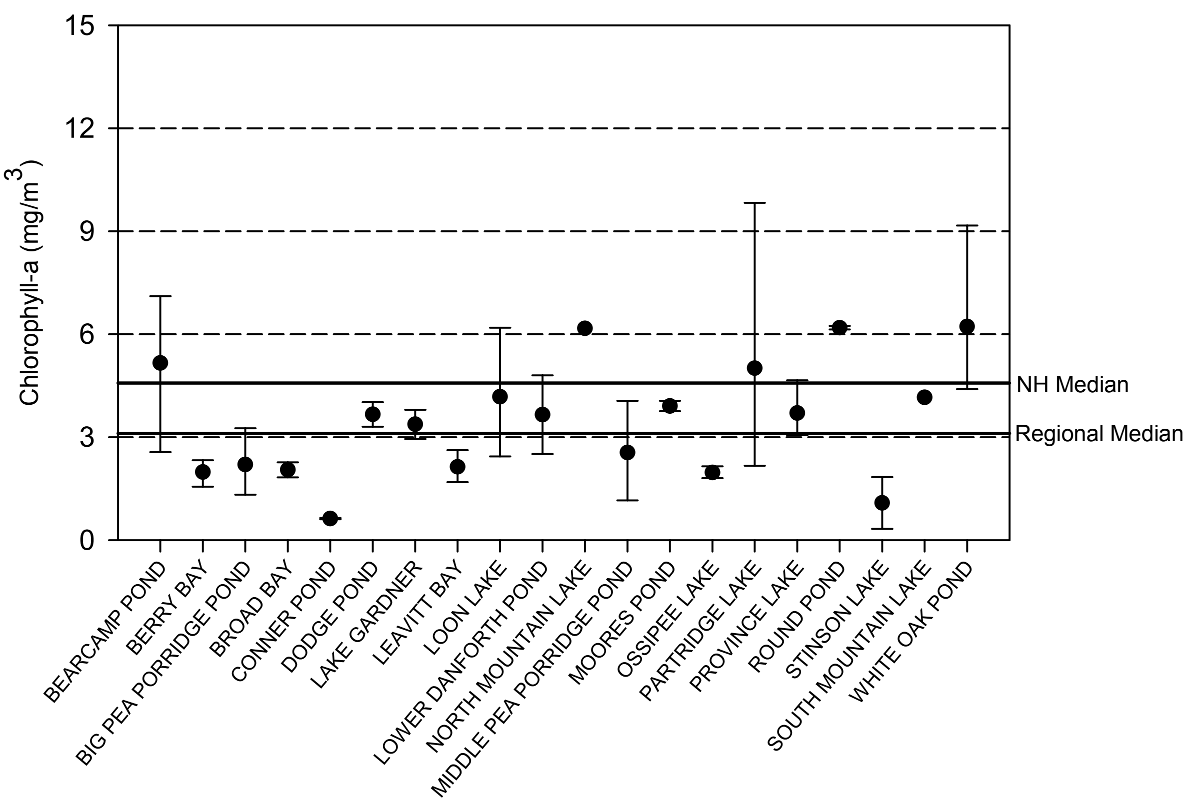
A complete list of monitoring parameters and how to interpret data are included in Appendix A.

Annual and Historical Chlorophyll-a Results

Algae are microscopic plants that are naturally found in the lake ecosystem. Algae and cyanobacteria contain chlorophyll-a, a pigment used for photosynthesis. The measurement of chlorophyll-a in the water gives biologists an estimation of the algal abundance or lake productivity. **The median summer chlorophyll-a concentration for New Hampshire's lakes and ponds is 4.58 mg/m3. The median chlorophyll-a concentration for the WM region is 3.11 mg/m^3.**

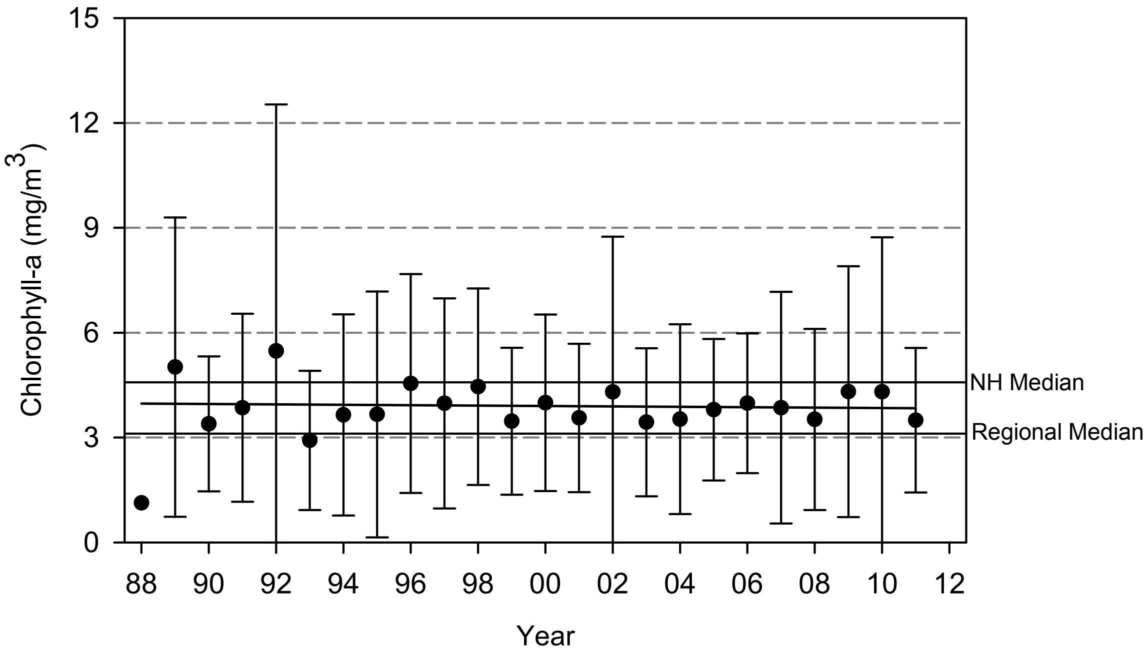
The 2011 average chlorophyll-a concentration for each lake in the WM region are represented in Figure 5. The regional and state medians are provided for reference. The average chlorophyll-a concentration at eight WM lakes are below the regional medians and are typically representative of good water quality. Seven lakes experienced average chlorophyll-a concentrations between the regional and state medians. Five lakes experienced average chlorophyll-a concentrations above the state median. Typically, chlorophyll-a concentrations that exceed 5.0 mg/m^3 are considered higher than desirable. Therefore, approximately 75 percent of the sampled deep spots have chlorophyll-a concentrations representative of Oligotrophic and Mesotrophic classifications.

Figure 5. 2011 Average Chlorophyll-a Concentration for WM Lakes



The average annual chlorophyll-a concentrations for the WM region are represented in Figure 6. Average chlorophyll-a concentrations for the region have generally remained between 3.0 and 5.0 mg/m^3 since 1988. Visual observation of the trend line indicates regional chlorophyll-a concentrations, and therefore algal growth, have remained stable over time.

Figure 6. WM Region Average Annual Chlorophyll-a Concentration



Chlorophyll-a Trend Analysis

WM region lakes with 10 or more consecutive years of data were subject to statistical analyses to determine whether water quality trends were significantly improving, degrading, stable, or variable, meaning values fluctuate between years and there is no clear trend. Chlorophyll-a trends were assessed for 12 lakes in the region. Seven lakes did not have 10 or more consecutive years of data, therefore, trend analyses were not conducted. Approximately 60 percent of the WM lakes have 10 or more years of consecutive data collection on record.

Table 2 represents the WM lake chlorophyll-a trends with the direction of the arrow indicating whether chlorophyll-a increased, decreased, or remained stable. Note that improving trends reflect a decrease in chlorophyll-s levels, and vice-versa. Approximately 90 percent of lakes have a stable or variable chlorophyll-a trend, meaning the chlorophyll-a concentrations have not significantly increased or decreased. One lake has an improving chlorophyll-a trend meaning chlorophyll-a concentrations have significantly decreased. Chlorophyll-a concentrations are typically related to phosphorus concentrations because as phosphorus increases, more algal growth occurs. The stable and improving chlorophyll-a trends are a positive sign for the region.

Table 2. Chlorophyll-a Trends in WM Lakes

Lake Name	Improve	Degrade	Stable	Variable
Partridge Lake	▼			
Bearcamp Pond			►◄	
Broad Bay			►◄	
Leavitt Bay			►◄	
Loon Lake			►◄	
Mountain Lake, South			►◄	
Big Pea Porridge Pond			►◄	
Province Lake			►◄	
Stinson Lake			►◄	
Mountain Lake, North				✶
Middle Pea Porridge Pond				✶
White Oak Pond				✶

Annual and Historical Transparency Results

Volunteer monitors use the Secchi disk, a 20 cm disk with alternating black and white quadrants, to measure how far a person can see into the water. Transparency, a measure of water clarity, can be affected by algae and sediment in the water, as well as the natural color of the water. Transparency may also be measured using a viewscope, a cylindrical tube, designed to decrease surface water properties that may cause difficulty in viewing the Secchi disk. A comparison of transparency readings collected with and without the use of a viewscope shows that the viewscope typically increases the depth to which the Secchi disk can be seen into the lake, particularly on sunny and windy days. **The median summer transparency for New Hampshire's lakes and ponds is 3.20 meters. The median transparency for the WM region is 4.00 meters.**

The WM region experienced above average rainfall during the 2011 sampling season, and was marked by Tropical Storm Irene at the end of August. This likely resulted in a lower overall transparency for many of the region's waterbodies as stormwater runoff transports exposed and unstable sediments and debris.

Figure 7 represents the 2011 average transparency for each lake in the WM region compared with state and regional medians. The average transparencies at seven WM lakes are below the state median and are typically representative of poor water quality conditions. Seven lakes fall between the regional and state median, and six are above the regional median and all are typically representative of good water quality. Overall lake depth plays an important role when interpreting transparency data. Shallow lakes will typically report lower transparencies than deeper lakes, yet these waterbodies may be quite clear. A better representation would be to look at how transparency changes over time.

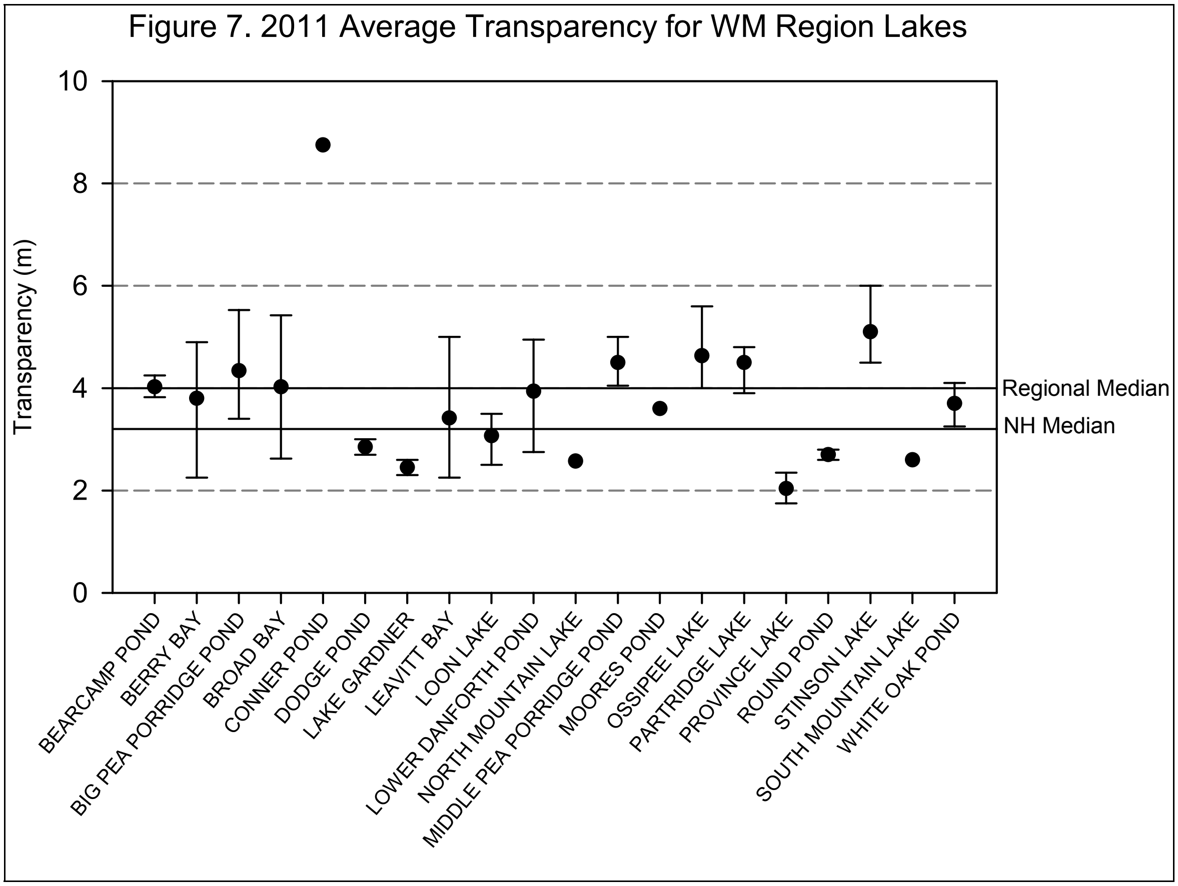
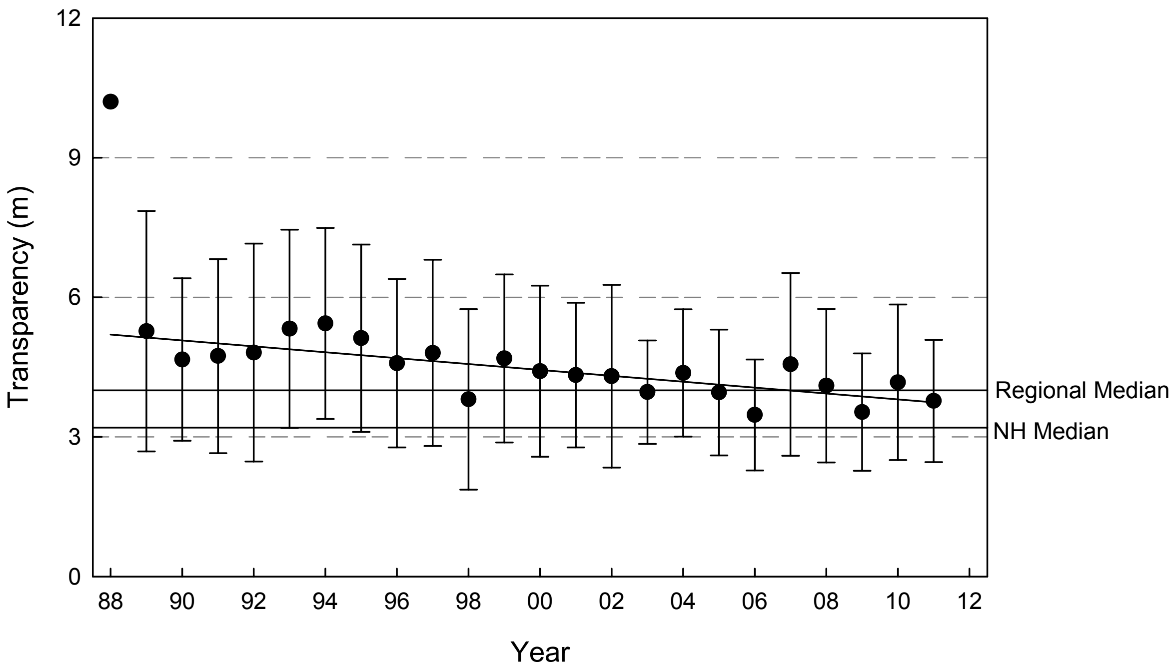


Figure 7. 2011 Average Transparency for WM Region Lakes
Transparency (m)
10
8
6
4
2
0
Regional Median
NH Median
BEARCAMP POND
BERRY BAY
BIG PEA PORRIDGE POND
BROAD BAY
CONNER POND
DODGE POND
LAKE GARDNER
LEAVITT BAY
LOON LAKE
LOWER DANFORTH POND
NORTH MOUNTAIN LAKE
MIDDLE PEA PORRIDGE POND
MOORES POND
OSSIPEE LAKE
PARTRIDGE LAKE
PROVINCE LAKE
ROUND POND
STINSON LAKE
SOUTH MOUNTAIN LAKE
WHITE OAK POND

Figure 8 represents the average annual transparency for the WM region. Average transparencies for the region remained well above the regional and state median from 1988 through 1999, and were typically close to 5.0 meters. Since then, average transparencies have declined to generally between the regional and state medians (3.0 to 4.0 meters). Visual observation of the trend line indicates regional transparency has decreased over time.

Figure 8. WM Region Average Annual Transparency



Transparency Trend Analyses

WM Region lakes with 10 or more consecutive years of data were subject to statistical analyses to determine whether water quality trends were significantly improving, degrading, stable, or variable, meaning values fluctuate between years and there is no clear trend. Transparency trends were assessed for 12 lakes in the region. Approximately 60 percent of the WM lakes have 10 or more years of consecutive data collection.

Table 3 represents the WM lake transparency trends with the direction of the arrow indicating whether the transparency increased, decreased, or remained stable. Note that improving trends reflect an increase in transparency, and vice-versa. Approximately 42 percent of lake deep spots in the region have a stable transparency trend, meaning the transparency has not significantly improved or degraded. Approximately 42 percent of the lake deep spots have a degrading trend, meaning transparency has worsened (decreased) over time.

Transparency, or water clarity, is typically affected by the amount of algae, color, and particulate matter within the water column. The stable transparency trends for the region are a positive sign; however transparency at 42 percent of the lake deep spots is degrading, or getting worse. The degrading transparency cannot be explained by a significant increase in algal growth. This suggests that the worsening transparency may be explained by an increase in suspended sediments. Stormwater runoff can transport exposed and unstable sediments and other debris to lake systems. It is imperative to identify potential areas of concern in the watershed and utilize best management practices to control stormwater and erosion. Please refer to Appendix B for reference material on do-it-yourself stormwater best management practices.

Table 3. Transparency Trends in WM Lakes

Lake Name	Improve	Degrade	Stable	Variable
Broad Bay		▼		
Leavitt Bay		▼		
Big Pea Porridge Pond		▼		
Province Lake		▼		
Stinson Lake		▼		
Bearcamp Pond			►◄	
Loon Lake			►◄	
Partridge Lake			►◄	
Middle Pea Porridge Pond			►◄	
White Oak Pond			►◄	
Mountain Lake, North				✶
Mountain Lake, South				✶

Annual and Historical Total Phosphorus Results

Phosphorus is typically the limiting nutrient for vascular plant and algal growth in New Hampshire's lakes and ponds. Excessive phosphorus in a pond can lead to increased plant and algal growth over time. **The median summer epilimnetic (upper layer) total phosphorus concentration of New Hampshire's lakes and ponds is 12 ug/L. The median epilimnetic total phosphorus concentration for the WM region is 8 ug/L.**

Figure 9 represents the 2011 average epilimnetic total phosphorus concentration for WM region lakes. The regional and state medians are provided as reference. The regional median is considerably lower than the state median, and is considered to be representative of Oligotrophic conditions. Thirteen WM lakes experienced average phosphorus concentrations equal to or below the regional median, five lakes experienced average phosphorus concentrations between the state and regional median, and only two lakes experienced average phosphorus concentrations above the state median. Overall, regional epilimnetic phosphorus concentrations are relatively low and representative of Oligotrophic and Mesotrophic conditions.

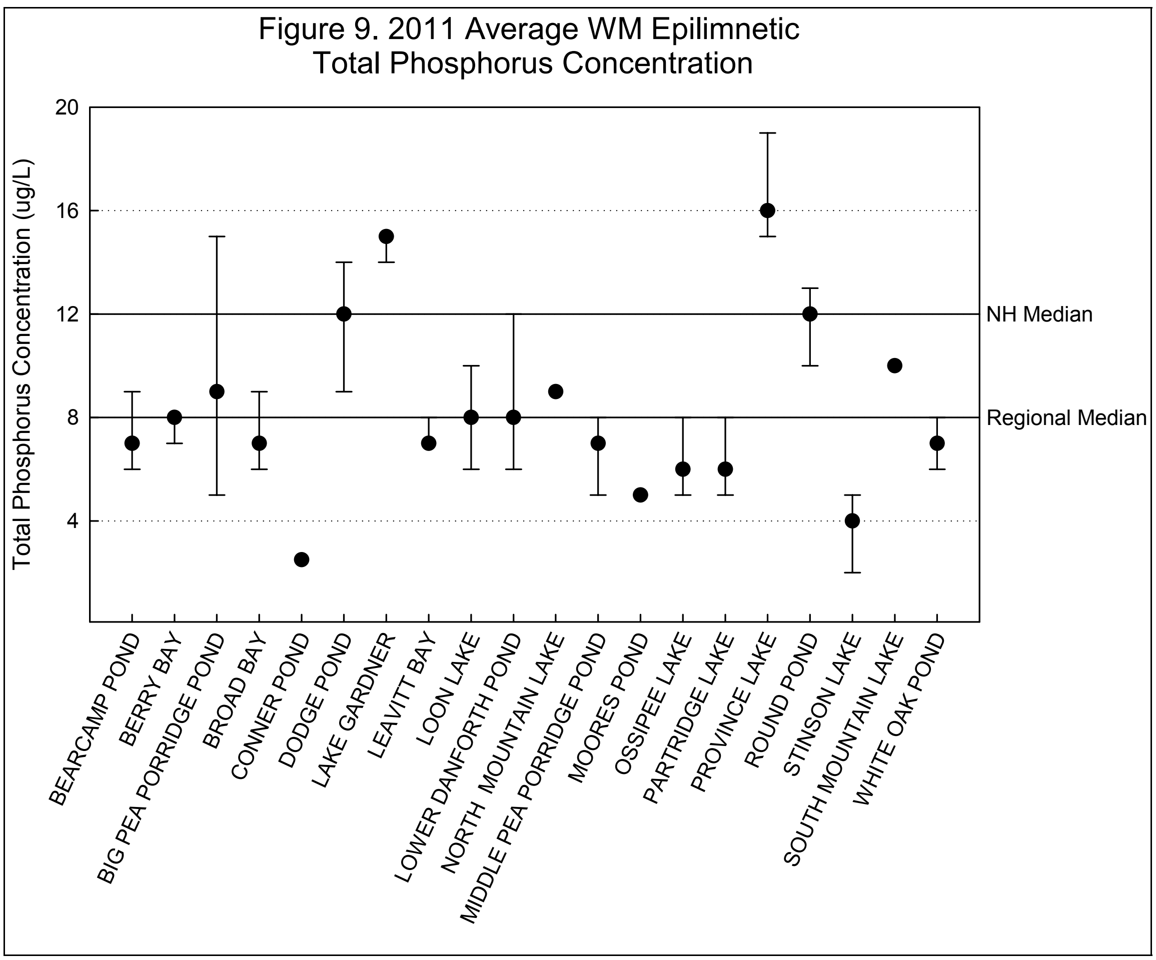
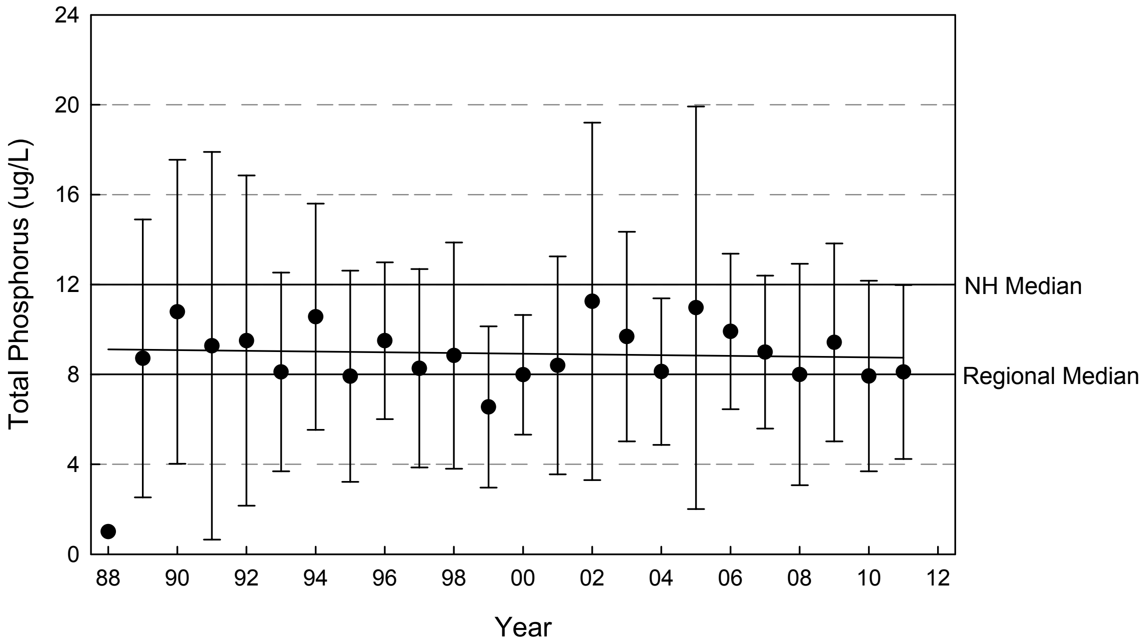


Figure 10 represents the average annual epilimnetic phosphorus concentration for the WM region. The average annual epilimnetic phosphorus concentrations have generally remained between the regional and state median since 1988, and more specifically tend to be between 8 and 9 ug/L, which is representative of Oligotrophic conditions. Visual observation of the trend line indicates regional epilimnetic phosphorus has remained relatively stable over time.

Figure 10. WM Region Average Annual Epilimnetic Phosphorus Concentration



Epilimnetic Phosphorus Trend Analyses

WM region lakes with 10 or more consecutive years of data were subject to statistical analyses to determine whether water quality trends were significantly improving, degrading, stable, or variable, meaning values fluctuate between years and there is no clear trend. Epilimnetic total phosphorus trends were assessed for 12 lakes in the region. Approximately 60 percent of the WM lakes have 10 or more years of consecutive data collection. This allows a more accurate picture of regional water quality trends.

Table 4 represents the WM lake epilimnetic total phosphorus trends with the direction of the arrow indicating whether the phosphorus has increased, decreased, or remained stable. Note that improving trends reflect a decrease in phosphorus levels, and vice-versa. Approximately 75 of lake deep spots have a stable or variable epilimnetic phosphorus trend, meaning the phosphorus concentrations have not significantly improved or degraded since monitoring began. Seventeen percent of the lake deep spots have an improving total phosphorus trend, meaning phosphorus concentrations have significantly decreased, which is a positive sign. And only one lake has a degrading phosphorus trend, meaning phosphorus concentrations have significantly increased.

Increasing epilimnetic phosphorus trends are often a result of phosphorus-enriched stormwater runoff related to increased watershed development. An increase in watershed development often results in an increase in impervious surfaces and unstable sediments. This contributes to an increase in stormwater runoff and sedimentation to rivers and lakes. Efforts should be made to adopt watershed ordinances to limit stormwater runoff and other phosphorus contributions. Watershed residents should be educated on utilizing and installing best management practices to control stormwater runoff from their own properties. For more information and resources to control phosphorus loading refer to Appendix B.

Table 4. Epilimnetic Total Phosphorus Trends in WM Lakes

Lake Name	Improve	Degrade	Stable	Variable
Loon Lake	▼			
Partridge Lake	▼			
Mountain Lake, North		▲		
Bearcamp Pond			►◄	
Big Pea Porridge Pond			►◄	
Middle Pea Porridge Pond			►◄	
Province Lake			►◄	
White Oak Pond			►◄	
Broad Bay				✶
Leavitt Bay				✶
Mountain Lake, South				✶
Stinson Lake				✶

Dissolved Oxygen Data Analysis

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, typically less than 5 mg/L, species intolerant, meaning sensitive, to this situation, such as trout, will be forced to migrate closer to the surface where there is more dissolved oxygen but the water is generally warmer, and the species may not survive. Temperature and time of day also play a role in the amount of dissolved oxygen in the water column. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than during the summer. Oxygen concentrations are typically lower overnight than during the day. Plants and algae respire (use oxygen) at night and photosynthesize (produce oxygen) during the day. Dissolved oxygen levels may shift depending on the abundance of aquatic plants and algae in the littoral (near shore) and pelagic (deep water) zones.

Dissolved oxygen and temperature profiles are collected at VLAP lakes on an annual or bi-annual basis. The average dissolved oxygen levels for the WM region is 6.87 mg/L, which is sufficient to support a wide range of aquatic life. For additional information regarding dissolved oxygen please refer to Appendix A.

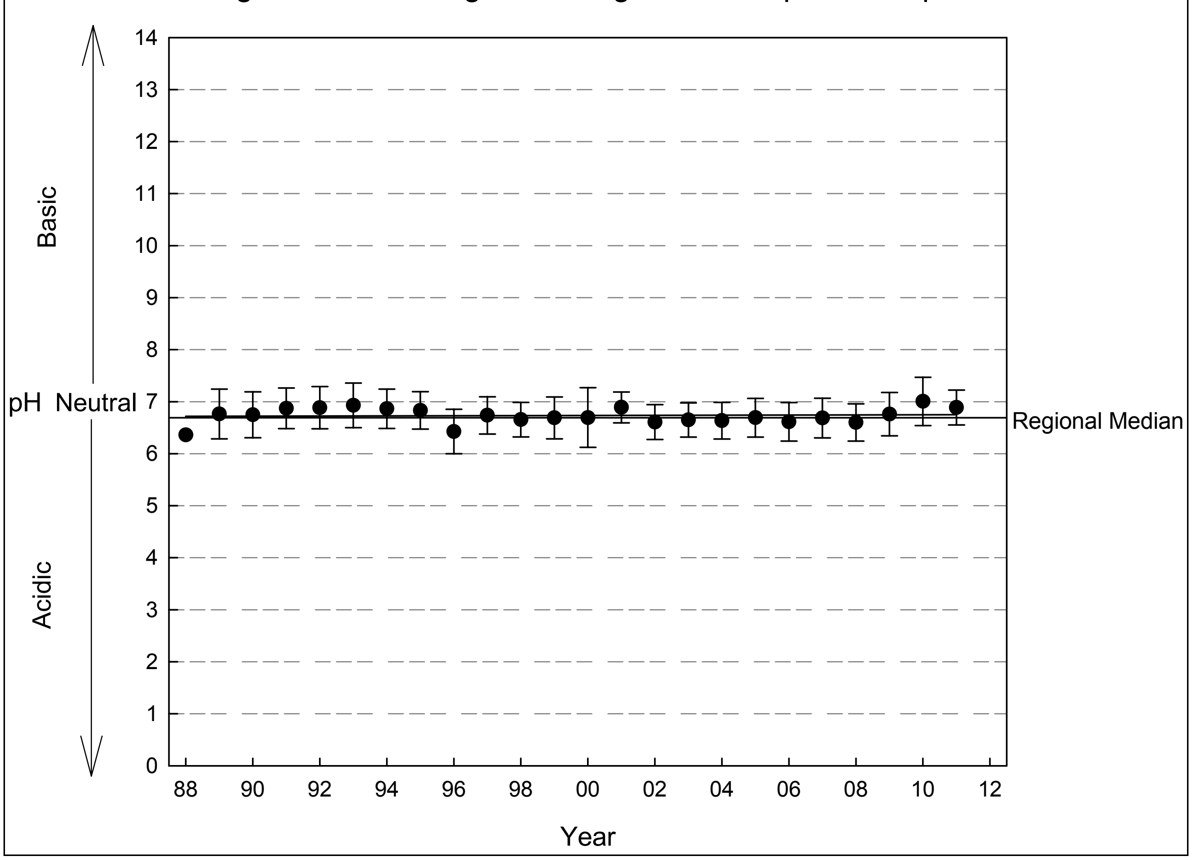
Annual and Historical Deep Spot pH Data Analysis

pH is measured on a logarithmic scale of 0 (acidic) to 14 (basic). pH is important to the survival and reproduction of fish and other aquatic life. A pH below 6.0 typically limits the growth and reproduction of fish. A waterbody is considered impaired for aquatic life when the pH falls below 6.5 or above 8.0. **The median epilimnetic pH value for New Hampshire's lakes is 6.6, which indicates that the state surface waters are slightly acidic. The median epilimnetic pH for the WM region is 6.69.**

Figure 11 represents the average annual pH value for WM lakes. The 2011 average epilimnetic pH value at WM lakes was 6.89, which means that the water is slightly acidic. The lowest, most acidic, average pH value was 6.18 measured at Conner Pond in Ossipee whereas; the highest, most basic, pH value was 7.59 measured at Partridge Lake in Littleton. Visual inspection of the trend line indicates regional pH has remained stable.

Variations in pH values between lakes and between different geographical regions may depend on the composition and weathering of underlying bedrock and the lake water chemistry. Another contributing factor to pH is acid deposition received as a result of emissions from power plants and vehicles. This increases levels of atmospheric carbon, nitrogen and sulfur which fall back to the earth in the form of acidic precipitation.

Figure 11. WM Region Average Annual Epilimnetic pH

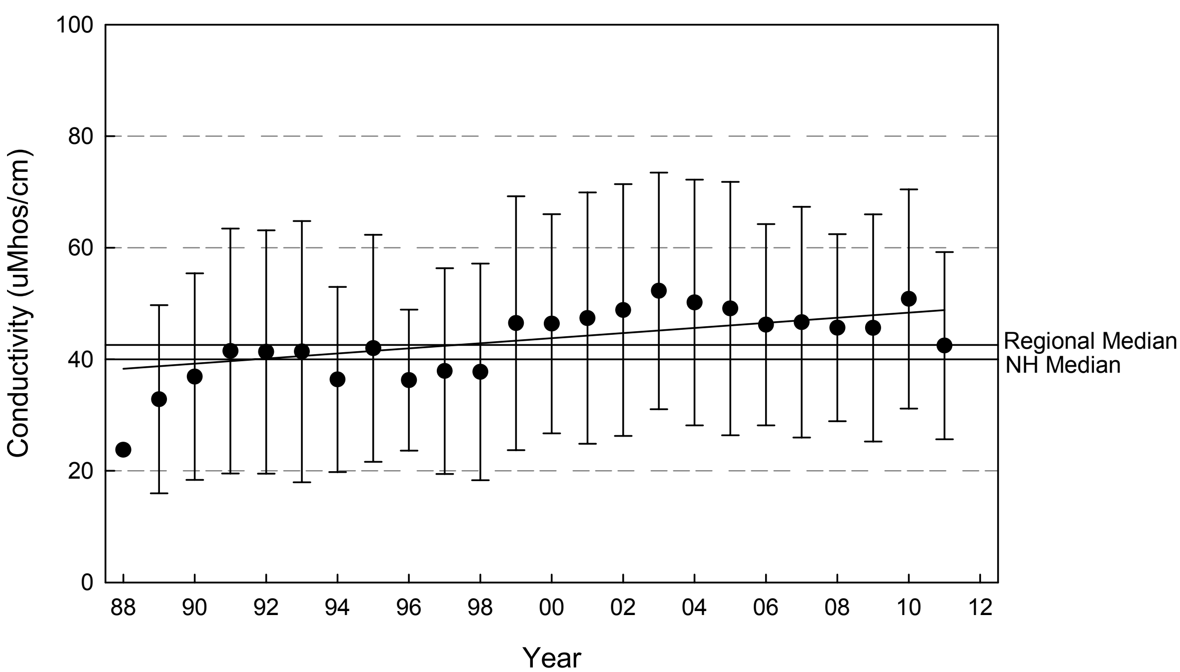


Annual and Historical Deep Spot Conductivity and Chloride Data Analysis

Conductivity is the numerical expression of the ability of water to carry an electric current, which is determined by the number of negatively charged ions from metals, salts, and minerals in the water column. The soft waters of New Hampshire have traditionally low conductivity values, generally less than 50 uMhos/cm. However, specific categories of good and bad levels cannot be constructed for conductivity because variations in watershed geology can result in natural fluctuations. **The median conductivity value for New Hampshire's lakes and ponds is 40.0 uMhos/cm. The median epilimnetic conductivity value for the WM region is 42.6 uMhos/cm.**

Figure 12 represents the average annual epilimnetic conductivity for the WM region. Conductivity values fluctuate widely among the region's lakes. The lowest value of 11.7 uMhos/cm was measured at Conner Pond in Ossipee, whereas the highest value of 72.7 uMhos/cm was measured at Dodge Pond in Lyman. A wide range of watershed types and degrees of development exists in the region. This coupled with unique chemical and physical properties of each lake can yield broad differences in conductivity. Overall, visual inspection of the trend line indicates regional conductivity has increased slightly since monitoring began.

Figure 12. WM Region Average Annual Epilimnetic Conductivity



Generally, conductivity values in New Hampshire lakes exceeding **100 uMhos/cm** indicate cultural, meaning human, disturbances. An elevated conductivity trend typically indicates point source and/or non-point sources of pollution are occurring within the watershed. These sources include failed or marginally functioning septic systems, agricultural runoff, and road runoff, and groundwater inputs. New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could also contribute to increasing conductivity. In addition, natural sources, such as mineral deposits in bedrock, can influence conductivity.

The chloride ion (Cl^-) is found naturally in some surface and ground waters and in high concentrations in seawater. Research has shown that elevated chloride levels can be toxic to freshwater aquatic life. In order to protect freshwater aquatic life in New Hampshire, the state has adopted **acute and chronic** chloride criteria of **860 and 230 mg/L** respectively. The chloride content in New Hampshire lakes is naturally low in surface waters located in remote areas away from habitation. Higher values are generally associated with salted highways and, to a lesser extent, with septic inputs. **The median chloride value for New Hampshire's lakes is 4 mg/L. The median epilimnetic chloride value for the WM region is 6 mg/L.**

Figure 13. WM Region Average Annual Epilimnetic Chloride

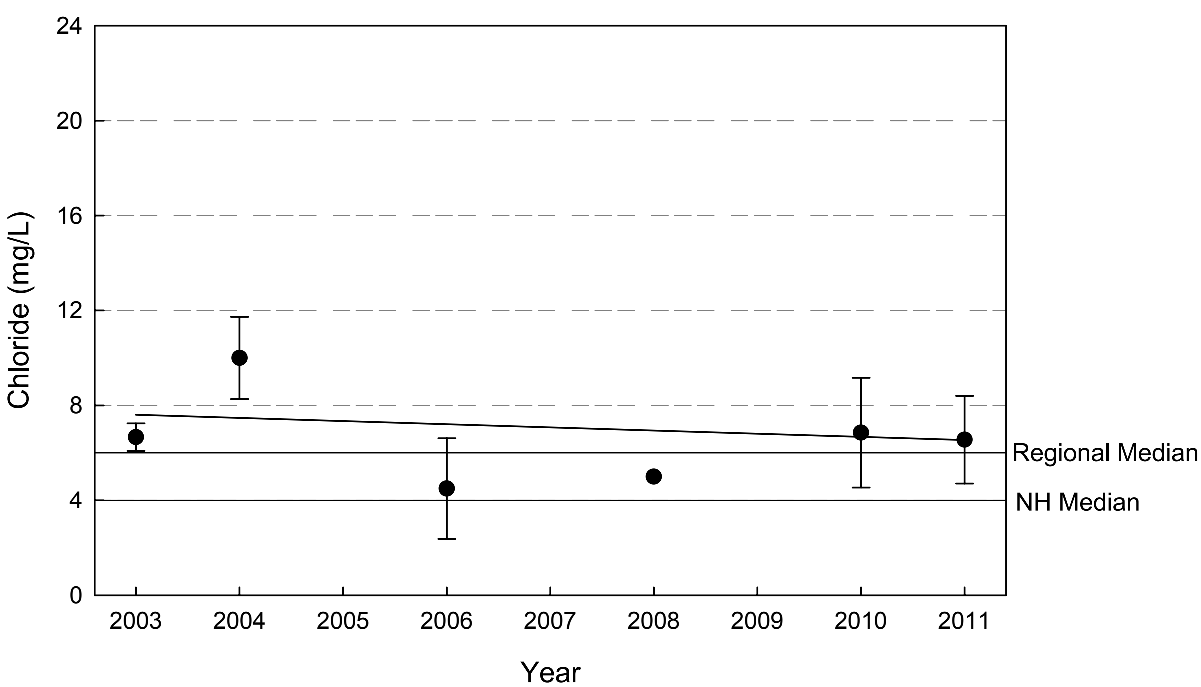


Figure 13 depicts average annual epilimnetic chloride levels for select regional lakes. The chloride measurement is relatively new for VLAP and is an optional analyte for participating lakes. Lakes that serve as water supplies or where conductivity levels may be influenced by chloride are analyzed annually. Average regional epilimnetic chloride levels generally range between 4 and 8 mg/L. Regional chloride levels are much less than the acute and chronic chloride criteria; however, they are slightly greater than what we would typically measure in undisturbed NH surface waters.

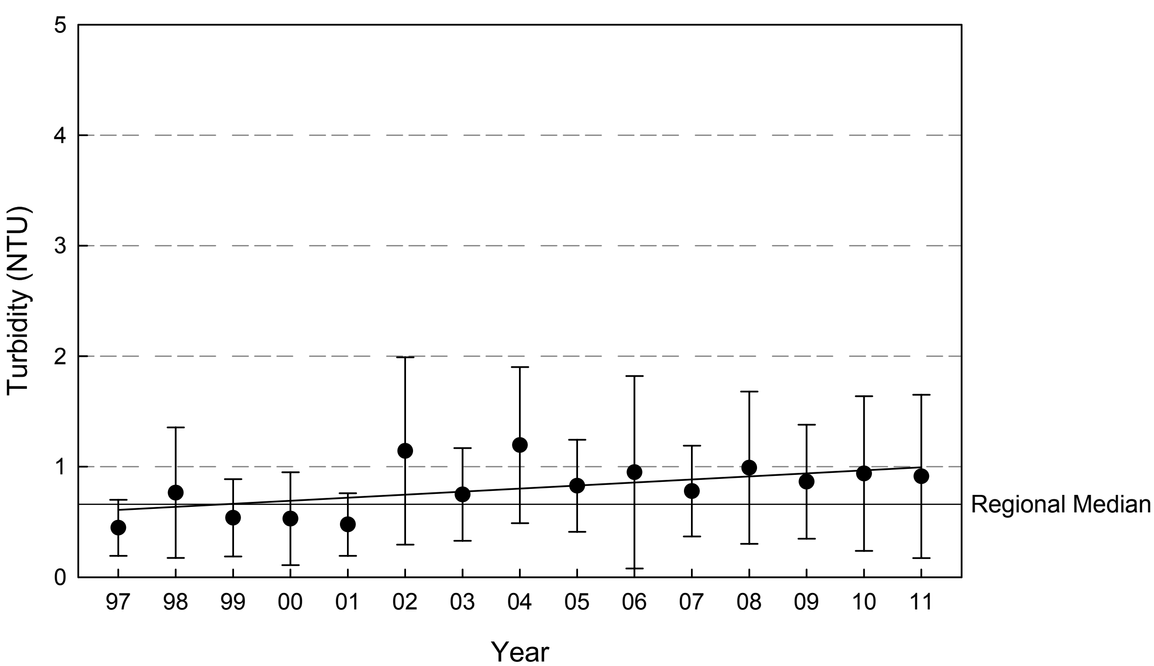
Watershed management efforts to control un-natural sources of conductivity and chloride in waterbodies should employ a combination of best management practices in regards to winter salting practices. State and local governments and private homeowners should evaluate the use of road salt and alternatives to reduce the amount of material applied while maintaining public safety. *For additional information on the relationship between conductivity and chloride, please refer to Appendix A. For additional information on best management practices please refer to Appendix B.*

Annual and Historical Deep Spot Turbidity Data Analysis

Turbidity in the water is caused by suspended matter (such as clay, silt, and algae) that cause light to be scattered and absorbed, not transmitted in straight lines through water. Water clarity is strongly influenced by turbidity. **The Class B surface water quality standard for turbidity is no greater than 10 NTUs over the lake background level. The median epilimnetic turbidity for the WM region is 0.66 NTU.**

Figure 14 represents the average annual epilimnetic turbidity for WM region lakes. The 2011 average epilimnetic turbidity at WM lakes was 0.91 NTU, which is slightly greater than the regional median. Regional epilimnetic turbidity is generally below 1.0 NTU and is average for most NH lakes. However, the trend line indicates average annual turbidity levels are slightly increasing, particularly since 2001. New Hampshire has experienced more significant rainfall events in recent years which may be contributing to an increase in stormwater runoff and turbidity in the region's lakes.

Figure 14. WM Region Average Annual Epilimnetic Turbidity



Elevated deep spot turbidity levels are typically the result of stormwater runoff, algal or cyanobacteria blooms, and/or disturbance of lake bottom sediments. Stormwater BMPs should be implemented when possible to reduce the amount of suspended sediments and debris transported to surface water. Boating activity in shallow areas should adhere to rules specified by the NH Marine Patrol in regards to speed and no wake zones. If an algal or cyanobacteria bloom is observed, please contact DES immediately. *For additional information on stormwater BMPs, boating, algae, and cyanobacteria please refer to Appendices A and B.*

Reference:

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