Prepared for:
United States Environmental Protection Agency
Boston, MA

Determination of Total Maximum Daily Load (TMDL) for 158 Acid Impaired and 21 Aluminum Impaired New Hampshire Ponds

Final

ENSR Corporation
September 2007
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Executive Summary

This Acid Pond TMDL Report is presented as part of ENSR Corporation's (ENSR) tasks under its United States Environmental Protection Agency (USEPA) contract CWQ-003 entitled "*New Hampshire Total Maximum Daily Load (TMDL) Development.*" ENSR is providing technical support to USEPA and the New Hampshire Department of Environmental Services (NHDES) in the development of TMDL for nutrient and acid-impaired waterbodies, as part of that state's Clean Water Act Section 303(d) compliance.

Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning Regulations (40 CFR Part 130) require states to develop TMDLs for water quality limited segments that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollutant sources and pond water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources.

ENSR compiled and synthesized watershed and water chemistry data required for development of TMDLs for acid-impaired waterbodies in New Hampshire. These waterbodies were listed as acid-impaired under New Hampshire's 2006 Clean Water Act (CWA) Section 303(d) list. The complete suite of 272 Assessment Units identified for the Acid TMDL study consists of 156 lakes, 2 impoundments, and 114 associated beaches. Figure 1 indicates the location and Table 1 provides a list of the 158 lakes and impoundments and 114 associated beaches, listed according to their associated Assessment Unit (AU) codes. In addition, a number of waterbodies were also identified on the State's 303(d) list as not meeting the state water quality criterion for aluminum for protection of sensitive aquatic receptors of 87 ug/L (= parts per million). These aluminum impaired ponds are also to be addressed by the TMDL process. Figure 2 indicates the location and Table 2 provides a list of the 21 aluminum-impaired waterbodies.

ENSR is simultaneously addressing the TMDL development for both acid- and aluminum-impaired ponds within the Acid Pond TMDL Report. USEPA and NHDES have approved the linkage of these two TMDL processes since the root cause (atmospheric deposition) is similar for both acid and aluminum impairment.

The Introduction (Section 1.0) provides the regulatory background and objectives of the Acid Pond TMDL Report and presents the organization of the report. In addition to the report narrative, supporting information is included within several appendices which provide background information, summarize the applicable water quality data, and document the calculations and data used for TMDL development.

The Problem Statement (Section 2.0) describes the nature of the acid impairment to New Hampshire ponds and its root causes. These causes are also applicable to aluminum impairment as well. The New Hampshire water quality standards and goals are defined in the section and applicable pH and aluminum limits are identified. The section also explains how the affected waterbodies came to be listed on New Hampshire's 2006 CWA Section 303(d) list.

To complete these TMDLs, ENSR used the Steady State Water Chemistry (SSWC) model originally developed by Henrikson and Posch (2001), with the assumptions and modifications adopted by the Vermont Department of Environmental Conservation (VTDEC), to calculate critical loads and develop TMDLs (see Appendix A for details). This method of determining critical loads is based on annual surface runoff (Appendix B), specified target Acid Neutralizing Capacity (ANC) (Appendix C), and water chemistry (Appendix D), and is consistent with the approach previously developed by New Hampshire and previously approved by Region 1 (i.e., NHDES, 2004).

Mean pH values were calculated for each lake using the minimum value observed on each sampling date across stations and depths (see Appendix C for greater information on pH calculation). Using the data from the 158 acid-impaired ponds, a simple linear regression of mean pH vs. mean Gran ANC was generated to derive a target ANC value (Figure 3). As indicated on the figure, at the NH criterion pH of 6.5, the corresponding $[ANC]_{limit}$ would be **6.24** mg/L (125 ueq/L). This $[ANC]_{limit}$ value was reviewed by USEPA and NHDES and approved for use in the TMDL development process. For purposes of aluminum impairment, the target water quality goal is longterm compliance with the freshwater chronic criterion value of 87 ug/L and the freshwater acute criterion of 750 ug/L..

Section 3.0 describes Existing Point and Nonpoint Sources. As part of the development of a TMDL, it is necessary to account for the anthropogenic contributions of point source (e.g., NPDES-permitted discharges) and nonpoint source loads (e.g., stormwater, atmospheric deposition, mine drainage).Due to the nature of the pollutants, there are no known point sources of low pH or aluminum discharging to the ponds evaluated in this TMDL nor are they present in their watersheds. On the other hand, it has long been established scientifically that the deposition of strong mineral acids and acid forming compounds from the atmosphere have been the primary source of the acidification for New Hampshire ponds. Therefore it is the regional atmospheric deposition of these pollutants that is the “driver” of pond acidity or watershed aluminum inputs.

Section 4.0 (TMDL and Allocations) provides the definition and individual components of a TMDL (section 4.1); the quantitative elements of the TMDL including seasonal considerations and margin of safety (MOS) (Section 4.2), and the TMDL Calculation and Load Allocation (Section 4.3).

For the current application to the TMDLs for acid-impaired ponds, a MOS at 10% was recommended by NHDES, with the consensus of USEPA. This MOS factor was selected because the current water chemistry data set includes data from all seasons and at a variety of pond water depths. The measured pH values tend to be lowest in winter and located at depth (i.e., near pond bottoms), often in stratified systems. This conservative pH data was used in the assessments, but was matched with cation data in the SSWC model that were taken from the summer, upper layer (since it was the only data available).

For the TMDLs for aluminum-impaired ponds, no explicit MOS is recommended. The primary reasons for this recommendation are: (1) the chronic criterion is already based on protection of sensitive salmonids; (2) the reported aluminum measurements are in total aluminum which is likely to underestimate the dissolved monomeric form that is the toxic fraction; and (3) site-specific water quality factors (e.g., dissolved organic carbon) are likely to mitigate toxic effects. As noted in Section 5.1, aluminum bioavailability is highly dependent on pH values. Therefore, mitigation of acid impairment will also concurrently address aluminum impairment. Since a MOS is already proposed for the acid TMDL, this will also serve as an implicit MOS with regard to the aluminum TMDL process.

The SSWC model was used to calculate critical loads for acid ponds. Using the project-specific water quality target of 6.24 mg/L of ANC, the critical load for each of the 158 ponds is given in Table 3. The critical loads are reported as both yearly ($meq/m^2/yr$) and daily ($meq/m^2/day$) loads. Positive critical load values indicate that the waterbody has some tolerance for acidic inputs and still be able to maintain the target ANC of 6.24 mg/L. On the other hand, negative critical loads represent situations where the selected ANC target of 6.24 mg/L is higher than the original, pre-acidification, base cation concentrations would naturally allow and the critical load is zero.

Table 4 summarizes the final TMDL acid allocations for all 158 of the acid impaired ponds covered under this TMDL. Since the source of all the acidity is considered to be non-point, the waste load allocation is equal to zero and the TMDL or critical load is divided between the load allocation and the MOS of 10%. These TMDL values indicate the permissible load to achieve compliance with water quality standards.

Section 5.0 (Evaluation of Aluminum-Impaired Ponds) is a condensed version of a literature review providing background on current theories and potential methods of identifying the source of aluminum impairment in New Hampshire waters. [Note: the full report is available as Appendix E]. The review does not attempt to cover the considerable scientific literature on aluminum chemistry but it identified a number of peer-reviewed papers that provide an updated overview on the subject with particular emphasis on potential sources of aluminum. The literature review indicates that the accepted paradigm of aluminum loadings controlled by low pH waters controlled largely by atmospheric deposition is giving way to the acknowledgment of the complex role played by organic acids in influencing the amounts, seasonality, and toxicity of aluminum in New England waters.

While the research efforts are promising, extrapolation of these theories to look for simple relationships between aluminum and potential causal factors that distinguish between natural and anthropogenic sources did not prove successful when data from the 21 aluminum-impaired lakes was applied (Section 5.4). Further work to reduce this uncertainty may be conducted, but may or may not result in useful predictive models. Overall, it is expected that a significant and long-term reduction in upwind emissions of acidifying pollutants are needed to reduce the aluminum exceedances in New Hampshire's waters.

Section 303(d)(1)(C) of the CWA provides that TMDLs must be established at a level necessary to implement the applicable water quality standard. Section 6.0 (Implementation and Reasonable Assurance) describes the activities that have been implemented or proposed to mitigate, monitor and/or restore acid-impaired and aluminum-impaired ponds in New Hampshire

To address the primary components of acid deposition –sulfur dioxide and nitrogen oxide air pollution emissions the NHDES, Air Resources Division has implemented various emission reduction programs and participated in regional and national efforts. The federal Acid Rain program caps SO_2 emissions in two phases - 1995 and 2000 and reduced NOx emissions in 1996 and 2000. The federal Clean Air Implementation Rule (CAIR) will further reduce NOx emissions in 2009 and SO2 emissions in 2010 in states with sources whose emissions are transported to New Hampshire.

In 1991, prior to the implementation of federal Acid Rain Program, New Hampshire adopted the New Hampshire Acid Deposition Control Program to cap SO_2 emissions at three electric utilities. New Hampshire also participates in the New England Governors and Eastern Canadian Premiers (NEG/ECP) Acid Rain and Air Quality Steering Committee. In 1998, New Hampshire supported the NEG/ECP Acid Rain Action Plan. To achieve the goals of this plan, New Hampshire codified a multi-pollutant (SO_2, NOx, mercury, and carbon dioxide) program addressed in the *New Hampshire Clean Air Strategy* (NHDES, 2001). New Hampshire amended this program in 2006 to require the installation of an SO_2 scrubber by July 1, 2013 at the largest electric utility in the state to reduce mercury (a co-benefit of SO_2 emission reductions). New Hampshire is also involved in regional planning efforts for Regional Haze focusing on SO_2 emission reductions. However, the bulk of the acidifying pollutants contributing to local acid impairments identified in this TMDL are from sources well beyond New Hampshire's borders. New Hampshire has little direct control over these sources and relies on national emission reduction programs spearheaded by the U.S. EPA.

Monitoring is conducted via long-term data collection (e.g., NHDES Environmental Monitoring Database) to provide the means to both monitor pond-specific WQS compliance as well as detect changes and regional trends in waterbodies. Four potential sources of water quality monitoring data are available in New Hampshire including monitoring of the following: Remote Ponds; Outlet Ponds; Trophic survey; and Volunteer Lake Assessment Program (VLAP) waterbodies. In addition, NHDES will continue to provide acid pond data for a selected 20 ponds in the Water Acidity Regional Network to Inform Northeast Governments network (NEG/ECP WARNING).

Section 7.0 (Public Participation and List of Substantive Changes) describes and documents the activities and processes by which NH DES solicits public input and comment on the Acid Pond TMDL Report, including description of the public participation process, the public comments on the Report and NHDES responses, and documentation of the substantive differences between the draft and final TMDL.

References for this document are contained in Section 8.0. Additional secondary references are included in many of the Appendices as well.

1.0 Introduction

This TMDL report is presented as part of ENSR Corporation's (ENSR) tasks under its United States Environmental Protection Agency (USEPA) contract CWQ-003 entitled "*New Hampshire Total Maximum Daily Load (TMDL) Development.*" ENSR is providing technical support to USEPA and the New Hampshire Department of Environmental Services (NHDES) in the development of TMDL for nutrient and acid-impaired waterbodies, as part of that state's Clean Water Act Section 303(d) compliance.

As part of this contract with USEPA, Region 1, ENSR is compiling and synthesizing the watershed and water chemistry data required for development of TMDLs for 272 acid-impaired Assessment Units (including waterbodies and associated beaches) in New Hampshire (i.e., Acid Pond TMDL Report). Figure 1 indicates the location and Table 1 provides a list of the 158 lakes and impoundments, listed according to their associated Assessment Unit (AU) codes. Table 1 also lists non-waterbody Assessment Units (i.e., parks and beaches) where water testing is conducted. However, individual TMDLs do not need be developed for these Units as they will be addressed by the development of a TMDL for the pond on which they are situated.

Within this TMDL document, ENSR is simultaneously addressing the TMDL development for 21 aluminum-impaired ponds. Figure 2 indicates the location and Table 2 provides a list of the 21 aluminum-impaired waterbodies and one beach. Both USEPA and NHDES have approved the linkage of these two TMDL processes since the root cause (atmospheric deposition) is similar for both acid and aluminum impairment.

1.1 Regulatory Background

Section 303(d) of the Clean Water Act (CWA) and EPA's Water Quality Planning Regulations (40 CFR Part 130) require states to develop TMDLs for water quality limited segments that are not meeting designated uses under technology-based controls for pollution. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollutant sources and lake water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources. States can also use this data to develop air quality based controls to reduce the acid compounds that form acid deposition affecting the water quality.

A total of 272 lakes, impoundments and beaches were identified on the State's 303(d) list as a high priority because of low pH values. These Assessment Units were listed as acid-impaired under New Hampshire's 2006 Clean Water Act (CWA) Section 303(d) list because testing indicated that pH values were less than (i.e., exceed acceptable limits) the State's surface water quality criterion of 6.5 pH standard units (SU) for protection of aquatic life. These ponds and associated beaches are considered high priority for TMDL development.

In addition, a number of waterbodies have also been identified on the State's 303(d) list as not meeting the state water quality chronic criterion for aluminum for protection of sensitive aquatic receptors of 87 ug/L (= parts per million). These aluminum impaired ponds are included in the TMDL process and are being addressed by this Report.

1.2 Objectives of the Acid Pond TMDL Report

The primary purpose of the Acid Pond TMDL Report is to develop TMDLs for 272 acid impaired New Hampshire lakes. This number includes the 266 waterbodies identified in the original NHDES request for proposals as well as six additional waterbodies and two more beaches added at the request of NHDES (e-mail from Margaret Foss, NHDES; dated March 13, 2007). The complete suite of 272 acid-impaired Assessment Units identified for the Acid Pond TMDL study consists of 156 lakes, 2 impoundments, and 114 associated beaches. For purposes of this TMDL document, these waterbodies are collectively referred to as ponds.

The purpose of the TMDL is to link acidic loading to a pond's Acid Neutralizing Capacity (ANC) and to quantify the maximum amount of acidity or critical load that a watershed can receive and maintain the target ANC to protect aquatic life. ENSR used the Steady State Water Chemistry (SSWC) model originally developed by Henrikson and Posch (2001), with the assumptions and modifications adopted by the Vermont Department of Environmental Conservation (VTDEC), to calculate critical loads and develop TMDLs. This method of determining critical loads is based on water chemistry, annual surface runoff, and a specified target ANC and is consistent with the approach previously developed by New Hampshire for acid TMDLs for 65 ponds and approved by Region 1 (i.e., NHDES, 2004).

Because the source and type of the problematic loading (in this case atmospheric acid deposition) was similar for all the lakes, a single analytical approach was used to determine each pond's acid loading capacity or critical load. This approach allowed the analysis and determination of critical loads for all 158 ponds and combining this information and determination into the Acid Pond TMDL report. [Note: although this document addresses both acid and aluminum impairments for convenience it will be referred to as the Acid Pond TMDL Report].

A secondary purpose of the TMDL report is to address 21 aluminum-impaired waterbodies identified as not meeting the state water quality criterion for aluminum. High aluminum concentrations in New Hampshire water bodies raise concern because of the potential toxic effects that aluminum can have on aquatic organisms under conditions of low pH and ANC conditions.

The high levels of aluminum found in these ponds has been somewhat puzzling as to their source(s), and for purposes of TMDL allocation, it is necessary to distinguish, if possible, between natural and anthropogenic sources of aluminum. Elevated aluminum levels in aquatic systems have long been associated with acid deposition (Schindler, 1988), but the presence of natural organic acids complicates the relationship between elevated aluminum and anthropogenic acid deposition. As part of the TMDL analysis, ENSR conducted a literature review to help identify potential methods of differentiating between natural and anthropogenic aluminum sources and evaluated available data for the aluminum-impaired ponds. The results of this investigation is included as part of the TMDL document.

1.3 Organization of the Acid Pond TMDL Report

This report follows the general organization of the previous NHDES Acid Pond TMDL Report (NHDES, 2004) and contains the following sections:

- Introduction – a brief statement of regulatory background and objectives of the report (Section 1.0);
- Problem Statement – description of the waterbodies, applicable water quality standards and goals, and evidence of water quality impairment (Section 2.0);
- Existing Point and Nonpoint Source Loads – definition and designation of point and nonpoint source load allocations (Section 3.0);
- Total Maximum Daily Load and Allocations – TMDL definition, methodology of determining TMDL including seasonal considerations, definition of Margin of Safety (MOS), and TMDL calculation and load allocation (Section 4.0);
- Evaluation of potential causes of aluminum impairment in impacted ponds (Section 5.0);
- Implementation/Reasonable Assurance – descriptions of activities to implement and achieve TMDLs (Section 6.0);

- Public Participation and Substantive Changes (placeholder section reserved for public comments and/or major revisions of draft TMDL report) (Section 7.0); and
- References – list of critical references and documents of interest (Section 8.0).

Supporting information for the Acid Pond TMDL Report is included within several appendices which provide background information, summarize the applicable water quality data, and document the calculations and data used for TMDL development. These appendices include:

- Appendix A – Background Information on the Steady-State Water Chemistry (SSWC) model;
- Appendix B – Estimated Runoff Values for Watersheds in Acid Pond TMDL Study;
- Appendix C – Determination of Acid Neutralizing Capacity (ANC) Target Value for Acid Pond TMDL Study;
- Appendix D – Calculations and Data Used for Acid Pond TMDL Derivations; and
- Appendix E – Evaluation of Potential Causes of Aluminum Impairment in New Hampshire Ponds.
- Appendix F – Public Notice of Draft Acid Pond TMDL Report

Table 1. Waterbody ID and Names of New Hampshire Acid-Impaired Lakes

TMDLID	AUID	AUName	Town	Pond
1	NHIMP700061403-04	POWWOW POND	KINGSTON	X
2	NHLAK600020202-01	FALLS POND	ALBANY	X
3	NHLAK600020302-01-01	ECHO LAKE	CONWAY	X
3	NHLAK600020302-01-02	ECHO LAKE - STATE PARK BEACH	CONWAY	
4	NHLAK600020303-03	IONA LAKE	ALBANY	X
4	NHLAK600020303-03-02	IONA LAKE - CAMP ALBANY BEACH	ALBANY	
5	NHLAK600020303-05	BIG PEA PORRIDGE POND	MADISON	X
6	NHLAK600020303-06	MIDDLE PEA PORRIDGE POND	MADISON	X
7	NHLAK600020303-07-01	PEQUAWKET POND	CONWAY	X
7	NHLAK600020303-07-02	PEQUAKET POND - REC DEPARTMENT BEACH	CONWAY	
8	NHLAK600020303-09	WHITTON POND	ALBANY	X
9	NHLAK600020604-03	MOORES POND	TAMWORTH	X
10	NHLAK600020701-02	LOWER BEECH POND	TUFTONBORO	X
10	NHLAK600020701-02-02	LOWER BEECH POND - WILLIAM LAWRENCE CAMP BEACH	TUFTONBORO	
11	NHLAK600020701-04	UPPER BEECH POND	WOLFEBORO	X
12	NHLAK600020702-01	DAN HOLE POND	TUFTONBORO	X
12	NHLAK600020702-01-02	DAN HOLE POND - CAMP MERROVISTA BEACH	TUFTONBORO	
12	NHLAK600020702-01-03	DAN HOLE POND - CAMP SENTINEL BAPTIST BEACH	TUFTONBORO	
13	NHLAK600020703-03	PINE RIVER POND	WAKEFIELD	X
14	NHLAK600020703-04	WHITE POND	OSSIPEE	X
15	NHLAK600020801-01	BLUE POND	MADISON	X
16	NHLAK600020801-05	MACK POND	MADISON	X
17	NHLAK600020801-06-01	SILVER LAKE	MADISON	X
17	NHLAK600020801-06-02	SILVER LAKE - MONUMENT BEACH	MADISON	
17	NHLAK600020801-06-03	SILVER LAKE - FOOT OF THE LAKE BEACH	MADISON	
17	NHLAK600020801-06-04	SILVER LAKE - NICHOLS BEACH	MADISON	
17	NHLAK600020801-06-05	SILVER LAKE - KENNETT PARK BEACH	MADISON	
18	NHLAK600020802-04-01	OSSIPEE LAKE	OSSIPEE	X
18	NHLAK600020802-04-02	OSSIPEE LAKE - CAMP CALUMET BEACH	OSSIPEE	
18	NHLAK600020802-04-03	OSSIPEE LAKE - DEER COVE PB BEACH	OSSIPEE	
18	NHLAK600020802-04-04	OSSIPEE LAKE - CAMP CODY FOR BOYS BEACH	FREEDOM	
19	NHLAK600020803-01-01	LOWER DANFORTH POND	FREEDOM	X
20	NHLAK600020803-01-02	MIDDLE DANFORTH POND	FREEDOM	X
21	NHLAK600020803-03	UPPER DANFORTH POND	FREEDOM	X
22	NHLAK600020803-08	SHAW POND	FREEDOM	X
22	NHLAK600020803-08-02	SHAW POND - CAMP WAKUTA BEACH	FREEDOM	
23	NHLAK600020804-01-01	BERRY BAY	FREEDOM	X
24	NHLAK600020804-01-02	LEAVITT BAY	OSSIPEE	X
25	NHLAK600020804-01-03	BROAD BAY	FREEDOM	X
25	NHLAK600020804-01-04	LEAVITT BAY - CAMP MARIST BEACH	EFFINGHAM	
25	NHLAK600020804-01-05	BROAD BAY - CAMP HUCKINS BEACH	FREEDOM	
25	NHLAK600020804-01-06	BROAD BAY - CAMP ROBIN HOOD BEACH	FREEDOM	
26	NHLAK600020902-01	PROVINCE LAKE	EFFINGHAM	X
27	NHLAK600021001-01	BALCH POND	WAKEFIELD	X
28	NHLAK600030403-02	HORN POND	WAKEFIELD	X
29	NHLAK600030601-05-01	SUNRISE LAKE	MIDDLETON	X
29	NHLAK600030601-05-02	SUNRISE LAKE - TOWN BEACH	MIDDLETON	
30	NHLAK600030602-03	ROCHESTER RESERVOIR	ROCHESTER	X
31	NHLAK600030605-01	NIPPO POND	BARRINGTON	X
32	NHLAK600030704-02-01	PAWTUCKAWAY LAKE	NOTTINGHAM	X
32	NHLAK600030704-02-02	PAWTUCKAWAY LAKE - PAWTUCKAWAY STATE PARK BEACH	NOTTINGHAM	
32	NHLAK600030704-02-03	PAWTUCKAWAY LAKE - TOWN BEACH	NOTTINGHAM	
33	NHLAK600030802-01	HUNT POND	SANDOWN	X
34	NHLAK700010104-02	LOON POND	LINCOLN	X
35	NHLAK700010205-01	MIRROR LAKE	WOODSTOCK	X
36	NHLAK700010304-04	MCCUTCHEON POND	DORCHESTER	X
37	NHLAK700010304-05	POUT POND	DORCHESTER	X
38	NHLAK700010401-03	CONE POND	THORNTON	X
39	NHLAK700010402-03	LOWER HALL POND	SANDWICH	X
40	NHLAK700010402-05	UPPER HALL POND	SANDWICH	X
41	NHLAK700010402-08	LITTLE PERCH POND	CAMPTON	X
42	NHLAK700010501-01	BARVILLE POND	SANDWICH	X
43	NHLAK700010501-02	INTERVALE POND	SANDWICH	X
44	NHLAK700010501-03	KUSUMPE POND	SANDWICH	X
45	NHLAK700010502-04	SKY POND	NEW HAMPTON	X
46	NHLAK700010701-03	ORANGE POND	ORANGE	X
47	NHLAK700010701-05	WAUKEENA LAKE	DANBURY	X
48	NHLAK700010702-02	SCHOOL POND	DANBURY	X
49	NHLAK700010802-03-01	HERMIT LAKE	SANBORNTON	X
49	NHLAK700010802-03-02	HERMIT LAKE - TOWN BEACH	SANBORNTON	

Table 1. Waterbody ID and Names of New Hampshire Acid-Impaired Lakes

TMDLID	AUID	AUName	Town	Pond
50	NHLAK700010802-04	RANDLETT POND	MEREDITH	X
51	NHLAK700010802-05	MOUNTAIN POND	SANBORNTON	X
52	NHLAK700010804-01-01	HIGHLAND LAKE	ANDOVER	X
52	NHLAK700010804-01-02	HIGHLAND LAKE - TOWN BEACH	ANDOVER	
53	NHLAK700010804-02-01	WEBSTER LAKE	FRANKLIN	X
53	NHLAK700010804-02-02	WEBSTER LAKE - GRIFFIN TOWN BEACH	FRANKLIN	
53	NHLAK700010804-02-03	WEBSTER LAKE - LEGACE TOWN BEACH	FRANKLIN	
54	NHLAK700020101-05-01	LAKE WENTWORTH	WOLFEBORO	X
54	NHLAK700020101-05-02	LAKE WENTWORTH - ALBEE BEACH	WOLFEBORO	
54	NHLAK700020101-05-03	LAKE WENTWORTH - WENTWORTH STATE PARK BEACH	WOLFEBORO	
54	NHLAK700020101-05-04	LAKE WENTWORTH - PUBLIC BEACH	WOLFEBORO	
54	NHLAK700020101-05-05	LAKE WENTWORTH - CAMP BERNADETTE BEACH	WOLFEBORO	
54	NHLAK700020101-05-06	LAKE WENTWORTH - CAMP PLEASANT VALLEY BEACH	WOLFEBORO	
54	NHLAK700020101-05-07	LAKE WENTWORTH - PIERCE CAMP BIRCHMONT BEACH	WOLFEBORO	
55	NHLAK700020101-07-01	RUST POND	WOLFEBORO	X
55	NHLAK700020101-07-02	RUST POND - WOLFEBORO CAMP SCHOOL BEACH	WOLFEBORO	
56	NHLAK700020108-02-01	LAKE WAUKEWAN	MEREDITH	X
57	NHLAK700020108-02-02	LAKE WINONA	NEW HAMPTON	X
57	NHLAK700020108-02-03	LAKE WAUKEWAN - TOWN BEACH	MEREDITH	
58	NHLAK700020108-04	HAWKINS POND	CENTER HARBOR	X
59	NHLAK700020110-02-01	PAUGUS BAY	LACONIA	X
59	NHLAK700020110-02-04	LAKE WINNIPESAUKEE - MELVIN VILLAGE LAKE TOWN BEACH	TUFTONBORO	
59	NHLAK700020110-02-05	LAKE WINNIPESAUKEE - MOULTONBOROUGH TOWN BEACH	MOULTONBOROUGH	
59	NHLAK700020110-02-07	LAKE WINNIPESAUKEE - PUBLIC BEACH	TUFTONBORO	
59	NHLAK700020110-02-08	LAKE WINNIPESAUKEE - CARRY BEACH	WOLFEBORO	
59	NHLAK700020110-02-09	LAKE WINNIPESAUKEE - BREWSTER BEACH	WOLFEBORO	
59	NHLAK700020110-02-10	LAKE WINNIPESAUKEE - ALTON BAY TOWN BEACH	ALTON	
59	NHLAK700020110-02-11	LAKE WINNIPESAUKEE - PUBLIC DOCK TOWN BEACH	ALTON	
59	NHLAK700020110-02-12	LAKE WINNIPESAUKEE - ELACOYA STATE PARK BEACH	GILFORD	
59	NHLAK700020110-02-13	LAKE WINNIPESAUKEE - GILFORD TOWN BEACH	GILFORD	
59	NHLAK700020110-02-14	LAKE WINNIPESAUKEE - ENDICOTT PARK WEIRS BEACH	LACONIA	
59	NHLAK700020110-02-15	LAKE WINNIPESAUKEE - LEAVITT PARK BEACH	MEREDITH	
59	NHLAK700020110-02-16	LAKE WINNIPESAUKEE - TOWN BEACH (CENTER HARBOR)	CENTER HARBOR	
59	NHLAK700020110-02-17	LAKE WINNIPESAUKEE - STATES LANDING TOWN BEACH	MOULTONBOROUGH	
60	NHLAK700020110-02-19	LAKE WINNIPESAUKEE	ALTON	X
60	NHLAK700020110-02-20	LAKE WINNIPESAUKEE - CAMP ALTON BEACH	ALTON	
60	NHLAK700020110-02-21	LAKE WINNIPESAUKEE - BROOKWOOD/DEER RUN BEACH	ALTON	
60	NHLAK700020110-02-22	LAKE WINNIPESAUKEE - CAMP KABEYUN BEACH	ALTON	
60	NHLAK700020110-02-23	LAKE WINNIPESAUKEE - CAMP LAWRENCE BEACH	MEREDITH	
60	NHLAK700020110-02-24	LAKE WINNIPESAUKEE - CAMP MENOTOMY BEACH	MEREDITH	
60	NHLAK700020110-02-25	LAKE WINNIPESAUKEE - CAMP NOKOMIS BEACH	MEREDITH	
60	NHLAK700020110-02-26	LAKE WINNIPESAUKEE - GENEVA POINT CENTER BEACH	MOULTONBOROUGH	
60	NHLAK700020110-02-27	LAKE WINNIPESAUKEE - WINAUKEE ISLAND CAMP BEACH	MOULTONBOROUGH	
60	NHLAK700020110-02-28	LAKE WINNIPESAUKEE - CAMP ROBINDEL FOR GIRLS BEACH	MOULTONBOROUGH	
60	NHLAK700020110-02-29	LAKE WINNIPESAUKEE - CAMP TECUMSEH BEACH	MOULTONBOROUGH	
60	NHLAK700020110-02-30	LAKE WINNIPESAUKEE - CAMP WINAUKEE BEACH	MOULTONBOROUGH	
60	NHLAK700020110-02-31	LAKE WINNIPESAUKEE - CAMP BELKNAP BEACH	TUFTONBORO	
60	NHLAK700020110-02-32	LAKE WINNIPESAUKEE - CAMP NORTH WOODS BEACH	TUFTONBORO	
60	NHLAK700020110-02-33	LAKE WINNIPESAUKEE - CAMP SANDY ISLAND BEACH	TUFTONBORO	
60	NHLAK700020110-02-34	LAKE WINNIPESAUKEE - CAMP DEWITT BEACH	ALTON	
60	NHLAK700020110-02-35	LAKE WINNIPESAUKEE - WANAKEE METHODIST CHURCH BEACH	MEREDITH	
61	NHLAK700020110-05	SALTMARSH POND	GILFORD	X
62	NHLAK700020201-05-01	LAKE WINNISQUAM	LACONIA	X
62	NHLAK700020201-05-02	LAKE WINNISQUAM - TOWN BEACH	SANBORNTON	
62	NHLAK700020201-05-03	LAKE WINNISQUAM - BARTLETTS BEACH	LACONIA	
62	NHLAK700020201-05-04	LAKE WINNISQUAM - BELMONT TOWN BEACH	BELMONT	
62	NHLAK700020201-05-05	LAKE WINNISQUAM - AHERN STATE PARK	LACONIA	
63	NHLAK700020202-03	POUT POND	BELMONT	X
64	NHLAK700020202-04	SARGENT LAKE	BELMONT	X
65	NHLAK700030101-08	GRASSY POND	RINDGE	X
66	NHLAK700030101-12	POOL POND	RINDGE	X
67	NHLAK700030101-13	BULLET POND	RINDGE	X
68	NHLAK700030103-02	TOLMAN POND	NELSON	X
69	NHLAK700030103-03	JUGGERNAUT POND	HANCOCK	X
70	NHLAK700030103-09	SPOONWOOD LAKE	NELSON	X
71	NHLAK700030103-10	DINSMORE POND	HARRISVILLE	X
72	NHLAK700030105-01-01	ZEPHYR LAKE	GREENFIELD	X
72	NHLAK700030105-01-02	ZEPHYR LAKE - TOWN BEACH	GREENFIELD	
73	NHLAK700030105-02-01	OTTER LAKE	GREENFIELD	X
73	NHLAK700030105-02-03	OTTER LAKE - GREENFIELD SP PICNIC BEACH	GREENFIELD	

Table 1. Waterbody ID and Names of New Hampshire Acid-Impaired Lakes

TMDLID	AUID	AUName	Town	Pond
73	NHLAK700030105-02-04	OTTER LAKE - GREENFIELD SP MIDDLE BEACH	GREENFIELD	
73	NHLAK700030105-02-05	OTTER LAKE - GREENFIELD SP CAMPING BEACH	GREENFIELD	
73	NHLAK700030105-02-06	OTTER LAKE - CAMP UNION BEACH	GREENFIELD	
73	NHLAK700030105-02-07	OTTER LAKE - GREENFIELD SP BEACH	GREENFIELD	
74	NHLAK700030105-03-01	SUNSET LAKE	GREENFIELD	X
74	NHLAK700030105-03-02	SUNSET LAKE - TOWN BEACH	GREENFIELD	
74	NHLAK700030105-03-03	SUNSET LAKE - NASHUA FRESH AIR CAMP BEACH	GREENFIELD	
75	NHLAK700030107-01	WILLARD POND	ANTRIM	X
76	NHLAK700030202-06	BAGLEY POND	WINDSOR	X
77	NHLAK700030203-02	SMITH POND	WASHINGTON	X
78	NHLAK700030203-03	TROUT POND	STODDARD	X
79	NHLAK700030204-04	LOON POND	HILLSBOROUGH	X
80	NHLAK700030302-02	BLAISDELL LAKE	SUTTON	X
81	NHLAK700030302-04-01	LAKE MASSASECUM	BRADFORD	X
82	NHLAK700030304-05	TOM POND	WARNER	X
83	NHLAK700030304-07	TUCKER POND	SALISBURY	X
84	NHLAK700030304-08	LAKE WINNEPOCKET	WEBSTER	X
85	NHLAK700030401-02	BUTTERFIELD POND	WILMOT	X
86	NHLAK700030402-01	CHASE POND	WILMOT	X
87	NHLAK700030402-02-01	PLEASANT LAKE	NEW LONDON	X
87	NHLAK700030402-02-02	PLEASANT LAKE - ELKINS BEACH	NEW LONDON	
88	NHLAK700030403-05	HORSESHOE POND	ANDOVER	X
89	NHLAK700030502-03	BEAR POND	WARNER	X
90	NHLAK700030505-01	CLEMENT POND	HOPKINTON	X
90	NHLAK700030505-01-02	CLEMENT POND - CAMP MERRIMAC BEACH	HOPKINTON	
91	NHLAK700040401-01-01	MELENDY POND	BROOKLINE	X
91	NHLAK700040401-01-02	MELENDY POND - TOWN BEACH	BROOKLINE	
92	NHLAK700040401-02-01	POTANIPO POND	BROOKLINE	X
92	NHLAK700040401-02-02	LAKE POTANIPO - TOWN BEACH	BROOKLINE	
92	NHLAK700040401-02-03	POTANIPO POND - CAMP TEVYA BEACH	BROOKLINE	
93	NHLAK700060101-01	SHAW POND	FRANKLIN	X
94	NHLAK700060101-02-01	SONDOGARDY POND	NORTHFIELD	X
94	NHLAK700060101-02-02	SONDOGARDY POND - GLINES PARK BEACH	NORTHFIELD	
95	NHLAK700060201-01-01	LOON POND	GILMANTON	X
95	NHLAK700060201-01-02	LOON LAKE - LOON LAKE BEACH	GILMANTON	
96	NHLAK700060201-03	NEW POND	CANTERBURY	X
97	NHLAK700060202-03-01	CLOUGH POND	LOUDON	X
97	NHLAK700060202-03-02	CLOUGH POND - TOWN BEACH	LOUDON	
98	NHLAK700060202-04	CROOKED POND	LOUDON	X
99	NHIMP700060302-02	HAYWARD BROOK/MORRILL POND	CANTERBURY	X
100	NHLAK700060401-02-01	CRYSTAL LAKE	GILMANTON	X
100	NHLAK700060401-02-02	CRYSTAL LAKE-TOWN BEACH	GILMANTON	
101	NHLAK700060401-06	MANNING LAKE	GILMANTON	X
101	NHLAK700060401-06-02	MANNING LAKE - CAMP BELL BEACH	GILMANTON	
102	NHLAK700060401-12	SUNSET LAKE	ALTON	X
103	NHLAK700060402-03	HALFMOON LAKE	ALTON	X
103	NHLAK700060402-03-02	HALFMOON LAKE - CAMP MI-TE-NA BEACH	ALTON	
104	NHLAK700060402-05	HUNTRESS POND	BARNSTEAD	X
105	NHLAK700060403-01	BIG WILLEY POND	STRAFFORD	X
105	NHLAK700060403-01-02	BIG WILLEY POND - CAMP FOSS BEACH	STRAFFORD	
105	NHLAK700060403-01-03	BIG WILLEY POND - PARKER MTN BEACH	STRAFFORD	
106	NHLAK700060403-02	LITTLE WILLEY POND	STRAFFORD	X
107	NHLAK700060501-03	WILD GOOSE POND	PITTSFIELD	X
107	NHLAK700060501-03-02	WILD GOOSE POND - WILD GOOSE POND BEACH	PITTSFIELD	
107	NHLAK700060501-03-03	WILD GOOSE POND - WILD GOOSE CAMP BEACH	PITTSFIELD	
108	NHLAK700060501-08	BERRY POND	PITTSFIELD	X
109	NHLAK700060502-03	CHESTNUT POND	EPSOM	X
110	NHLAK700060503-01	BEAR HILL POND	ALLENSTOWN	X
110	NHLAK700060503-01-02	BEAR HILL POND - BEAR HILL POND BEACH	ALLENSTOWN	
111	NHLAK700060601-01	DEERING RESERVOIR	DEERING	X
112	NHLAK700060601-02	DUDLEY POND	DEERING	X
113	NHLAK700060601-03-01	PLEASANT POND	HENNIKER	X
113	NHLAK700060601-03-02	PLEASANT LAKE - PUBLIC ACCESS BEACH	HENNIKER	
114	NHLAK700060602-02	MOUNT WILLIAM POND	WEARE	X
115	NHLAK700060604-01	PLEASANT POND	FRANCESTOWN	X
116	NHLAK700060607-03	LONG POND	DUNBARTON	X
117	NHLAK700060702-03	MASSABESIC LAKE	AUBURN	X
118	NHLAK700060802-02	LAKINS POND	HOOKSETT	X
119	NHLAK700060802-03	PINNACLE POND	HOOKSETT	X
120	NHLAK700060803-02	STEVENS POND	MANCHESTER	X

Table 1. Waterbody ID and Names of New Hampshire Acid-Impaired Lakes

TMDLID	AUID	AUName	Town	Pond
121	NHLAK700061002-03	HORSESHOE POND	MERRIMACK	X
122	NHLAK700061101-01-01	ISLAND POND	HAMPSTEAD	X
123	NHLAK700061203-06-01	ROBINSON POND	HUDSON	X
123	NHLAK700061203-06-02	ROBINSON POND - TOWN BEACH	HUDSON	
123	NHLAK700061203-06-03	UNKNOWN POND - CAMP WINAHUPE BEACH	HUDSON	
124	NHLAK700061204-02	LITTLE ISLAND POND	PELHAM	X
124	NHLAK700061204-02-02	LITTLE ISLAND POND - CAMP RUNELS BEACH	PELHAM	
125	NHLAK700061204-03	ROCK POND	WINDHAM	X
126	NHLAK700061205-01	GUMPAS POND	PELHAM	X
127	NHLAK801010102-03	ROUND POND	PITTSBURG	X
128	NHLAK801010707-01-01	CHRISTINE LAKE	STARK	X
128	NHLAK801010707-01-02	CHRISTINE LAKE - TB BEACH	STARK	
129	NHLAK801040201-03	LAKE TARLETON	PIERMONT	X
129	NHLAK801040201-03-02	LAKE TARLETON - KINGSWOOD CAMP BEACH	PIERMONT	
130	NHLAK801040203-01-01	POST POND	LYME	X
130	NHLAK801040203-01-02	POST POND - CHASE TOWN BEACH	LYME	
131	NHLAK801060101-03	CUMMINS POND	DORCHESTER	X
132	NHLAK801060101-05	RESERVOIR POND	DORCHESTER	X
133	NHLAK801060103-02	LITTLE GOOSE POND	CANAAN	X
134	NHLAK801060104-02	GRAFTON POND	GRAFTON	X
135	NHLAK801060401-06	EASTMAN POND	GRANTHAM	X
136	NHLAK801060401-08-01	KOLELEMOOK LAKE	SPRINGFIELD	X
136	NHLAK801060401-08-02	KOLEMOOK LAKE - TOWN BEACH	SPRINGFIELD	
137	NHLAK801060402-04-01	LITTLE SUNAPEE LAKE	NEW LONDON	X
137	NHLAK801060402-04-02	LITTLE SUNAPEE LAKE - BUCKLIN TOWN BEACH	NEW LONDON	
137	NHLAK801060402-04-03	LITTLE LAKE SUNAPEE - COLBY LODGE BEACH	NEW LONDON	
138	NHLAK801060402-05-01	SUNAPEE LAKE	SUNAPEE	X
138	NHLAK801060402-05-02	SUNAPEE LAKE - GEORGES MILL TOWN BEACH	SUNAPEE	
138	NHLAK801060402-05-03	SUNAPEE LAKE - DEWEY (TOWN) BEACH	SUNAPEE	
138	NHLAK801060402-05-04	SUNAPEE LAKE - BLODGETT'S LANDING BEACH	NEWBURY	
138	NHLAK801060402-05-05	SUNAPEE LAKE - SUNAPEE STATE PARK BEACH	NEWBURY	
138	NHLAK801060402-05-06	SUNAPEE LAKE - DEPOT BEACH	NEWBURY	
139	NHLAK801060402-11	MOUNTAINVIEW LAKE	SUNAPEE	X
140	NHLAK801060402-12-01	OTTER POND	SUNAPEE	X
140	NHLAK801060402-12-02	OTTER POND - MORGAN BEACH	NEW LONDON	
141	NHLAK801060403-01	GILMAN POND	UNITY	X
142	NHLAK801060403-04-01	RAND POND	GOSHEN	X
142	NHLAK801060403-04-02	RAND POND - PUBLIC WAY BEACH	GOSHEN	
143	NHLAK801060404-01	ROCKYBOUND POND	CROYDON	X
144	NHLAK801070201-01	CRESCENT LAKE	CRESCENT LAKE	X
145	NHLAK801070503-01-01	SPOFFORD LAKE	CHESTERFIELD	X
145	NHLAK801070503-01-02	SPOFFORD LAKE - ACCESS RD TOWN BEACH	CHESTERFIELD	
145	NHLAK801070503-01-03	SPOFFORD LAKE - N SHORE RD TOWN BEACH	CHESTERFIELD	
145	NHLAK801070503-01-04	SPOFFORD LAKE - WARES GROVE TOWN BEACH	CHESTERFIELD	
145	NHLAK801070503-01-05	SPOFFORD LAKE - CAMP SPOFFORD BEACH	CHESTERFIELD	
145	NHLAK801070503-01-06	SPOFFORD LAKE - ROADS END FARM BEACH	CHESTERFIELD	
146	NHLAK802010102-05	BARRETT POND	WASHINGTON	X
147	NHLAK802010104-01	CALDWELL POND	ALSTEAD	X
148	NHLAK802010104-03	CRANBERRY POND	ALSTEAD	X
149	NHLAK802010202-02	CHILDS BOG	HARRISVILLE	X
150	NHLAK802010202-07	RUSSELL RESERVOIR	HARRISVILLE	X
150	NHLAK802010202-07-02	RUSSEL RESERVOIR - CHESHAM BEACH	HARRISVILLE	
151	NHLAK802010202-14	BABBIDGE RESERVOIR	ROXBURY	X
152	NHLAK802010302-01-01	SWANZEY LAKE	SWANZEY	X
152	NHLAK802010302-01-02	SWANZEY LAKE - RICHARDSON PARK TOWN BEACH	SWANZEY	
152	NHLAK802010302-01-03	SWANZEY LAKE - CAMP SQUANTO BEACH	SWANZEY	
153	NHLAK802010303-02	MEETINGHOUSE POND	MARLBOROUGH	X
154	NHLAK802010303-07	SAND POND	TROY	X
155	NHLAK802010303-10	WILSON POND	SWANZEY	X
156	NHLAK802020103-04	EMERSON POND	RINDGE	X
157	NHLAK802020202-01	COLLINS POND	FITZWILLIAM	X
158	NHIMP700060502-01	DURGIN POND OUTLET	NORTHWOOD	X

Table 2. Waterbody ID and Names of New Hampshire Aluminum-Impaired Lakes

TMDLID	AUID	AUName	Town	Pond
159	NHLAK400010502-02	CORSER POND	ERROL	X
160	NHLAK400010502-05	SWEAT POND	ERROL	X
161	NHLAK600020102-02	LITTLE SAWYER POND LITTLE	LIVERMORE	X
162	NHLAK600020602-02	FLAT MOUNTAIN POND (1&2)	WATERVILLE VALLEY	X
163	NHLAK700010104-01	BLACK POND	LINCOLN	X
164	NHLAK700010201-03	LONESOME LAKE	LINCOLN	X
165	NHLAK700010203-02	RUSSELL POND	WOODSTOCK	X
166	NHLAK700010204-01	EAST POND	LIVERMORE	X
167	NHLAK700010205-02	PEAKED HILL POND	THORNTON	X
168	NHLAK700010304-02	DERBY POND	ORANGE	X
169	NHLAK700010307-01	LOON LAKE	PLYMOUTH	X
170	NHLAK700010401-04	GREELEY POND (UPPER)	LIVERMORE	X
171	NHLAK700010402-04	MIDDLE HALL POND	SANDWICH	X
172	NHLAK700030301-01	LAKE SOLITUDE	NEWBURY	X
173	NHLAK801010103-03	WRIGHT POND	PITTSBURG	X
174	NHLAK801010706-01	LITTLE BOG POND	ODELL	X
175	NHLAK801030302-01-01	ECHO LAKE	FRANCONIA	X
175	NHLAK801030302-01-02	FRANCONIA STATE PARK ECHO LAKE	FRANCONIA	
176	NHLAK801030701-01	LAKE CONSTANCE	PIERMONT	X
177	NHLAK801060401-07	HALFMILE POND	ENFIELD	X
178	NHLAK802010101-04	LONG POND	LEMPSTER	X
179	NHLAK802010101-06-01	MILLEN POND	WASHINGTON	X

FIGURE 1
TMDL STUDY OF ACID IMPAIRED PONDS NEW HAMPSHIRE 2007

Legend

Acid-Impaired Ponds

Watershed

Town Boundary

See Table 1 for pond information.

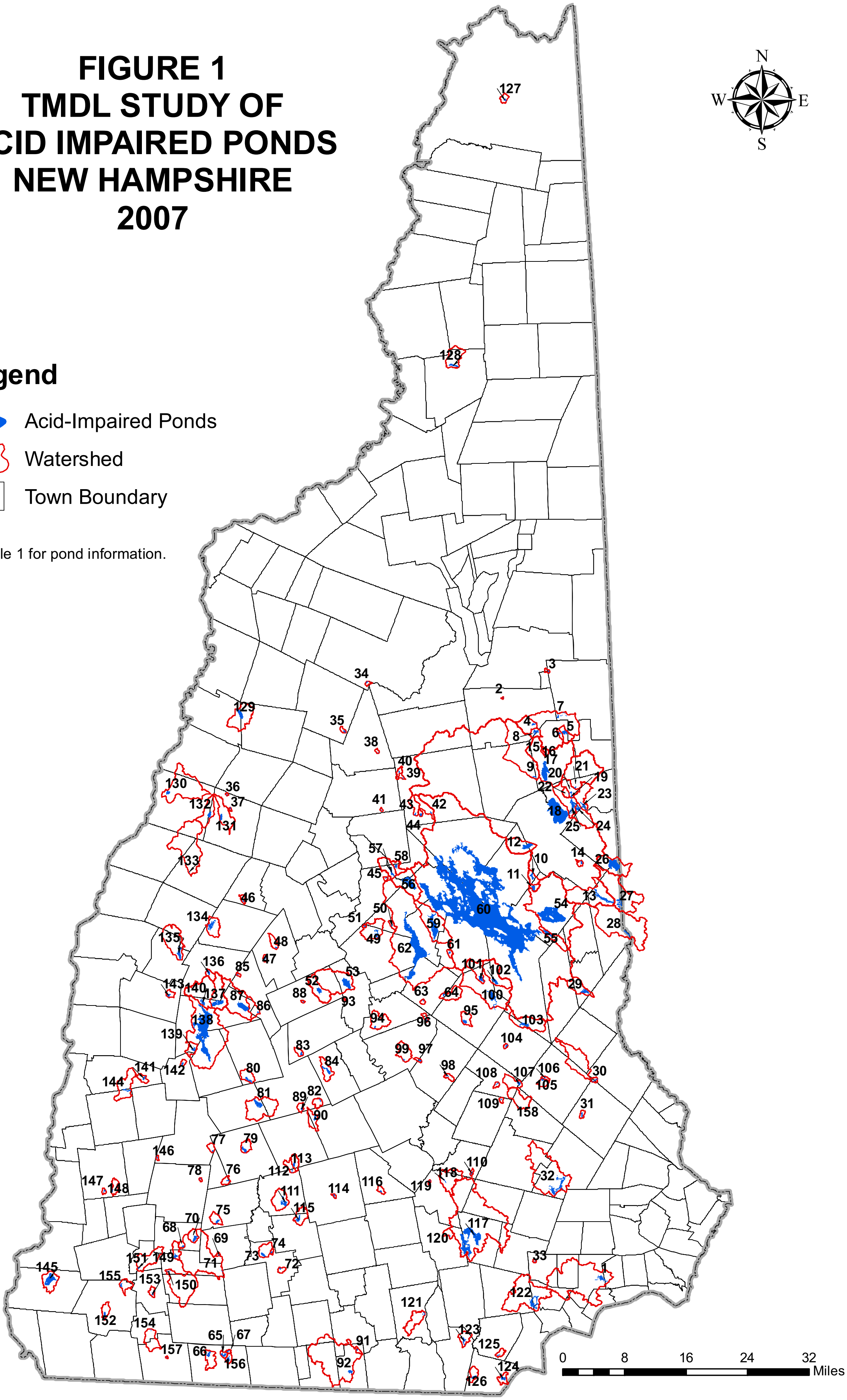

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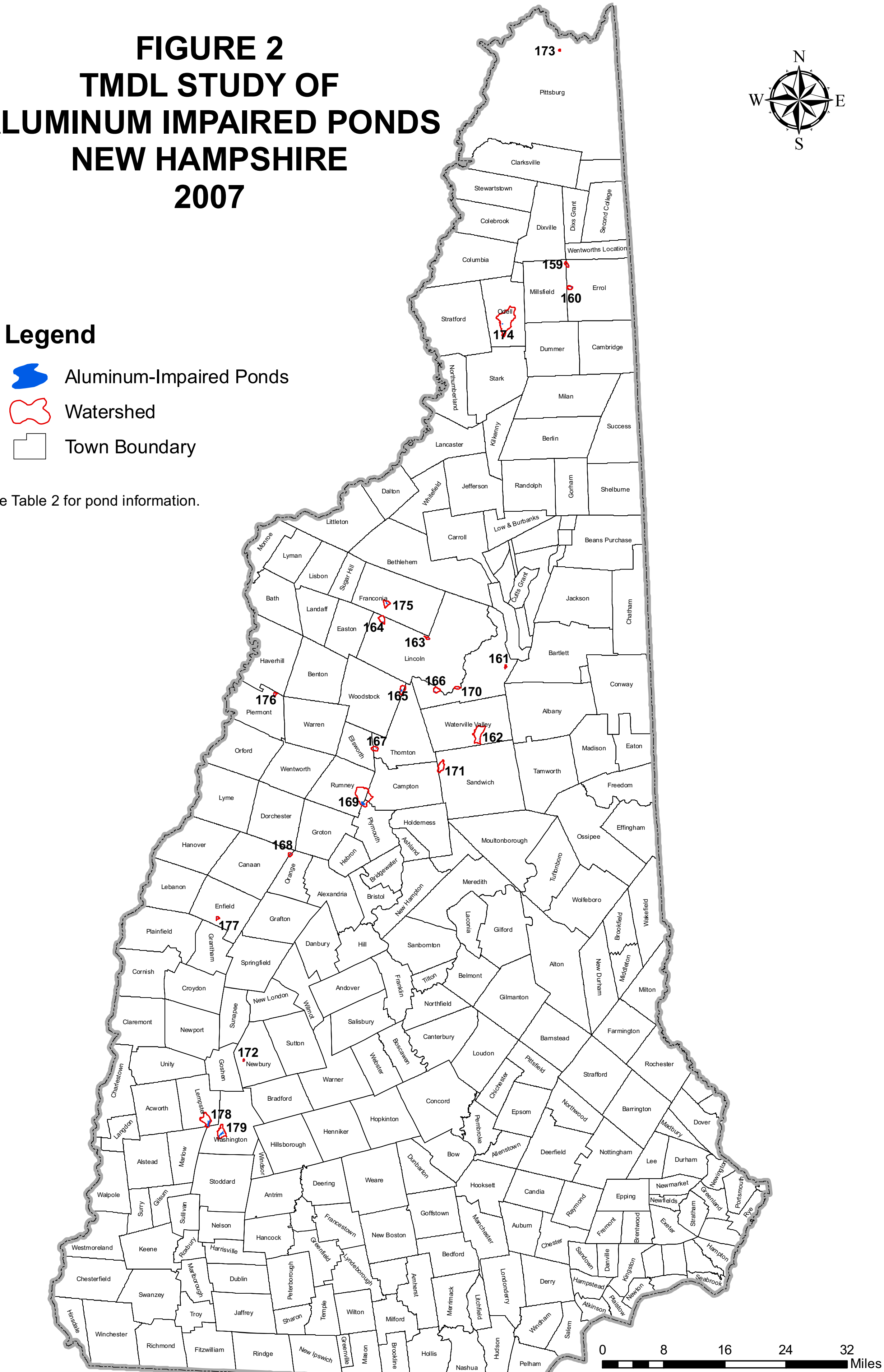
FIGURE 2
TMDL STUDY OF ALUMINUM IMPAIRED PONDS NEW HAMPSHIRE 2007



Aluminum-Impaired Ponds
Development of Total Maximum Daily Loads (TMDL)
New Hampshire
Project No. EPA-SMP-07-002

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September

2.0 Problem Statement

The Problem Statement describes the nature of the acid impairment to New Hampshire ponds and its root causes. These causes are also applicable to aluminum impairment as well. The New Hampshire water quality standards and goals are defined in the section and applicable pH and aluminum limits are identified. The section also explains how the affected waterbodies came to be listed on New Hampshire's 2006 CWA Section 303(d) list.

2.1 Acid Impairment in New Hampshire Ponds

Acid deposition (commonly called acid rain) is an important factor in determining the water quality of many ponds in northern New England. Acid deposition occurs when emissions of sulfur dioxide (SO_2) or nitrogen oxides (generically referred to as NO_x) react in the atmosphere with water, oxygen and oxidants to form acidic compounds. These compounds are carried varying distances from their source and are deposited as precipitation (rain, snow), as fog, or as dry particles (dust or dry deposition). Acid deposition is a major environmental concern for a variety of reasons, including the potential for direct (low pH) and indirect (increased aluminum) toxic impacts to aquatic life in surface waters.

The NHDES has been monitoring the impacts of acid rain in sensitive New Hampshire ponds since 1981 under the remote pond (30 lakes) and acid outlet (20 lakes) programs. In addition, pond pH values are regularly measured in the Volunteer Lake Assessment Program (VLAP) lakes (initiated in 1985) and in the Lake Trophic Survey program (initiated in 1975). The assessment of data from these various programs resulted in 272 identifiable locations (including ponds, impoundments and beaches) representing 158 ponds being listed as impaired for pH on the New Hampshire 2006 303(d) list. The ponds and associated watersheds are located on Figure 1 and the assessment unit IDs along with the name and town are provided in Table 1.

Monitoring of aluminum levels has also been conducted in some New Hampshire ponds and waterbodies (remote and outlet ponds – see section 6.2.2 for description). For example, many of the ponds originally addressed by the NH DES (2004) Acid Pond TMDL were also found to have exceedances of the aluminum criterion. These ponds with aluminum exceedances require the development of a TMDL for aluminum impairment. Figure 2 indicates the location and Table 2 provides a list of the 21 aluminum-impaired waterbodies.

2.1.1 Selection of Site-Specific Water Chemistry (SSWC) Model

The SSWC model was selected as the primary determinant of the critical loading estimate to be used in development of a TMDL for the 158 New Hampshire waterbodies. The SSWC model estimates the critical load of acidity to a watershed where the critical load is defined as the level below which significant harmful effects to specified elements of the environment do not occur. The underlying concept of the model is that excess base cations in a catchment should be equal to or greater than the acid anion inputs. This balance maintains the lake's ANC and its ability to support healthy and diverse aquatic communities.

The use of the SSWC model for critical load determination has many benefits. First, the model has a successful track record in northern Europe and Canada supporting establishment of source reduction targets (e.g., Henriksen and Posch, 2001; Henriksen, Dillon and Aherne, 2002) as well as in the State of Vermont. Second, the inputs for the model were generally available so that only limited additional data collection was required. Third, the model has the flexibility to adapt to a user-specific ANC target. This flexibility allows the direct output of the necessary critical loads without additional extrapolation.

The primary weakness of the model is not in its ability to calculate critical loads, but rather in its inability to predict responses to reduced deposition. For example, a reduction in acid loading may alter current weathering rates, soil base cation depletion or mineralization rates. Any of these changes may affect the future critical load. However, under the steady state conditions required by the model, the critical loading limits in this TMDL are the best estimates available with current data.

The primary source of acidity to these lakes is from wet and dry atmospheric deposition. As previously noted, the ultimate source of this atmospheric acidity is air emissions, primarily from fossil fuel burning power plants and motor vehicles. While these emissions can originate both within New Hampshire and outside the state and region, the mid-western region (the seven states of the Ohio River Valley) of the United States emits the greatest amount of sulfur and nitrogen oxides of any region in the nation (Driscoll, et al., 2001a). Therefore, for the purposes of this TMDL, the total pollutant load, minus the explicit margin of safety, is allocated to nonpoint sources. Because of the difficulty of determining the specific air contaminant sources polluting New Hampshire's waters, no attempt has been made to sub-allocate the load allocation among either different geographic regions or types or sources of atmospheric acid.

Key information on the SSWQ is provided as Appendix A "*Background Information on the Site-Specific Water Chemistry (SSWC) Model.*" The underlying theory, key assumptions, and further details on the SSWC are provided in Henriksen and Posch (2001), Henriksen, Dillon and Aherne (2002) and NHDES (2004). The SSWC calculations were conducted using the spreadsheet, assumptions, equations, and modifications developed by the Vermont Department of Environmental Conservation, as provided by Heather Pembrooke (VTDEC) whose cooperation and insights are gratefully acknowledged.

2.1.2 Determination of Critical Loads

The method of determining critical loads was based on water chemistry, annual surface runoff, and specified target Acid Neutralizing Capacity (ANC) and is consistent with the approach previously developed by New Hampshire for acid TMDLs for 65 ponds and approved by Region 1 (i.e., NHDES, 2004).

Critical loads (CL_{ac}) were determined for the 158 acid-impaired ponds. The CL_{ac} is the flux of acid anions arising from acid deposition that results in the target ANC_{limit} when subtracted from the pre-industrial flux of base cations according to the following equation:

$$\mathbf{CL_{ac} = ([BC']_o - [ANC]_{limit}) * Q}$$

where: CL_{ac} = Critical load of acidity;

$[BC']_o$ = pre-industrial concentration of base cations (corrected for sea salts);

$[ANC]_{limit}$ = critical ANC concentration; and

Q = annual runoff (m/yr).

Estimated annual runoff for the acid ponds were derived from statewide maps of isopleths of annual runoff, extrapolated to GIS files of pond watershed as provided by NH GRANIT. Details and documentation of the derivation of annual runoff values are provided in Appendix B "*Estimated Runoff Values for Watersheds in Acid Pond TMDL Study*." NH DES reviewed and approved the acid pond annual runoff values.

The critical ANC ($[ANC]_{limit}$) derivation is described in Section 2.3. Details and documentation of the derivation of the $[ANC]_{limit}$ are provided in Appendix C "*Determination of Acid Neutralizing Capacity (ANC) Target Value for Acid Pond TMDL Study*." NH DES reviewed and approved the target ANC value of 6.24 mg/L (125 ueq/L).

Calculations of $[BC']_o$ values were based on pond-specific water chemistry data obtained from NH DES. Water quality data for base cations (Ca, Mg, K, Na) and anions (Cl, SO_4, NO_3) were obtained by ENSR from the NHDES OneStop Data Retrieval Site (http://www.des.state.nh.us/OneStop.htm). Specifically, data were obtained by querying the Environmental Monitoring Database for the various ponds. Queries were preferentially obtained from the period of 01/01/1996 through 01/01/2008 (the default end date in the database query page), unless no data were available for the pond; in which case, more historic data were obtained.

Outputs from the database were formatted as Microsoft Excel files and were then placed in a Microsoft Access database, constructed by ENSR.

The water quality data used to support the SSWC calculations are provided in Appendix D "*Calculations and Data Used for Acid Pond TMDL Derivations*" which also identifies those ponds which required application of historic data. Appendix D also provides a summary of the input parameters and secondary calculations (e.g., correction for sea salts) needed for SSWC determination of CL_{ac}. These calculations formed the basis of the TMDL values further described in Section 4.0. NH DES reviewed and approved the critical load calculations for the 158 acid-impaired ponds.

The establishment of critical loads of acidity for the ponds provided an important component to fully document the acid depositional process. The critical loads establish the necessary levels of acidic deposition to each watershed to allow for the recovery of the lakes (i.e., to meet applicable water quality standards). However, additional information on distant sources and transport patterns are necessary to initiate proper controls.

The critical load provides a framework from which to "backtrack" and trace the origin and magnitude of the acidity sources to the atmosphere and their transport to New Hampshire. Combined with atmospheric transport and deposition modeling, they will provide a basis for evaluating the environmental effectiveness of alternative national or regional emission control programs, or quantifying the adverse contributions from specific emission sources if effective national legislation is not forthcoming. They also provide a "benchmark" from which to quantitatively measure the effects of future changes in emissions and deposition. The critical loads established in this TMDL will facilitate a better understanding of the status and magnitude of acidic atmospheric deposition on New Hampshire ponds and ultimately lead to the control of significant acid sources.

2.2 Applicable New Hampshire Water Quality Standards

2.2.1 Overview

Water Quality Standards (WQS) determine the baseline water quality that all surface waters of the State must meet in order to protect their intended uses. They are the "yardstick" for identifying where water quality violations exist and for determining the effectiveness of regulatory pollution control and prevention programs. The standards are composed of three parts: classification, criteria, and antidegradation regulations.

Classification of New Hampshire surface waters is accomplished by state legislation under the authority of RSA 485-A:9 and RSA 485-A:10. By definition, (RSA 485-A:2, XIV), "*surface waters of the state means streams, lakes, ponds, and tidal waters within the jurisdiction of the state, including all streams, lakes, or ponds, bordering on the state, marshes, water courses and other bodies of water, natural or artificial*".

All State surface waters are either classified as Class A or Class B, with the majority of waters being Class B. NHDES maintains a list which includes a narrative description of all the legislative classified waters. Designated uses for each classification may be found in State statute RSA 485-A:8 and are summarized below.

Classification Designated Uses

Class A - These are generally of the highest quality and are considered potentially usable for water supply after adequate treatment. Discharge of sewage or wastes is prohibited to waters of this classification.

Class B - Of the second highest quality, these waters are considered acceptable for fishing, swimming and other recreational purposes, and, after adequate treatment, for use as water supplies.

The second major component of the water quality standards is the "criteria". These are numerical or narrative criteria which define the water quality requirements for Class A or Class B waters. Criteria assigned to each classification are designed to protect the legislative designated uses for each classification. A waterbody that meets the criteria for its assigned classification is considered to meet its intended use. Water quality criteria for each classification may be found in RSA 485-A:8, I-V and in the State of New Hampshire Surface Water Quality Regulations (Env-Ws 1700)

The third component of water quality standards are antidegradation provisions which are designed to preserve and protect the existing beneficial uses of the State's surface waters and to limit the degradation allowed in receiving waters. Antidegradation regulations are included in Part Env-Ws 1708 of the New Hampshire Surface Water Quality Regulations. According to Env-Ws 1708.02, antidegradation applies to the following:

- all new or increased activity, including point and nonpoint source discharges of pollutants that would lower water quality or affect the existing or designated uses; a proposed increase in loadings to a waterbody when the proposal is associated with existing activities;
- an increase in flow alteration over an existing alteration; and
- all hydrologic modifications, such as dam construction and water withdrawals.

2.2.2 Water Quality Standards Most Applicable to the Pollutant of Concern

The Acid Pond TMDL Report addresses ponds impaired because of excess acidity and aluminum. The water quality criterion that applies to acidity is pH. Under RSA 485-A:8 and Env-Ws 1703.18, the pH criteria are:

The pH of Class A waters shall be as naturally occurs.

The pH of Class B waters shall be 6.5 to 8.0, unless due to natural causes.

Based on New Hampshire's Consolidated Assessment and Listing Methodology or CALM (NHDES, 2006) for listing impaired waters, low pH exceedances in waters where the apparent color was greater than 30 color units (based on visual comparisons to potassium chloroplatinate standards) were considered to be due to natural causes (i.e., natural tannic and humic acids in the water). The criterion for Class A waters is interpreted as the same as for Class B: the pH is considered natural unless the pH is less than 6.5 and the color is 30 or less.

The water quality criteria for aluminum also apply equally to Class A and B waters. Under Env-Ws 1703.21(b); Table 1703.1, the aluminum criteria are:

Freshwater Chronic Criterion = 87 ug/L.

Freshwater Acute Criterion = 750 ug/L.

2.3 Target Water Quality Goals

Acid neutralizing capacity (ANC) of water is the endpoint of the SSWC model used to calculate critical loads of acidity. While pH is a measure of the acidity (and violations of the pH criterion is the reason for the impaired listing), ANC is used as the endpoint of the model because ANC is the best criterion for the protection of aquatic life. Further, the goal of this TMDL is to reduce the amount of acid deposition to the lakes not only to protect aquatic life but to allow the pH values to return to the water quality criterion level of 6.5.

To use the SSWC model, a target or critical ANC concentration or $[ANC]_{limit}$ needs to be selected. For the previous TMDL (NHDES, 2004), a regression of pH and ANC for the lakes in question determined that an ANC of 3 mg/L (60 ueq/L) was approximately equivalent to a pH of 6.5 and was selected as the target goal.

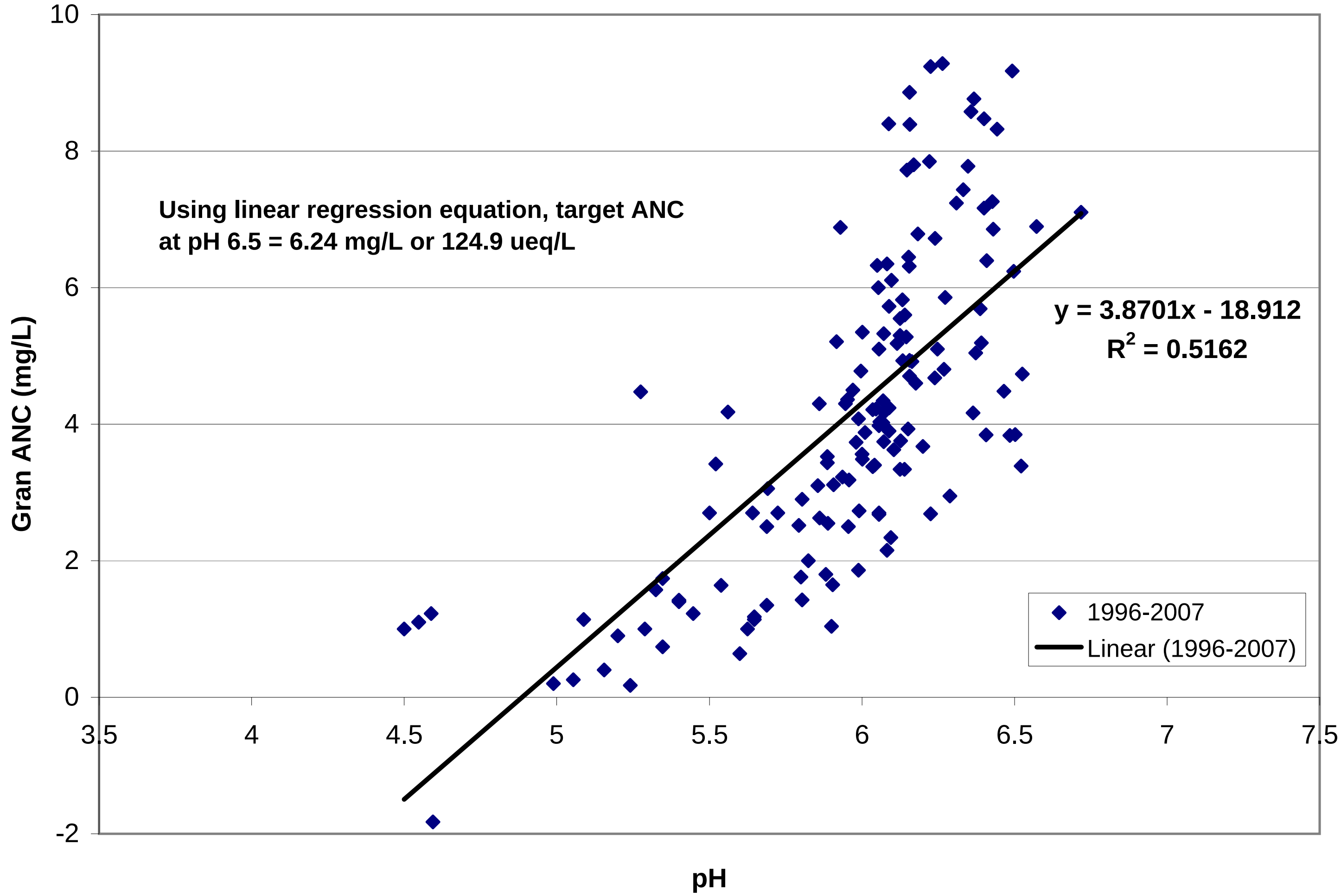
As part of this TMDL, this target $[ANC]_{limit}$ was revisited using pH and ANC data from the 158 waterbodies in the study. Water quality data (pH and Gran ANC) were obtained from the NHDES OneStop Data Retrieval Site (http://www.des.state.nh.us/OneStop.htm). Data were available for 157 of the 158 lakes. No pH or Gran ANC data were available for Horseshoe Pond (NHLAK700030403-05) for the time period of interest. There were approximately 7,023 pH data points from 276 sampling stations and 2,828 Gran ANC data points from 195 sampling stations. The majority of samples were collected in the summer (June, July, and August).

The mean pH values were calculated for each lake using the minimum value observed on each sampling date across stations and depths (see Appendix C for greater information on pH calculation). A mean Gran ANC value was calculated for each lake using all data obtained from the NHDES database for the specified time period. To eliminate the influence of what appeared to be several outliers of ANC data, ANC values greater than 10 mg/L (2000 ueq/L) were eliminated from the analysis.

Using the data from the 158 ponds, a simple linear regression of mean pH vs. mean Gran ANC was generated (Figure 3). As indicated on the figure, at the NH criterion pH of 6.5, the corresponding $[ANC]_{limit}$ would be **6.24** mg/L (125 ueq/L). This $[ANC]_{limit}$ value was reviewed by USEPA and NHDES and approved for use in the TMDL development process.

For purposes of aluminum impairment, the target water quality goal is longterm compliance with the freshwater chronic criterion value of 87 ug/L.

Figure 3. pH vs ANC for Acid Impaired Lakes



3.0 Existing Point and Nonpoint Source Loads

As part of the development of a TMDL it is necessary to account for the anthropogenic contributions of point source (e.g., NPDES-permitted discharges) and nonpoint source loads (e.g., stormwater, atmospheric deposition, mine drainage). This section identifies and discusses the potential point (Section 3.1) and nonpoint (Section 3.2) sources for consideration and inclusion in the development of the Acid Pond TMDLs.

3.1 Existing Point Source Loads

New Hampshire has placed restrictions on the discharge of wastewater treatment or industrial facilities to lacustrine environments, preferring to direct such discharges into riverine environments. Accordingly, there are no known point sources of low pH or aluminum discharging to the ponds evaluated in this TMDL nor are they present in their watersheds.

3.2 Existing Nonpoint Source Loads

Of the potential nonpoint source loads of acidity, the one of greatest concerns is the contribution of atmospheric deposition to the ponds in New Hampshire. It has long been understood that the deposition of strong mineral acids and acid forming compounds from the atmosphere have been the primary source of the acidification of hundreds of lakes throughout northeast North America as well as in other regions of the country and the world. The overwhelming source of acidity to these pond watersheds is from atmospheric deposition through rain, snow, fog and dust, and the source of the acids in the atmosphere is the emission of sulfur dioxides (SO_2) and nitrogen oxides (NOx) from a variety of sources. While the specific sources of these acidifying pollutants are not identified here, national atmospheric emission inventories and decades of atmospheric modeling results clearly implicate coal-fired electric utilities and boilers in areas upwind of New Hampshire as a predominant historical and continuing source of wet and dry sulfate depositions in New England (and eastern Canada). While nitric acid deposition is heavily contributed to by coal-fired utilities, it also results from a broader range of emission source types including motor vehicles and industrial sources. From a water quality perspective, it is not the atmospheric concentrations of these acidic constituents but rather the regional atmospheric deposition of these pollutants that is the “driver” of pond acidity or watershed aluminum inputs.

4.0 Total Maximum Daily Load and Allocations

This section provides the definition and individual components of a TMDL (section 4.1); the quantitative elements of the TMDL including seasonal considerations and margin of safety (Section 4.2), and the TMDL Calculation and Load Allocation (Section 4.3).

4.1 Definition of a Total Maximum Daily Load (TMDL)

According to the 40 CFR Part 130.2, the TMDL for a waterbody is equal to the sum of the individual loads from point sources (i.e., wasteload allocations or WLAs), and load allocations (LAs) from nonpoint sources (including natural background conditions). Section 303(d) of the CWA also states that the TMDL must be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. In equation form, a TMDL may be expressed as follows:

TMDL = WLA + LA + MOS

where:

WLA = Waste Load Allocation (i.e., loadings from point sources);

LA = Load Allocation (i.e., loadings from nonpoint sources including natural background); and

MOS = Margin of Safety.

TMDLs can be expressed in terms of either mass per time, toxicity or other appropriate measure [40 CFR, Part 130.2 (i)). The MOS can be either explicit or implicit. If an explicit MOS is used, a portion of the total allowable loading is actually allocated to the MOS. If the MOS is implicit, a specific value is not assigned to the MOS. Use of an implicit MOS is appropriate when assumptions used to develop the TMDL are believed to be so conservative that they sufficiently account for the MOS (see Section 4.2.2).

4.2 Determination of Total Maximum Daily Load (Loading Capacity)

4.2.1 Seasonal Considerations/Critical Conditions

The use of the term "Total Maximum *Daily* Load" for purposes of assessing and allocating the potential acceptable loading for waterbody compliance with the pH criterion is somewhat misleading. Due to the long-term nature and variability of acidic deposition, both wet and dry forms, and the slow response of watershed and internal pond processes to changes in deposition load, it is more ecologically appropriate to express the load as an annual load rather than a daily load. A watershed load expressed as a daily loading limit is easy enough to produce computationally, but it is of limited practical use for purposes of long-term trend analyses or in monitoring of implementation success. It is the overall annual acid loading that affects the ponds' pH and ANC, and ultimately dictates the potential impact to biological communities.

Due to this long-term perspective, the TMDL critical loads should be calculated using yearly representative values of lake conditions (i.e., average or median values) but, to be more protective of biota, are sometimes calculated using minimum values or spring time values. This is appropriate since it is during the spring snowmelt runoff events, often associated with rain events and the melting of the residual seasonal snowpack, that the annual acidity load peaks and the pulse of lowest pH runoff occurs.

As discussed earlier, the water chemistry data for the pH analysis comes from a variety of monitoring programs with spring overturn, fall overturn and summer values all used. While the sampling programs were seasonally diverse, they were overrepresented by pH measurement from summer and fall. As a conservative measure, NHDES advised that the mean pH values should be calculated for each pond using the minimum value observed on each sampling date across stations and depths (see Table 1). While this provides some compensation for the bias towards summer sampling, the critical loads thus calculated may not be fully protective for the worst case conditions of the spring. This concern is reflected in the selection of the MOS (see below).

4.2.2 Margin of Safety

The TMDL regulations require that a TMDL include a MOS factor to account for the lack of knowledge (i.e., uncertainty) concerning the true relationship between loading and attainment of water quality standards. This uncertainty is often a product of data gaps, either temporally or spatially, in the measurement of water quality. The higher the anticipated level of uncertainty, the greater the MOS should be made to compensate. The MOS is generally based on a qualitative assessment of the relative amount of uncertainty as a matter of best professional judgment (BPJ).

For example, Vermont conducted a TMDL for its acid ponds in 2003 and used a MOS of 5%, based on the fact that their water quality data were recent and reflected springtime conditions when peak acidity loads would be expected. Furthermore, sampling was conducted on relatively remote acid ponds where most pH values were well below 6.0 (VTDEC, 2003). In their previous Acid Pond TMDL, New Hampshire used a somewhat higher MOS value of 7.5% (NH DES, 2004) because some of the water quality data used were older and were collected during the summer which may be less protective than spring data (i.e., not worst case).

For the current application to acid-impaired ponds, a MOS at 10% was recommended by NHDES, with the consensus of USEPA, (e-mail from Margaret Foss, NHDES; dated May 4, 2007). This MOS factor was selected because the current water chemistry data set includes data from all seasons and at a variety of pond water depths. The measured pH values tend to be lowest in winter and at depth in stratified systems (i.e., near pond bottoms). This conservative pH data was used in the assessments, but was matched with cation data in the SSWC model that were taken from the summer, upper layer (since it was the only data available).

In addition, most of the 158 ponds being considered in the study are less acidic and are located in more developed watersheds than the 2004 ponds. These ponds may be influenced by local watershed influences such as road salt and it may affect the model's predictions. Therefore, NHDES recommended that the MOS be raised to 10% because of the relatively greater degree of uncertainty in application of this data set for development of a TMDL.

4.2.3 TMDL Calculation and Load Allocation

The purpose of the TMDL is to provide the link between acidic loadings and a pond's ANC by quantifying the maximum amount of acidity the watershed can receive to maintain the selected ANC. For this TMDL, the SSWC model was used to make this connection. Since the source of all the acidity is considered to be non-point, the waste load allocation is equal to zero and the TMDL or critical load is:

$$\mathbf{TMDL = LA + MOS}$$

The SSWC model calculates critical loads based on in-lake water chemistry and accounts for annual surface runoff amounts and a user specified ANC limit. The ability to set a predefined ANC limit forces the model to output a critical load based directly on the project-specific water quality target of 6.24 mg/L of ANC. The critical load for each of the 158 ponds is given in Table 3 below. The critical loads are reported as both yearly ($meq/m^2/yr$) and daily ($meq/m^2/day$) loads.

Positive critical load values indicate that the waterbody has some tolerance for acidic inputs and still is able to maintain the target ANC of 6.24 mg/L. The greater the critical load, the greater the tolerance of the waterbody to acid inputs. On the other hand, negative critical loads represent situations where the selected ANC target of

6.24 mg/L is higher than the original, pre-acidification, base cation concentrations would naturally allow. For these areas the critical load is zero. In other words, these lakes can accept no acid loadings and, in fact, if loadings were reduced to zero, acidic conditions would continue.

Table 4 summarizes the final TMDL acid allocations for all 158 of the acid impaired ponds (and by extension, the associated beaches) covered under this TMDL. This listing of ponds also incorporates the required MOS, which reduces the allowable load allocations by 10%. These TMDL values indicate the permissible loading to comply with water quality standards.

Table 3. Critical Loads of Acidity for New Hampshire Acid-Impaired Ponds

Count	Pond ID	Pond Name	Yearly Critical Load meq/m^2/yr	Daily Critical Load meq/m^2/day
1	NHIMP700060302-02	HAYWARD BROOK - MORRILL POND	**-14.83**	**-0.04**
2	NHIMP700060502-01	UNKNOWN RIVER - DURGIN POND OUTLET	**-28.83**	**-0.08**
3	NHIMP700061403-04	POWWOW RIVER - POWWOW POND	**56.11**	**0.15**
4	NHLAK600020202-01	FALLS POND	**39.60**	**0.11**
5	NHLAK600020302-01-01	ECHO LAKE	**-53.98**	**-0.15**
6	NHLAK600020303-03	IONA LAKE	**40.87**	**0.11**
7	NHLAK600020303-05	BIG PEA PORRIDGE POND	**-8.05**	**-0.02**
8	NHLAK600020303-06	MIDDLE PEA PORRIDGE POND	**-37.13**	**-0.10**
9	NHLAK600020303-07-01	PEQUAWKET POND	**75.45**	**0.21**
10	NHLAK600020303-09	WHITTON POND	**-24.55**	**-0.07**
11	NHLAK600020604-03	MOORES POND	**36.93**	**0.10**
12	NHLAK600020701-02	LOWER BEECH POND	**-6.36**	**-0.02**
13	NHLAK600020701-04	UPPER BEECH POND	**9.81**	**0.03**
14	NHLAK600020702-01	DAN HOLE POND	**34.30**	**0.09**
15	NHLAK600020703-03	PINE RIVER POND	**41.33**	**0.11**
16	NHLAK600020703-04	WHITE POND	**5.29**	**0.01**
17	NHLAK600020801-01	BLUE POND	**29.39**	**0.08**
18	NHLAK600020801-05	MACK POND	**74.38**	**0.20**
19	NHLAK600020801-06-01	SILVER LAKE	**35.50**	**0.10**
20	NHLAK600020802-04-01	OSSIPEE LAKE	**61.97**	**0.17**
21	NHLAK600020803-01-01	LOWER DANFORTH POND	**68.31**	**0.19**
22	NHLAK600020803-01-02	MIDDLE DANFORTH POND	**102.92**	**0.28**
23	NHLAK600020803-03	UPPER DANFORTH POND	**115.25**	**0.32**
24	NHLAK600020803-08	SHAW POND	**14.57**	**0.04**
25	NHLAK600020804-01-01	BERRY BAY	**112.12**	**0.31**
26	NHLAK600020804-01-02	LEAVITT BAY	**68.11**	**0.19**
27	NHLAK600020804-01-03	BROAD BAY	**61.68**	**0.17**
28	NHLAK600020902-01	PROVINCE LAKE	**44.74**	**0.12**
29	NHLAK600021001-01	BALCH POND	**100.05**	**0.27**
30	NHLAK600030403-02	HORN POND	**23.94**	**0.07**
31	NHLAK600030601-05-01	SUNRISE LAKE	**55.94**	**0.15**
32	NHLAK600030602-03	ROCHESTER RESERVOIR	**-34.66**	**-0.09**
33	NHLAK600030605-01	NIPPO POND	**12.26**	**0.03**
34	NHLAK600030704-02-01	PAWTUCKAWAY LAKE	**7.50**	**0.02**
35	NHLAK600030802-01	HUNT POND	**-47.88**	**-0.13**
36	NHLAK700010104-02	LOON POND	**-35.15**	**-0.10**
37	NHLAK700010205-01	MIRROR LAKE	**27.29**	**0.07**
38	NHLAK700010304-04	MCCUTCHEON POND	**-38.88**	**-0.11**
39	NHLAK700010304-05	POUT POND	**-11.24**	**-0.03**
40	NHLAK700010401-03	CONE POND	**-42.19**	**-0.12**
41	NHLAK700010402-03	LOWER HALL POND	**5.94**	**0.02**
42	NHLAK700010402-05	UPPER HALL POND	**-21.15**	**-0.06**
43	NHLAK700010402-08	LITTLE PERCH POND	**-15.31**	**-0.04**
44	NHLAK700010501-01	BARVILLE POND	**54.51**	**0.15**
45	NHLAK700010501-02	INTERVALE POND	**25.17**	**0.07**
46	NHLAK700010501-03	KUSUMPE POND	**16.69**	**0.05**
47	NHLAK700010502-04	SKY POND	**6.24**	**0.02**
48	NHLAK700010701-03	ORANGE POND	**46.89**	**0.13**
49	NHLAK700010701-05	WAUKEENA LAKE	**53.52**	**0.15**
50	NHLAK700010702-02	SCHOOL POND	**40.56**	**0.11**
51	NHLAK700010802-03-01	HERMIT LAKE	**-141.86**	**-0.39**
52	NHLAK700010802-04	RANDLETT POND	**10.08**	**0.03**
53	NHLAK700010802-05	MOUNTAIN POND	**-17.91**	**-0.05**
54	NHLAK700010804-01-01	HIGHLAND LAKE	**52.66**	**0.14**
55	NHLAK700010804-02-01	WEBSTER LAKE	**20.53**	**0.06**
56	NHLAK700020101-05-01	LAKE WENTWORTH	**25.61**	**0.07**
57	NHLAK700020101-07-01	RUST POND	**71.86**	**0.20**
58	NHLAK700020108-02-01	LAKE WAUKEWAN	**48.69**	**0.13**
59	NHLAK700020108-02-02	LAKE WINONA	**46.35**	**0.13**
60	NHLAK700020108-04	HAWKINS POND	**30.88**	**0.08**
61	NHLAK700020110-02-01	PAUGUS BAY	**31.60**	**0.09**
62	NHLAK700020110-02-19	LAKE WINNIPESAUKEE	**33.94**	**0.09**

Table 3. Critical Loads of Acidity for New Hampshire Acid-Impaired Ponds

Count	Pond ID	Pond Name	Yearly Critical Load meq/m^2/yr	Daily Critical Load meq/m^2/day
63	NHLAK700020110-05	SALTMARSH POND	**-73.88**	**-0.20**
64	NHLAK700020201-05-01	LAKE WINNISQUAM	**71.90**	**0.20**
65	NHLAK700020202-03	POUT POND	**23.43**	**0.06**
66	NHLAK700020202-04	SARGENT LAKE	**-64.52**	**-0.18**
67	NHLAK700030101-08	GRASSY POND	**-49.27**	**-0.13**
68	NHLAK700030101-12	POOL POND	**-61.13**	**-0.17**
69	NHLAK700030101-13	BULLET POND	**-51.35**	**-0.14**
70	NHLAK700030103-02	TOLMAN POND	**27.43**	**0.08**
71	NHLAK700030103-03	JUGGERNAUT POND	**-17.78**	**-0.05**
72	NHLAK700030103-09	SPOONWOOD LAKE	**5.60**	**0.02**
73	NHLAK700030103-10	DINSMORE POND	**18.30**	**0.05**
74	NHLAK700030105-01-01	ZEPHYR LAKE	**12.73**	**0.03**
75	NHLAK700030105-02-01	OTTER LAKE	**-35.03**	**-0.10**
76	NHLAK700030105-03-01	SUNSET LAKE	**-118.72**	**-0.33**
77	NHLAK700030107-01	WILLARD POND	**-28.15**	**-0.08**
78	NHLAK700030202-06	BAGLEY POND	**-0.71**	**0.00**
79	NHLAK700030203-02	SMITH POND	**27.60**	**0.08**
80	NHLAK700030203-03	TROUT POND	**-29.99**	**-0.08**
81	NHLAK700030204-04	LOON POND	**16.59**	**0.05**
82	NHLAK700030302-02	BLAISDELL LAKE	**49.13**	**0.13**
83	NHLAK700030302-04-01	MASSASECUM LAKE	**-78.22**	**-0.21**
84	NHLAK700030304-05	TOM POND	**32.30**	**0.09**
85	NHLAK700030304-07	TUCKER POND	**21.49**	**0.06**
86	NHLAK700030304-08	LAKE WINNEPOCKET	**27.70**	**0.08**
87	NHLAK700030401-02	BUTTERFIELD POND	**-29.95**	**-0.08**
88	NHLAK700030402-01	CHASE POND	**2.45**	**0.01**
89	NHLAK700030402-02-01	PLEASANT LAKE	**-30.47**	**-0.08**
90	NHLAK700030403-05	HORSESHOE POND	**145.10**	**0.40**
91	NHLAK700030502-03	BEAR POND	**42.58**	**0.12**
92	NHLAK700030505-01	CLEMENT POND	**80.90**	**0.22**
93	NHLAK700040401-01-01	MELENDY POND	**-5.89**	**-0.02**
94	NHLAK700040401-02-01	POTANIPO POND	**17.25**	**0.05**
95	NHLAK700060101-01	SHAW POND	**-4.91**	**-0.01**
96	NHLAK700060101-02-01	SONDOGARDY POND	**1.40**	**0.00**
97	NHLAK700060201-01-01	LOON POND	**81.22**	**0.22**
98	NHLAK700060201-03	NEW POND	**6.10**	**0.02**
99	NHLAK700060202-03-01	CLOUGH POND	**40.80**	**0.11**
100	NHLAK700060202-04	CROOKED POND	**21.02**	**0.06**
101	NHLAK700060401-02-01	CRYSTAL LAKE	**-1.01**	**0.00**
102	NHLAK700060401-06	MANNING LAKE	**27.14**	**0.07**
103	NHLAK700060401-12	SUNSET LAKE	**8.08**	**0.02**
104	NHLAK700060402-03	HALFMOON LAKE	**17.96**	**0.05**
105	NHLAK700060402-05	HUNTRESS POND	**12.90**	**0.04**
106	NHLAK700060403-01	BIG WILLEY POND	**-39.06**	**-0.11**
107	NHLAK700060403-02	LITTLE WILLEY POND	**-25.88**	**-0.07**
108	NHLAK700060501-03	WILD GOOSE POND	**-3.19**	**-0.01**
109	NHLAK700060501-08	BERRY POND	**16.26**	**0.04**
110	NHLAK700060502-03	CHESTNUT POND	**20.17**	**0.06**
111	NHLAK700060503-01	BEAR HILL POND	**-39.11**	**-0.11**
112	NHLAK700060601-01	DEERING RESERVOIR	**7.51**	**0.02**
113	NHLAK700060601-02	DUDLEY POND	**30.86**	**0.08**
114	NHLAK700060601-03-01	PLEASANT POND	**64.98**	**0.18**
115	NHLAK700060602-02	MOUNT WILLIAM POND	**16.26**	**0.04**
116	NHLAK700060604-01	PLEASANT POND	**-7.74**	**-0.02**
117	NHLAK700060607-03	LONG POND	**-10.05**	**-0.03**
118	NHLAK700060702-03	MASSABESIC LAKE	**-32.64**	**-0.09**
119	NHLAK700060802-02	LAKINS POND	**-10.32**	**-0.03**
120	NHLAK700060802-03	PINNACLE POND	**-31.73**	**-0.09**
121	NHLAK700060803-02	STEVENS POND	**-1659.62**	**-4.55**
122	NHLAK700061002-03	HORSESHOE POND	**-209.09**	**-0.57**
123	NHLAK700061101-01-01	ISLAND POND	**103.57**	**0.28**
124	NHLAK700061203-06-01	ROBINSON POND	**93.60**	**0.26**

Table 3. Critical Loads of Acidity for New Hampshire Acid-Impaired Ponds

Count	Pond ID	Pond Name	Yearly Critical Load $meq/m^2/yr$	Daily Critical Load $meq/m^2/day$
125	NHLAK700061204-02	LITTLE ISLAND POND	**58.97**	**0.16**
126	NHLAK700061204-03	ROCK POND	**88.45**	**0.24**
127	NHLAK700061205-01	GUMPAS POND	**24.41**	**0.07**
128	NHLAK801010102-03	ROUND POND	**243.66**	**0.67**
129	NHLAK801010707-01-01	CHRISTINE LAKE	**38.40**	**0.11**
130	NHLAK801040201-03	LAKE TARLETON	**5.44**	**0.01**
131	NHLAK801040203-01-01	POST POND	**221.54**	**0.61**
132	NHLAK801060101-03	CUMMINS POND	**-6.28**	**-0.02**
133	NHLAK801060101-05	RESERVOIR POND	**-1.57**	**0.00**
134	NHLAK801060103-02	LITTLE GOOSE POND	**43.57**	**0.12**
135	NHLAK801060104-02	GRAFTON POND	**31.64**	**0.09**
136	NHLAK801060401-06	EASTMAN POND	**-22.54**	**-0.06**
137	NHLAK801060401-08-01	KOLELEMOOK LAKE	**-28.75**	**-0.08**
138	NHLAK801060402-04-01	LITTLE SUNAPEE LAKE	**-112.24**	**-0.31**
139	NHLAK801060402-05-01	SUNAPEE LAKE	**32.77**	**0.09**
140	NHLAK801060402-11	MOUNTAINVIEW LAKE	**-213.60**	**-0.59**
141	NHLAK801060402-12-01	OTTER POND	**61.19**	**0.17**
142	NHLAK801060403-01	GILMAN POND	**21.76**	**0.06**
143	NHLAK801060403-04-01	RAND POND	**53.96**	**0.15**
144	NHLAK801060404-01	ROCKYBOUND POND	**45.88**	**0.13**
145	NHLAK801070201-01	CRESCENT LAKE	**11.07**	**0.03**
146	NHLAK801070503-01-01	SPOFFORD LAKE	**74.44**	**0.20**
147	NHLAK802010102-05	BARRETT POND	**-36.60**	**-0.10**
148	NHLAK802010104-01	CALDWELL POND	**-40.21**	**-0.11**
149	NHLAK802010104-03	CRANBERRY POND	**-42.27**	**-0.12**
150	NHLAK802010202-02	CHILDS BOG	**-50.40**	**-0.14**
151	NHLAK802010202-07	RUSSELL RESERVOIR	**-50.97**	**-0.14**
152	NHLAK802010202-14	BABBIDGE RESERVOIR	**3.25**	**0.01**
153	NHLAK802010302-01-01	SWANZEY LAKE	**55.65**	**0.15**
154	NHLAK802010303-02	MEETINGHOUSE POND	**-36.11**	**-0.10**
155	NHLAK802010303-07	SAND POND	**-0.44**	**0.00**
156	NHLAK802010303-10	WILSON POND	**23.98**	**0.07**
157	NHLAK802020103-04	EMERSON POND	**-10.40**	**-0.03**
158	NHLAK802020202-01	COLLINS POND	**-38.20**	**-0.10**

Table 4. Total Maximum Daily Loads (TMDLs) and Allocations for New Hampshire Acid-Impaired Ponds.

Count	Pond ID	Pond Name	WLA meq/m²/yr	LA meq/m²/yr	MOS meq/m²/yr	TMDL meq/m²/yr	TMDL meq/m²/day
1	NHIMP700060302-02	HAYWARD BROOK - MORRILL POND	0	-13.34	1.48	-14.83	-0.041
2	NHIMP700060502-01	UNKNOWN RIVER - DURGIN POND OUTLET	0	-25.95	2.88	-28.83	-0.079
3	NHIMP700061403-04	POWWOW RIVER - POWWOW POND	0	50.50	5.61	56.11	0.154
4	NHLAK600020202-01	FALLS POND	0	35.64	3.96	39.60	0.108
5	NHLAK600020302-01-01	ECHO LAKE	0	-48.58	5.40	-53.98	-0.148
6	NHLAK600020303-03	IONA LAKE	0	36.78	4.09	40.87	0.112
7	NHLAK600020303-05	BIG PEA PORRIDGE POND	0	-7.24	0.80	-8.05	-0.022
8	NHLAK600020303-06	MIDDLE PEA PORRIDGE POND	0	-33.42	3.71	-37.13	-0.102
9	NHLAK600020303-07-01	PEQUAWKET POND	0	67.91	7.55	75.45	0.207
10	NHLAK600020303-09	WHITTON POND	0	-22.10	2.46	-24.55	-0.067
11	NHLAK600020604-03	MOORES POND	0	33.24	3.69	36.93	0.101
12	NHLAK600020701-02	LOWER BEECH POND	0	-5.72	0.64	-6.36	-0.017
13	NHLAK600020701-04	UPPER BEECH POND	0	8.83	0.98	9.81	0.027
14	NHLAK600020702-01	DAN HOLE POND	0	30.87	3.43	34.30	0.094
15	NHLAK600020703-03	PINE RIVER POND	0	37.20	4.13	41.33	0.113
16	NHLAK600020703-04	WHITE POND	0	4.76	0.53	5.29	0.014
17	NHLAK600020801-01	BLUE POND	0	26.45	2.94	29.39	0.081
18	NHLAK600020801-05	MACK POND	0	66.94	7.44	74.38	0.204
19	NHLAK600020801-06-01	SILVER LAKE	0	31.95	3.55	35.50	0.097
20	NHLAK600020802-04-01	OSSIPEE LAKE	0	55.77	6.20	61.97	0.170
21	NHLAK600020803-01-01	LOWER DANFORTH POND	0	61.48	6.83	68.31	0.187
22	NHLAK600020803-01-02	MIDDLE DANFORTH POND	0	92.63	10.29	102.92	0.282
23	NHLAK600020803-03	UPPER DANFORTH POND	0	103.73	11.53	115.25	0.316
24	NHLAK600020803-08	SHAW POND	0	13.11	1.46	14.57	0.040
25	NHLAK600020804-01-01	BERRY BAY	0	100.90	11.21	112.12	0.307
26	NHLAK600020804-01-02	LEAVITT BAY	0	61.30	6.81	68.11	0.187
27	NHLAK600020804-01-03	BROAD BAY	0	55.51	6.17	61.68	0.169
28	NHLAK600020902-01	PROVINCE LAKE	0	40.27	4.47	44.74	0.123
29	NHLAK600021001-01	BALCH POND	0	90.04	10.00	100.05	0.274
30	NHLAK600030403-02	HORN POND	0	21.55	2.39	23.94	0.066
31	NHLAK600030601-05-01	SUNRISE LAKE	0	50.35	5.59	55.94	0.153
32	NHLAK600030602-03	ROCHESTER RESERVOIR	0	-31.19	3.47	-34.66	-0.095
33	NHLAK600030605-01	NIPPO POND	0	11.04	1.23	12.26	0.034
34	NHLAK600030704-02-01	PAWTUCKAWAY LAKE	0	6.75	0.75	7.50	0.021
35	NHLAK600030802-01	HUNT POND	0	-43.09	4.79	-47.88	-0.131
36	NHLAK700010104-02	LOON POND	0	-31.63	3.51	-35.15	-0.096
37	NHLAK700010205-01	MIRROR LAKE	0	24.56	2.73	27.29	0.075
38	NHLAK700010304-04	MCCUTCHEON POND	0	-35.00	3.89	-38.88	-0.107
39	NHLAK700010304-05	POUT POND	0	-10.11	1.12	-11.24	-0.031
40	NHLAK700010401-03	CONE POND	0	-37.97	4.22	-42.19	-0.116
41	NHLAK700010402-03	LOWER HALL POND	0	5.34	0.59	5.94	0.016
42	NHLAK700010402-05	UPPER HALL POND	0	-19.04	2.12	-21.15	-0.058
43	NHLAK700010402-08	LITTLE PERCH POND	0	-13.78	1.53	-15.31	-0.042
44	NHLAK700010501-01	BARVILLE POND	0	49.06	5.45	54.51	0.149
45	NHLAK700010501-02	INTERVALE POND	0	22.65	2.52	25.17	0.069
46	NHLAK700010501-03	KUSUMPE POND	0	15.02	1.67	16.69	0.046
47	NHLAK700010502-04	SKY POND	0	5.62	0.62	6.24	0.017
48	NHLAK700010701-03	ORANGE POND	0	42.20	4.69	46.89	0.128
49	NHLAK700010701-05	WAUKEENA LAKE	0	48.17	5.35	53.52	0.147
50	NHLAK700010702-02	SCHOOL POND	0	36.50	4.06	40.56	0.111
51	NHLAK700010802-03-01	HERMIT LAKE	0	-127.68	14.19	-141.86	-0.389
52	NHLAK700010802-04	RANDLETT POND	0	9.07	1.01	10.08	0.028
53	NHLAK700010802-05	MOUNTAIN POND	0	-16.11	1.79	-17.91	-0.049
54	NHLAK700010804-01-01	HIGHLAND LAKE	0	47.40	5.27	52.66	0.144
55	NHLAK700010804-02-01	WEBSTER LAKE	0	18.48	2.05	20.53	0.056
56	NHLAK700020101-05-01	LAKE WENTWORTH	0	23.05	2.56	25.61	0.070
57	NHLAK700020101-07-01	RUST POND	0	64.68	7.19	71.86	0.197
58	NHLAK700020108-02-01	LAKE WAUKEWAN	0	43.82	4.87	48.69	0.133
59	NHLAK700020108-02-02	LAKE WINONA	0	41.72	4.64	46.35	0.127
60	NHLAK700020108-04	HAWKINS POND	0	27.79	3.09	30.88	0.085
61	NHLAK700020110-02-01	PAUGUS BAY	0	28.44	3.16	31.60	0.087
62	NHLAK700020110-02-19	LAKE WINNIPESAUKEE	0	30.54	3.39	33.94	0.093
63	NHLAK700020110-05	SALTMARSH POND	0	-66.49	7.39	-73.88	-0.202
64	NHLAK700020201-05-01	LAKE WINNISQUAM	0	64.71	7.19	71.90	0.197
65	NHLAK700020202-03	POUT POND	0	21.09	2.34	23.43	0.064
66	NHLAK700020202-04	SARGENT LAKE	0	-58.07	6.45	-64.52	-0.177
67	NHLAK700030101-08	GRASSY POND	0	-44.34	4.93	-49.27	-0.135
68	NHLAK700030101-12	POOL POND	0	-55.02	6.11	-61.13	-0.167
69	NHLAK700030101-13	BULLET POND	0	-46.22	5.14	-51.35	-0.141
70	NHLAK700030103-02	TOLMAN POND	0	24.69	2.74	27.43	0.075
71	NHLAK700030103-03	JUGGERNAUT POND	0	-16.00	1.78	-17.78	-0.049
72	NHLAK700030103-09	SPOONWOOD LAKE	0	5.04	0.56	5.60	0.015
73	NHLAK700030103-10	DINSMORE POND	0	16.47	1.83	18.30	0.050
74	NHLAK700030105-01-01	ZEPHYR LAKE	0	11.45	1.27	12.73	0.035
75	NHLAK700030105-02-01	OTTER LAKE	0	-31.53	3.50	-35.03	-0.096
76	NHLAK700030105-03-01	SUNSET LAKE	0	-106.85	11.87	-118.72	-0.325
77	NHLAK700030107-01	WILLARD POND	0	-25.34	2.82	-28.15	-0.077
78	NHLAK700030202-06	BAGLEY POND	0	-0.64	0.07	-0.71	-0.002
79	NHLAK700030203-02	SMITH POND	0	24.84	2.76	27.60	0.076
80	NHLAK700030203-03	TROUT POND	0	-26.99	3.00	-29.99	-0.082

Table 4. Total Maximum Daily Loads (TMDLs) and Allocations for New Hampshire Acid-Impaired Ponds.

Count	Pond ID	Pond Name	WLA meq/m^2/yr	LA meq/m^2/yr	MOS meq/m^2/yr	TMDL meq/m^2/yr	TMDL meq/m^2/day
81	NHLAK700030204-04	LOON POND	0	14.93	1.66	16.59	0.045
82	NHLAK700030302-02	BLAISDELL LAKE	0	44.22	4.91	49.13	0.135
83	NHLAK700030302-04-01	MASSASECUM LAKE	0	-70.40	7.82	-78.22	-0.214
84	NHLAK700030304-05	TOM POND	0	29.07	3.23	32.30	0.088
85	NHLAK700030304-07	TUCKER POND	0	19.34	2.15	21.49	0.059
86	NHLAK700030304-08	LAKE WINNEPOCKET	0	24.93	2.77	27.70	0.076
87	NHLAK700030401-02	BUTTERFIELD POND	0	-26.96	3.00	-29.95	-0.082
88	NHLAK700030402-01	CHASE POND	0	2.21	0.25	2.45	0.007
89	NHLAK700030402-02-01	PLEASANT LAKE	0	-27.42	3.05	-30.47	-0.083
90	NHLAK700030403-05	HORSESHOE POND	0	130.59	14.51	145.10	0.398
91	NHLAK700030502-03	BEAR POND	0	38.32	4.26	42.58	0.117
92	NHLAK700030505-01	CLEMENT POND	0	72.81	8.09	80.90	0.222
93	NHLAK700040401-01-01	MELENDY POND	0	-5.30	0.59	-5.89	-0.016
94	NHLAK700040401-02-01	POTANIPO POND	0	15.52	1.72	17.25	0.047
95	NHLAK700060101-01	SHAW POND	0	-4.42	0.49	-4.91	-0.013
96	NHLAK700060101-02-01	SONDOGARDY POND	0	1.26	0.14	1.40	0.004
97	NHLAK700060201-01-01	LOON POND	0	73.09	8.12	81.22	0.223
98	NHLAK700060201-03	NEW POND	0	5.49	0.61	6.10	0.017
99	NHLAK700060202-03-01	CLOUGH POND	0	36.72	4.08	40.80	0.112
100	NHLAK700060202-04	CROOKED POND	0	18.92	2.10	21.02	0.058
101	NHLAK700060401-02-01	CRYSTAL LAKE	0	-0.91	0.10	-1.01	-0.003
102	NHLAK700060401-06	MANNING LAKE	0	24.42	2.71	27.14	0.074
103	NHLAK700060401-12	SUNSET LAKE	0	7.27	0.81	8.08	0.022
104	NHLAK700060402-03	HALFMOON LAKE	0	16.17	1.80	17.96	0.049
105	NHLAK700060402-05	HUNTRESS POND	0	11.61	1.29	12.90	0.035
106	NHLAK700060403-01	BIG WILLEY POND	0	-35.15	3.91	-39.06	-0.107
107	NHLAK700060403-02	LITTLE WILLEY POND	0	-23.29	2.59	-25.88	-0.071
108	NHLAK700060501-03	WILD GOOSE POND	0	-2.87	0.32	-3.19	-0.009
109	NHLAK700060501-08	BERRY POND	0	14.63	1.63	16.26	0.045
110	NHLAK700060502-03	CHESTNUT POND	0	18.15	2.02	20.17	0.055
111	NHLAK700060503-01	BEAR HILL POND	0	-35.20	3.91	-39.11	-0.107
112	NHLAK700060601-01	DEERING RESERVOIR	0	6.76	0.75	7.51	0.021
113	NHLAK700060601-02	DUDLEY POND	0	27.78	3.09	30.86	0.085
114	NHLAK700060601-03-01	PLEASANT POND	0	58.48	6.50	64.98	0.178
115	NHLAK700060602-02	MOUNT WILLIAM POND	0	14.64	1.63	16.26	0.045
116	NHLAK700060604-01	PLEASANT POND	0	-6.97	0.77	-7.74	-0.021
117	NHLAK700060607-03	LONG POND	0	-9.04	1.00	-10.05	-0.028
118	NHLAK700060702-03	MASSABESIC LAKE	0	-29.38	3.26	-32.64	-0.089
119	NHLAK700060802-02	LAKINS POND	0	-9.29	1.03	-10.32	-0.028
120	NHLAK700060802-03	PINNACLE POND	0	-28.55	3.17	-31.73	-0.087
121	NHLAK700060803-02	STEVENS POND	0	-1493.66	165.96	-1659.62	-4.547
122	NHLAK700061002-03	HORSESHOE POND	0	-188.18	20.91	-209.09	-0.573
123	NHLAK700061101-01-01	ISLAND POND	0	93.21	10.36	103.57	0.284
124	NHLAK700061203-06-01	ROBINSON POND	0	84.24	9.36	93.60	0.256
125	NHLAK700061204-02	LITTLE ISLAND POND	0	53.07	5.90	58.97	0.162
126	NHLAK700061204-03	ROCK POND	0	79.60	8.84	88.45	0.242
127	NHLAK700061205-01	GUMPAS POND	0	21.97	2.44	24.41	0.067
128	NHLAK801010102-03	ROUND POND	0	219.29	24.37	243.66	0.668
129	NHLAK801010707-01-01	CHRISTINE LAKE	0	34.56	3.84	38.40	0.105
130	NHLAK801040201-03	LAKE TARLETON	0	4.90	0.54	5.44	0.015
131	NHLAK801040203-01-01	POST POND	0	199.38	22.15	221.54	0.607
132	NHLAK801060101-03	CUMMINS POND	0	-5.65	0.63	-6.28	-0.017
133	NHLAK801060101-05	RESERVOIR POND	0	-1.41	0.16	-1.57	-0.004
134	NHLAK801060103-02	LITTLE GOOSE POND	0	39.22	4.36	43.57	0.119
135	NHLAK801060104-02	GRAFTON POND	0	28.48	3.16	31.64	0.087
136	NHLAK801060401-06	EASTMAN POND	0	-20.29	2.25	-22.54	-0.062
137	NHLAK801060401-08-01	KOLELEMOOK LAKE	0	-25.87	2.87	-28.75	-0.079
138	NHLAK801060402-04-01	LITTLE SUNAPEE LAKE	0	-101.02	11.22	-112.24	-0.308
139	NHLAK801060402-05-01	SUNAPEE LAKE	0	29.49	3.28	32.77	0.090
140	NHLAK801060402-11	MOUNTAINVIEW LAKE	0	-192.24	21.36	-213.60	-0.585
141	NHLAK801060402-12-01	OTTER POND	0	55.07	6.12	61.19	0.168
142	NHLAK801060403-01	GILMAN POND	0	19.58	2.18	21.76	0.060
143	NHLAK801060403-04-01	RAND POND	0	48.57	5.40	53.96	0.148
144	NHLAK801060404-01	ROCKYBOUND POND	0	41.29	4.59	45.88	0.126
145	NHLAK801070201-01	CRESCENT LAKE	0	9.96	1.11	11.07	0.030
146	NHLAK801070503-01-01	SPOFFORD LAKE	0	67.00	7.44	74.44	0.204
147	NHLAK802010102-05	BARRETT POND	0	-32.94	3.66	-36.60	-0.100
148	NHLAK802010104-01	CALDWELL POND	0	-36.19	4.02	-40.21	-0.110
149	NHLAK802010104-03	CRANBERRY POND	0	-38.04	4.23	-42.27	-0.116
150	NHLAK802010202-02	CHILDS BOG	0	-45.36	5.04	-50.40	-0.138
151	NHLAK802010202-07	RUSSELL RESERVOIR	0	-45.87	5.10	-50.97	-0.140
152	NHLAK802010202-14	BABBIDGE RESERVOIR	0	2.93	0.33	3.25	0.009
153	NHLAK802010302-01-01	SWANZEY LAKE	0	50.09	5.57	55.65	0.152
154	NHLAK802010303-02	MEETINGHOUSE POND	0	-32.50	3.61	-36.11	-0.099
155	NHLAK802010303-07	SAND POND	0	-0.39	0.04	-0.44	-0.001
156	NHLAK802010303-10	WILSON POND	0	21.58	2.40	23.98	0.066
157	NHLAK802020103-04	EMERSON POND	0	-9.36	1.04	-10.40	-0.028
158	NHLAK802020202-01	COLLINS POND	0	-34.38	3.82	-38.20	-0.105

5.0 Evaluation of Aluminum-Impaired Ponds

This section is a condensed version of a literature report conducted as part of ENSR Corporation's (ENSR) tasks under its United States Environmental Protection Agency (USEPA) contract CWQ-003 entitled "New Hampshire Total Maximum Daily Load (TMDL) Development." As part of the TMDL contract, ENSR was tasked with conducting a literature review to help identify potential methods of differentiating between natural and anthropogenic aluminum sources. The full report is available as Appendix E to this document.

The literature review provided background on current theories and potential methods of identifying the source of aluminum impairment in New Hampshire waters. It does not attempt to cover the considerable scientific literature on aluminum chemistry, but it identified a number of peer-reviewed papers that provide an updated overview on the subject with particular emphasis on potential sources of aluminum. While the primary focus was on aluminum impairment of ponds, lakes, and impoundments (i.e., lentic waters), this literature is also relevant to aluminum impairment of New Hampshire rivers and streams (i.e., lotic waters) which will be considered separately as another task of ENSR's TMDL project.

5.1 Aluminum Aqueous Chemistry and Toxicity

Aluminum is one of the most ubiquitous elements found in nature. Aluminum in ecosystems originates primarily from mineral weathering processes and biological cycling. In the northeastern United States, aluminum adsorbs to soil particles via dissolution of secondary minerals, such as silicates (Palmer et al., 2005). Relatively small amounts of aluminum become available through mineral weathering. Decaying organic matter also contributes aluminum to the exchangeable pool between soil, water, and biota in the ecosystem (Gensemer and Playle, 1999).

The concentration of aluminum in ecosystem soils and water largely depends on pH because aluminum solubility increases in acidic (pH<6) and alkaline (pH>8) conditions (Gensemer and Playle, 1999). Aluminum is amphoteric and can react with mineral acids to form soluble salts and to evolve hydrogen. Aluminum solubility also increases at lower temperatures and in the presence of ligands, such as humic and fulvic acids. Due to its high reactivity, aluminum is rarely found as a pure metal and it rapidly complexes to form inorganic and organic species (Ščančar and Milačič, 2006). Monomeric hydroxyl aluminum, referred to as inorganic monomeric aluminum (Al_{IM}) is the predominant inorganic aqueous species found in watersheds. Decaying organic matter generates dissolved organic carbon (DOC) that consists of organic ligands such as humic and fulvic acids that bind aluminum into organic forms.

Like aluminum solubility, aluminum speciation is primarily controlled by pH. At pH < 5, the inorganic monomeric aluminum (Al_{IM}) species, Al^{+3}, is most prevalent and as pH increases aluminum instantaneously transforms into other inorganic forms (Ščančar and Milačič, 2006). Speciation and pH also influences the potential toxicity to aquatic organisms (Sparling and Lowe, 1993). The Al_{IM} fractions are most acutely toxic for aquatic organisms (Lydersen et al., 2002), while Al_{OM} has been shown to have very little adverse effect. In acidic waters, Al_{IM} can cause acute mortality by interrupting ion-regulation in the gills of fish, causing hypoxia and has similar effects to some gilled macroinvertebrates (Gensemer and Playle, 1999). Studies suggest that Al_{IM} may be most toxic for algae at pH ~6 and is incrementally less toxic at lower pH, but more study is necessary to establish this (Passy, 2006; Gensemer and Playle, 1999). Greater detail of aluminum speciation and toxicity can be found in Gensemer and Playle (1999), Lydersen et al. (2002), Yokel (2004), and Ščančar and Milačič (2006).

5.2 Natural Aluminum Sources and Sinks and Anthropogenic Alteration

The mechanisms controlling aluminum concentration and speciation also determine the sources and sinks of aqueous aluminum. Aluminum is naturally present throughout ecosystems and can be controlled by natural acids. Humans often alter aluminum equilibrium into ecosystems by acidifying water bodies through atmospheric pollution or acid mine drainage (Driscoll et al., 2003). Hence, identifying sources and movement of aluminum in watersheds is integral to identifying as well as controlling or mitigating anthropogenic-induced aluminum impairment.

Watershed soils serve as a natural source of aluminum in water bodies due to the accumulation of aluminum from mineralization and the decay of organic material in the upper organic soil horizons, or O horizon. Aluminum adsorbed on mineral soil particles can then be transported into streams through soil water movement (interflow) during precipitation and snowmelt events (Cory et al., 2006). Pellerin et al. (2002) found evidence of aluminum movement from watershed upland soils to riparian areas in the Bear Brook Watershed of Maine.

Wetlands can serve as both potential sources and sinks of aluminum in watersheds due to the influence of organic acid derived from decomposition of peat and woody debris. Wetlands generate considerable amounts of DOC that can bind aluminum and reduce its inherent toxicity. Wetlands, particularly riparian wetlands, can therefore serve as an aluminum sink (Yavitt et al., 2006). However, wetlands can also export DOC and introduce Al_{OM} into a water body (Gorham et al., 1998). This results in a typically strong positive relationship between Al_{OM} and DOC in freshwaters (Palmer et al., 2005). In addition to binding aluminum, strong organic acids generated by DOC can lower pH and increase the solubility of Al_{IM} in waters (Munsen and Gherini, 1993; Lawrence et al., 2007). This suggests that natural acidity may mobilize Al_{IM} and result in lowered pH which shifts the aluminum toward more toxic forms. However, Lawrence et al. (2007) indicated that the presence of strong organic acids would not mobilize Al_{IM} if there were adequate buffering capacity as was found in the high DOC streams in the Adirondacks of New York.

Acid deposition introduces strong inorganic acids into watersheds and consequently alters the equilibrium of aluminum in water bodies. Elevated aluminum concentrations originate from the same natural sources, but tend to increase the flux of inorganic aluminum in waters from mineral soils in the watershed (Cory et al., 2006). Aluminum concentrations in soils increase in these acidified waters as a result of enhanced solubility. Aluminum ions attach to soil cation exchange sites after cations, such as Ca^{2+} and Mg^{2+}, have been stripped by hydrogen ions (H^{+}) and other strong acids from the soil. As soils become saturated with aluminum, larger concentrations are transported to streams and lakes during acidic rain or snowmelt events (Adams et al., 2006).

Aluminum mobilized from mineral soils is typically Al_{IM} due to the absence of organic ligands, although some organic species may be mobilized from soil organic matter. Taking this into account as well as the fact that Al_{IM} is the most toxic form for aquatic life, Lawrence et al. (2007) suggested that the presence of Al_{IM} in water bodies is indicative of anthropogenic impairment. The role of natural acids in mobilization of Al_{IM} is only beginning to be researched, but they appear to be a minor factor driving Al_{IM} mobilization compared to strong inorganic acids introduced by anthropogenic inputs.

5.3 Differentiating natural and anthropogenic sources of aluminum

Due to the complexity that wetlands and natural acidity adds to differentiating sources of aluminum impairment, various models and categorization techniques are beginning to be developed in order to assist in identifying natural and anthropogenic components. These models are beginning to revise the previously simple model of aluminum mobilization solely by atmospheric deposition. At this point, however, no strong consensus has emerged regarding the best paradigm to use.

Models developed for northeastern United States streams and lakes have identified potentially important watershed characteristics that aid in the prediction of surface water aluminum concentrations (see Appendix A). Palmer et al. (2005) modeled aluminum and DOC in the Hubbard Brook, NH watershed based on soil characteristics. The study identified hydrologic flowpaths and residence times as potentially influential landscape characteristics. Streams with the greatest total aluminum concentrations had shallow hydrologic flowpaths and short residence times. However, streams with deep organic soils and hence long hydrologic flow paths also had high aluminum concentrations. The high concentrations of DOC in the streams with a greater influence of deep organic soils suggested that the aluminum contained a higher percentage of Al_{OM}. Ito et al. (2005) similarly found the highest annual flux of aluminum into Adirondack lakes of New York was associated with lakes with thin till soils in sub-watersheds. Lakes with highest average DOC had the highest concentration of monomeric aluminum than those without, but the exact speciation was not indicated.

In addition to predicting aluminum concentration from landscape characteristics, models have been developed in Sweden to estimate the anthropogenic component using aluminum speciation. Bishop et al., (2000) proposed the Boreal Dilution Model to separate natural and anthropogenic components of pH decline in boreal streams impaired by episodic acidification. Episodic acidification is a short-term decline in ANC to less than zero and pH to below 6 that occurs in streams during acidic storm-events and snowmelt (Wigington et al., 1996). The model uses base flow stream chemistry as the baseline for natural conditions and estimates the effect of base cation dilution, organic acids, and strong inorganic acids from acid deposition on pH during a storm event. This is used to predict the low pH conditions (often worst case for aquatic receptors) associated with spring runoff-snowmelt conditions.

Building upon the Boreal Dilution Model, Cory et al. (2006) predicted the anthropogenic component of aluminum increase in streams during episodic acidification. The study determined that the factors of greatest significance to aluminum concentration and speciation were landscape type (% of wetland area in the sub-watershed), stream pH and DOC. The Swedish streams were classified by wetland land cover in sub-watersheds. As anticipated, streams with the largest percentage of wetlands in their sub-watershed had a lower average Al_{IM}/Al_{total} ratio due to the domination of Al_{OM}. Using the average Al_{IM}/Al_{total} ratio and the relationship between pH and Al in the each stream category, Cory et al. (2006) estimated the portion of Al_{IM} increase linked with the estimated anthropogenic pH decline from Boreal Dilution Model results.

These models and classification techniques require further validation, but provide a potential basis on which to determine the source of aluminum impairment in New Hampshire ponds and streams. Accordingly, some of these concepts were further investigated using water chemistry and watershed data from the aluminum-impaired ponds of interest (see Section 5.4).

5.4 Evaluation of Aluminum-Impaired Ponds

As indicated in Section 5.2, some recent studies suggest that aluminum levels are potentially linked to pond water quality parameters or watershed characteristics (Palmer et al., 2005; Ito et al., 2005; Cory et al., 2006). We examined the water chemistry and watershed characteristics of the 21 aluminum-impaired ponds to see if these relationships held and/or provided insight into attributing levels of aluminum to either natural or anthropogenic sources for purposes of TMDL development. These water quality parameters included pH, color (used as a surrogate for DOC), and chloride, as well as the composite values of acid neutralizing capacity (gran ANC) and the annual critical loading ($[CL_{ac}]$) factor (Henriksen and Posch, 2001). In addition, the percentage of wetlands (% wetlands) in the watershed was considered.

The rationales for selection of these parameters were as follows – pH and color were used since both have been shown to influence the amount of aluminum mobilized. Lower values of pH are associated with higher values of soluble (free) aluminum due to its amphoteric nature. DOC may also influence aluminum mobility, but its influence is harder to predict. We did not have DOC values for the 21 ponds but used color as a surrogate parameter since color of a pond is usually highly related to the DOC content (Pace and Cole, 2002).

The gran ANC and $[CL_{ac}]$ values were used as indicators of the relative magnitude of atmospheric deposition – the lower these values (or more negative) the less the ability of the pond to offset the effects of mineral acid inputs, the higher the expected aluminum levels. Chloride was used as an indirect indicator of anthropogenic influence because higher levels of chloride are often associated with watershed development and impervious areas due to road salt and other applied materials (e.g., fertilizers). As indicated by Figure 2, the aluminum-impaired watersheds are not located near the ocean so that maritime-derived salts should not be a factor.

Finally, the % wetlands in a watershed has been shown to be an important determinant of aluminum availability because of the introduction of organic acids (Cory et al., 2006)

Water chemistry data for the aluminum-impaired ponds were obtained from the NHDES Environmental Monitoring Database. Data were preferentially obtained from 1996-2007, but data for some parameters for select ponds were not always available from this time period. In these instances, data from 1991-1995 were used instead. An arithmetic mean was calculated for each water quality parameter for each lake. The resulting means were used in the regression analysis.

Annual [CL_{ac}] values were calculated using watershed runoff and mean concentrations of base cations and mineral acids, all corrected for the influence of sea salt (for details on the determination of [CL_{ac}] values refer to Henriksen and Posch (2001) or Henriksen, Dillon, and Aherne (2002)).

The percentage of wetlands in the watershed was determined by summing the wetland area (as determined by the U.S. Fish and Wildlife National Wetlands Inventory data taken from the 1:24,000 scale topographic maps digitized by NH GRANIT) and comparing this to total watershed area. For purposes of this calculation, we eliminated the actual pond areas (i.e., areas identified as L1UB and PUBH codes) from the total wetlands/watershed assessment.

The relationship between total aluminum concentrations and the water quality parameters were analyzed for trends and statistical relevancy using simple linear and polynomial regressions (see Figures 2-7 in Appendix E), although statistical significance (p-value) was only calculated for the linear regression. There were no strong or significant relationships between aluminum and any of the water quality parameters assessed. The lack of significant correlation for pH, color, gran ANC and [CL_{ac}] suggests these factors do not explain the range and level of aluminum seen in the ponds.

The use of surrogate indicators for watershed development, including chloride and % wetland, indicated that they are poor predictors. Chloride data from the 21 ponds tended to be very much skewed to low values and are not suitable for regression. Also, these low chloride levels may have been expected from the rather remote central location of the pond watersheds away from centers of population. Finally, the % wetlands was not a good predictor, but we note that the range of percentages (<1 % - 3.5%) is very limited and only occupies a small portion of the range of percentage classes (i.e., from <1 to 40%) used in the Cory et al. (2006) paper. It should be noted that most of the aluminum-impaired ponds are remote, high-elevation waterbodies, with similar watershed characteristics including small size and shallow depth to bedrock, and or represented by water quality samples collected once yearly (late spring). The similarity of the watershed/pond settings is likely to reduce the ability of the existing data set to distinguish potential trends between aluminum and potential causal factors.

The failure to find meaningful relationships in the available New Hampshire data set between aluminum and water chemistry or watershed characteristics for the 21 ponds does not mean that such relationships may not exist. The reliance on total aluminum concentrations may mask potential influence of these factors. For example, a relationship between these water quality and watershed parameters and selected fractions of aluminum (e.g., Al_{IM}) may exist. This would be of importance since it would provide a more useful index of potential toxicity to sensitive aquatic receptors. Further investigation would be required to fully evaluate these potential relationships and could include: (1) measurement of water chemistry (pH, ANC, DOC) and aluminum during the spring runoff event vs. during base or low flow conditions; (2) analyses of the relevant aluminum fractions (total and dissolved, Al_{IM}, Al_{OM}, etc.); and (3) re-examination of the relationship with % wetlands in a watershed over a larger range of percentiles. Other potential avenues of inquiry include further characterization of aluminum fractions with regard to watershed soils, the nature and depth of soils in watersheds and/or hydrologic flowpath combinations. Recent research on the interaction among pH, DOC, and aluminum levels in relation to toxicity to juvenile Atlantic salmon in eastern Maine rivers may also shed light on the subject (NOAA and MASC, 2006).

Based on the current data set, the lack of correlation of aluminum with the water chemistry data or watershed characteristics does not conclusively define the nature or the source of aluminum impairment in New Hampshire ponds and streams. However, the lack of a discernible relationship of aluminum levels with either color of the % wetland in the watershed does not support the theory of a strong natural source of aluminum due to organic acids. With the present data and understanding of the field, the most likely explanation may be that the major source of aluminum impairment is due to the anthropogenic influence of atmospheric deposition.

5.5 NH Aluminum TMDL Process

According to the 40 CFR Part 130.2, the TMDL for a waterbody is equal to the sum of the individual loads from point sources (i.e., wasteload allocations or WLAs), and load allocations (LAs) from nonpoint sources (including natural background conditions) (see Section 4.1 for additional details).

As noted in Section 3.1, New Hampshire has placed restrictions on the discharge of wastewater treatment or industrial facilities to lacustrine environments, preferring to direct such discharges into riverine environments. Therefore, with regard to the WLA term, there are no known point sources (i.e., permitted discharges) of aluminum discharging to the ponds evaluated in this TMDL nor are they present in their watersheds. This term is accordingly defined as zero.

The LA term represents the aluminum load derived from nonpoint sources including natural background. While the actual source of the aluminum is weathering and mobilization of bedrock and organic materials by acidic inputs to the watershed, the ultimate “load” of concern is the acid components themselves and how they are divided into anthropogenic sources (strong inorganic acids derived from atmospheric deposition) or natural background (organic acids arising from decomposition).

Based on the discussion presented in Section 5.3, the influence or magnitude of natural background (the influence of organic acids in DOC fractions) is not significantly correlated with aluminum levels. Accordingly, at this time, it must be conservatively concluded that the major source of aluminum representing the LA fraction is the soil and rock dissolution by atmospheric deposition of acids.

For the current application to aluminum-impaired ponds, no explicit MOS is recommended. The primary reasons for this recommendation are: (1) the chronic criterion is already based on protection of sensitive salmonids; (2) the reported aluminum measurements are in total aluminum which is likely to underestimate the dissolved monomeric form that is the toxic fraction; and (3) site-specific water quality factors (e.g., dissolved organic carbon) are likely to mitigate toxic effects. As noted in Section 5.1, aluminum bioavailability is highly dependent on pH values. Therefore, mitigation of acid impairment will also concurrently address aluminum impairment. Since a MOS is already proposed for the acid TMDL, this will also serve as an implicit MOS with regard to the aluminum TMDL process.

5.6 Summary and Conclusions

This literature report was conducted as part of the investigation of aluminum-impaired ponds and to help identify potential methods of differentiating between natural and anthropogenic aluminum sources. Aluminum chemistry and its interaction with environmental factors is an important and active research field. The accepted paradigm of aluminum loadings due to low pH waters controlled largely by atmospheric deposition is giving way to the acknowledgment of the complex role played by organic acids in influencing the amounts, seasonality, and toxicity of aluminum in New England waters.

While the research efforts are promising, extrapolation of these theories to look for simple relationships between aluminum and potential causal factors that distinguish between natural and anthropogenic sources did not prove successful. Further work to reduce this uncertainty may be conducted, but may or may not result in useful predictive models. Even if predictive models are generated, it is doubtful these would result in direct application to TMDL implementation efforts for purposes of mitigating aluminum impairment in New Hampshire waters, since it has been recognized that the bulk of the causal acidifying pollutants contributing to these impairments are from sources well beyond New Hampshire’s borders (USEPA, 2003; Kahl et al., 2004). It is expected that reduction in upwind emissions of acidifying pollutants are needed to reduce the aluminum exceedances in New Hampshire’s waters. Given the iterative nature (adaptive management) of the TMDL process, this issue may be relegated to review in a future regulatory cycle.

6.0 Implementation and Reasonable Assurance

6.1 Statutory / Regulatory Requirements

Section 303(d)(1)(C) of the CWA provides that TMDLs must be established at a level necessary to implement the applicable water quality standard. The following is a description of activities that have been implemented or proposed to restore acid-impaired and aluminum-impaired ponds in New Hampshire.

6.2 Description of Activities to Achieve TMDL

6.2.1 Implementation Plan

As discussed earlier, most acidifying and aluminum leaching compounds originate with air pollution. This acid deposition has been occurring for decades causing depletion of soils and watershed nutrients (Driscoll, 2001b). Sulfur dioxide (SO_2) and nitrogen oxides (NOx) are the primary air pollutants leading to acid deposition. The SO_2 and NOx react in the atmosphere with water, oxygen, and oxidants to form various acidic compounds including sulfuric acid and nitric acid that fall to earth. To address the SO_2 and NOx emissions, the NHDES, Air Resources Division, has implemented various emission reduction programs and participated in regional and national programs.

The 1990 federal Clean Air Act (CAA) Amendments contained the Federal Acid Rain Program (in Title IV of the CAA) provisions regulating SO_2 and NOx emissions from electric utilities. The Federal Acid Rain Program regulated SO_2 emissions in two phases starting in 1995; Phase II occurred in 2000. NOx emission rates were reduced in 1996 and 2000. Prior to implementation of the Federal Acid Rain Program, New Hampshire adopted the New Hampshire Acid Deposition Control Program (RSA 125-D and Env-A 400) in 1991 to cap SO_2 emissions at boilers at three of the electric utilities in New Hampshire.

New Hampshire is also a participant in the New England Governors and Eastern Canadian Premiers (NEG/ECP) Acid Rain and Air Quality Steering Committee. In 1998, NHDES supported the adoption of the NEG/ECP Acid Rain Action Plan. The Action Plan called for additional U.S. and Canadian reductions of sulfur dioxide emissions by an amount 50% greater than the then current commitments by 2010, and reductions of nitrogen oxide emissions by an amount 20-30% greater than the then current commitments by 2007.

New Hampshire achieved these goals of the NEG/ECP Acid Rain Action Plan through the implementation of the program contained in the *New Hampshire Clean Air Strategy* (NHDES, 2001) that contains an acid deposition component. The *New Hampshire Clean Power Strategy* was codified as the Multiple Pollutant Reduction Program or Clean Power Act (RSA 125-O) which became effective July 2002. This program caps emission of four harmful air pollutants (SO_2, NO_x, mercury and CO_2) at three fossil fuel-burning power plants in New Hampshire. In 2007, the SO_2 and NOx emission caps were applicable. In 2006, the Multiple Pollutant Reduction Program was amended to include specific mercury reduction requirements. To comply with these mercury provisions, the largest electric utility in the state will install a SO_2 scrubber by July 1, 2013. While designed primarily to reduce SO2 emissions by over 95 percent, these scrubbers will result in a co-benefit of the requisite mercury emission reductions.

In 2005, the USEPA adopted the federal Clean Air Implementation Rule (CAIR) with an initial compliance date of 2009 for NOx emissions and 2010 for SO_2 emissions from sources in selected states. Even though New Hampshire is not part of this program, the affected emissions are the primary source of acid producing pollutants and are transported to New Hampshire.

New Hampshire is also involved in regional planning efforts currently focusing on SO_2 emissions as part of the Regional Haze Program. New Hampshire, along with other Northeastern states, is exploring potential strategies, including reduced sulfur in fuel oil, for reducing SO_2 emissions. As part of the Regional Haze

Program, selected facilities in New Hampshire and other states from which emissions are transported must also meet BART-the Best Available Retrofit Technology for SO_2.

New Hampshire will continue to work with the state legislature, regional multi-state organizations, the USEPA and participate in the NEG/ECP Committee to pursue all appropriate available avenues and adopt new and innovative strategies to reduce sulfur and nitrogen oxide emissions within the state. However, as discussed earlier, the bulk of the acidifying pollutants contributing to acid impairments identified in this TMDL are from sources well beyond New Hampshire's borders. Because of sensitive ecosystems and high deposition rates, aquatic resources in New Hampshire, as well as all of northeast North America, continue to suffer more damage from acidic deposition than other regions of the country. Aside from participating in litigation to uphold federal requirements, New Hampshire has little direct control over these sources and is relies on national enforcement efforts spearheaded by the U.S. EPA. It is expected that continuing reduction in upwind emissions of acidifying pollutants will be needed to reduce the critical load exceedances in New Hampshire's acid-impaired ponds. This reduction in upwind emissions will also serve to implement recovery of the aluminum-impaired ponds.

In summary, implementation of this TMDL is primarily the responsibility of the U.S. EPA, which has begun to address acid rain and other water quality impairing air contaminants under Title IV (the federal Acid Rain Program) and Section 112m of the Clean Air Act and more recently with CAIR. However, 17 years after the passage of the CAA amendments of 1990, acid-impaired waters remain. The U.S. General Accounting Office (USGAO, 2000) and U.S. EPA (2003), among others (e.g., Jeffries et al., 2003), have concluded that, despite reductions in sulfur emissions and deposition, reduction targets in existing legislation may not be sufficient for recovery in sensitive ecosystems and additional reductions are required.

6.2.2 Monitoring

NHDES is committed to long-term monitoring of water quality parameters (including pH and aluminum) in the lakes and ponds of the state. This long-term data collection (e.g., NHDES Environmental Monitoring Database) will provide the means to both monitor pond-specific WQS compliance as well as detect changes and regional trends in waterbodies as a result of national progress in reduction of acid deposition. As described in NHDES (2004) and elsewhere, there are five potential sources of water quality monitoring data available although only one or two of these are likely to apply to any specific acid- or aluminum-impaired pond. These five programs include:

- **Remote Ponds** – These are mostly high elevation, remote ponds. They are sampled, mid-pond at 0.5 meter depth in the spring by helicopter. Analysis of the complete suite of cations and anions began in 2000;

- **Outlet Ponds** – For these ponds the outlets are sampled during spring and fall overturn when outlet water represents average in-lake values. The compete suite of cations and anions were analyzed beginning in the fall of 1999;

- **Trophic survey lakes** – Most New Hampshire lakes have been sampled at one time or another under this program. The complete suite of ions is sampling during the summer at the deep spot in the mid-epilimnion or upper one-third of depth for unstratified lakes. However, sampling occurs only once every 10 to 20 years in this program so much of the available data may be dated, but this is a potential data source if data are not available from the above two programs;

- **Volunteer Lake Assessment Program (VLAP**) – Lakes are sampled every year, usually three times per year during the summer period in this program. Samples are collected during the summer at the deep spot in the mid-epilimnion or upper one-third of depth for unstratified lakes. The pH data from this program can be used for use impairment assessments, but the program does not collect the necessary anion and cation data needed for the critical loads model. This is a potential source of pH and ANC values; and

- **Lakes Lay Monitoring Program**. The Lakes Lay Monitoring Program (LLMP) is a collaborative research effort between UNH and citizen volunteers for New Hampshire lakes. The LLMP has a quality assurance project plan (QAPP) in place to make certain the lake data collected and reported are credible and accurate. The LLMP routinely samples temperature, color, chlorophyll a, secchi disk transparency depth, alkalinity and also less frequently dissolved oxygen, nutrients, pH, conductivity and other parameters.

In addition, NHDES will continue to provide acid pond data for a selected 20 ponds in the Water Acidity Regional Network to Inform Northeast Governments network (NEG/ECP WARNING). This network collects acid rain data from the states and provinces of the region and periodically evaluates trends (NHDES, 2004).

These programs provide a means to collect and interpret data to evaluate the progress of implementation and compliance with acid deposition abatement. However, recent work in the Northeast and Canada (Jeffries et al., 2003; VTDEC, 2007) indicates that the recovery period of the biotic community may significantly lag the reduction of atmospheric derived acidity. Therefore, it may be several years before the pond pH and aluminum levels begin to respond significantly.

7.0 Public Participation and List of Substantive Changes

7.1 Description of Public Participation Process

EPA regulations [40 CFR 130.7 (c) (ii)] require that calculations to establish TMDLs be subject to public review. On July 24, 2007, NH DES publicly noticed the draft TMDL (see Appendix F for copy of Public Notice) at: http://www.des.state.nh.us/wmb/tmdl/draft_tmdl.html#acid. Instructions for submitting comments were provided at: http://www.des.state.nh.us/wmb/tmdl/commentform.htm. In addition to the general notice on the website, emails were sent to member and active participants on the NH DES Water Quality Standards Advisory Committee (WQSAC) notifying them of the opportunity to comment on the draft TMDL. The WQSAC and non-members who regularly attend meetings include representatives from the following agencies / organizations:

Appalachian Mountain Club
Business and Industry Association (BIA)
City of Concord
City of Keene
City of Portsmouth
Conservation Law Foundation
Consulting Engineers of NH
NH Association of Conservation Commissions
NH Association of Conservation Districts
NH Department of Environmental Services
NH Department of Health and Human Services
NH Farm Bureau
NH Fish and Game Department
NH Lakes Association
NH Rivers Council
NH Timberland Association
NH Travel Council
U.S. Environmental Protection Agency, Region I
University of New Hampshire
U.S. Fish and Wildlife Service

In addition to the WQSAC, emails were also sent to the following organizations:

Clean Water Action
Connecticut Rivers Joint Commission
Environment New Hampshire (formerly NH PIRG)
Granite State Conservation Voters
Lakes Management and Advisory Committee (LMAC)
Local River Management Advisory Committee (LRMAC)
NH Audubon Society
NH Water Council
Rivers Management Advisory Committee
Sierra Club

Public comments were solicited over a month-long period which ended on August 23, 2007.

7.2 Public Comment and NHDES Response

During the public comment period, NH DES received acknowledgements of the emails informing recipients of the Public Notice. However, no public comments on the Acid Pond TMDL were received by the close of the public comment period.

7.3 Substantive Differences between Final and Draft TMDL

There were no substantive differences in the text between the final and draft TMDL. The only changes made were the deletion of the “Draft” identifier on cover pages, updating the date of issue from July 2007 to September 2007, inclusion of a copy of the NH DES Public Notice as a new Appendix F, and substitution for the phrase "load allocations" for "critical loads." in Section 4.2.2. (see last paragraph). The TMDLs reported in the draft Report Table 4 were incorrect due to the misapportionment of the MOS (added instead of subtracted). This problem has been corrected in the final version.

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