Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH:

North Tributary to Canobie Lake in Windham, NH

Photo Credit: New Hampshire Department of Transportation

April 18, 2008

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH:

North Tributary to Canobie Lake in Windham, NH

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1. Introduction

Section 303(d) of the Clean Water Act (CWA) and Environmental Protection Agency's Water Quality Planning Regulations (40 CFR Part 130) require states to develop total maximum daily loads (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 instream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources.

The purpose of this study is to develop a TMDL for chloride in the North Tributary to Canobie Lake watershed located in Windham, N.H. The goal is to reduce chloride loads so that water quality standards for all the designated uses affected by chloride pollution are met in all areas of the North Tributary to Canobie Lake watershed.

2. Problem Statement

a. Waterbody Description

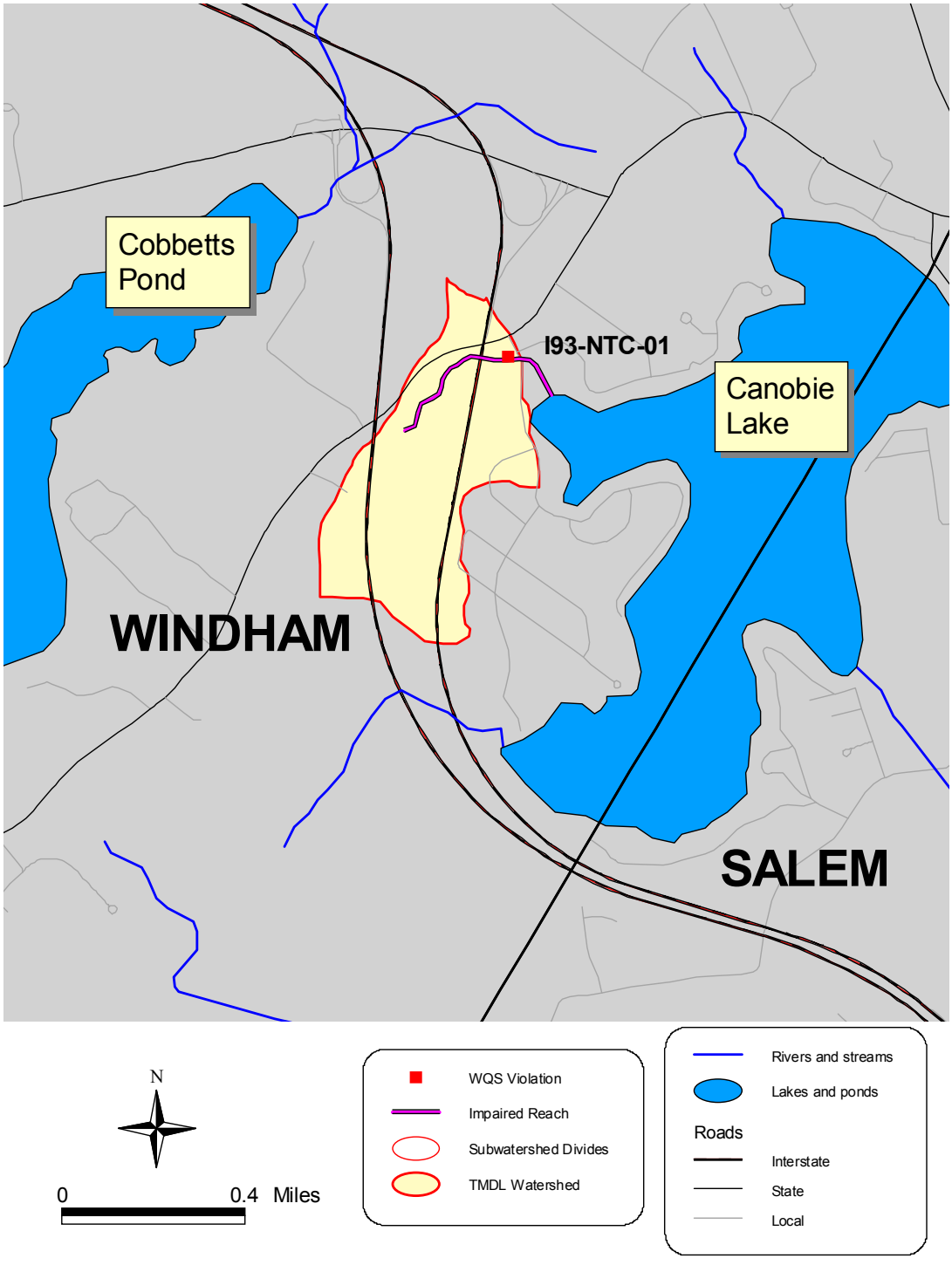
The assessment unit for this TMDL is North Tributary to Canobie Lake (NHRIV700061102-23). It is a stream segment of 0.5 miles located in Windham, N.H. The watershed for this assessment unit is 0.20 square miles (Figure 1). Land use characteristics of the watershed are listed in Table 1. The North Tributary to Canobie Lake discharges to the western embayment of Canobie Lake.

Table 1: Land use in the North Tributary to Canobie Lake watershed

Land Use and Demographics	North Tributary to Canobie Lake Watershed	Units
Agriculture	7.85	% of area
Cleared	19.15	% of area
Developed	2.99	% of area
Forested	38.93	% of area
Transportation	18.84	% of area
Wetland	12.24	% of area
Drainage Area	0.20	Square miles
Population	38	People
Housing Units	15	Number
Population Density	191	People/sq.mi.
"Urbanized Area" Classification	100	% of area

Data Source: DES (2007b)

Figure 1: Impaired Assessment Units and Water Quality Violations in the North Tributary to Canobie Lake Watershed



b. Applicable Water Quality Standards and Water Quality Numeric Targets

Water Quality Standards determine the baseline water quality that all surface waters of the State must meet in order to protect their intended (designated) 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: designated uses; criteria; and antidegradation regulations.

In New Hampshire, all state surface waters are classified as either Class A or Class B, with the majority of waters being Class B. A general description of designated uses for each classification may be found in state statute, RSA 485-A. According to New Hampshire's Consolidated Assessment and Listing Methodology (CALM; DES, 2005), designated uses for New Hampshire surface waters include those shown in Table 2.

The second major component of water quality standards is the "criteria." These are numeric 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 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 [www.gencourt.state.nh.us/rsa/html/L/485-A/485-A-8.htm] and in the State of New Hampshire Surface Water Quality Regulations (Env-Ws 1700) [www.des.nh.gov/rules/env-ws1700.pdf]. The CALM (DES, 2005) describes the methodologies for comparing water quality data with the criteria to assess designated use support.

The third component of water quality standards consists of 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. Antidegradation is not a consideration for this TMDL study.

North Tributary to Canobie Lake is a Class B waterbody. According to Env-Ws 1703.21, the water quality criteria for chloride in nontidal Class B waterbodies to protect aquatic life is that concentrations should not exceed 860 mg/L for acute exposures or 230 mg/L for chronic exposures. Acute aquatic life criteria are based on an average concentration over a one-hour period and chronic criteria are based on an average concentration over a period of four days (EPA, 1991) The frequency of violations for either acute or chronic criteria should not be more than once every three years, on average (EPA, 1991).

Table 2: Designated Uses for New Hampshire Surface Waters

Designated Use	DES Definition	Applicability
Aquatic Life	Waters that provide suitable chemical and physical conditions for supporting a balanced, integrated and adaptive community of aquatic organisms.	All surface waters
Fish Consumption	Waters that support fish free from contamination at levels that pose a human health risk to consumers.	All surface waters
Shellfish Consumption	Waters that support a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.	All tidal surface waters
Drinking Water Supply	Waters that with adequate treatment will be suitable for human intake and meet state/federal drinking water regulations.	All surface waters
Primary Contact Recreation (i.e. swimming)	Waters suitable for recreational uses that require or are likely to result in full body contact and/or incidental ingestion of water.	All surface waters
Secondary Contact Recreation	Waters that support recreational uses that involve minor contact with the water.	All surface waters
Wildlife	Waters that provide suitable physical and chemical conditions in the water and the riparian corridor to support wildlife as well as aquatic life.	All surface waters

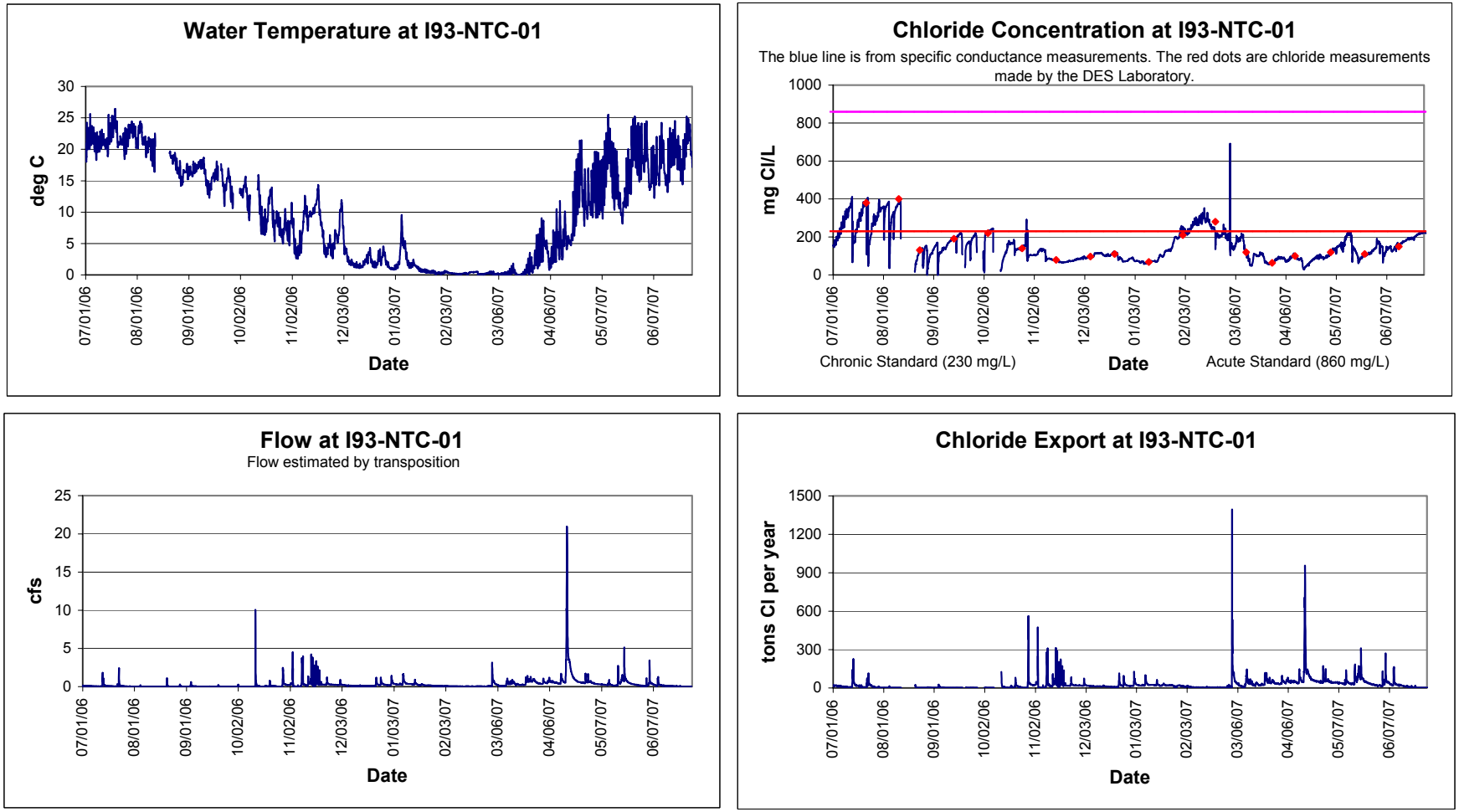
3. North Tributary to Canobie Lake Receiving Water Quality Characterization

In the winters ending in 2003, 2004, 2005 and 2006, the New Hampshire Department of Environmental Services (DES), the US Environmental Protection Agency (EPA), and the New Hampshire Department of Transportation (DOT) monitored chloride in watersheds in the vicinity of I-93 in southern New Hampshire. Chloride concentrations were primarily measured in winter with near continuous specific conductance readings by data loggers[1]. DES placed the assessment unit NHRIV700061102-23 on New Hampshire's 2006 Section 303(d) list because measurements of chloride concentrations through 2005 demonstrated exceedences of State surface water quality standards. This assessment unit, along with all rivers and lakes in the state, is also listed as impaired for the fish consumption designated use due to the state-wide fish consumption advisory for mercury.

For this TMDL study, DES, EPA and DOT developed a monitoring program to collect a comprehensive and standardized dataset for chloride, stream flow, and chloride imports to and exports from the watershed (DES, 2006). The monitoring plan was implemented between July 1, 2006 and June 30, 2007. The data from this monitoring program have been summarized in a Data Quality Audit (DES 2007a) and a Data Report (DES 2007b). The difference between the TMDL monitoring and the previous efforts is that data were collected at the same time at all stations to allow comparison between stations under similar conditions. Stream flow data were collected so that chloride flow duration curves and export calculations could be made. Figure 2 shows the near continuous measurements of temperature, chloride, stream flow (transposed from a nearby gage), and chloride export (product of chloride concentration and stream flow) at station I93-NTC-01 between July 1, 2006, and June 30, 2007. The average values for these parameters over the year were 9.79 ^{o}C, 152.27 mg Cl/L, 0.28 cfs, and 26.15 tons Cl/yr, respectively. For perspective, typical concentrations of chloride in New Hampshire rivers in 1920, before salt was used as a deicer, were 1.3 mg Cl/L (Hall, 1975).

[1] Data loggers are devices which can be programmed to read and store values from sensors deployed in the field at a set frequency. For this study, data loggers were used to record measurements of water temperature and specific conductance in various streams every 15 minutes.

Figure 2: Time Series of Temperature, Chloride, Stream Flow and Chloride Export at Station I93-NTC-01

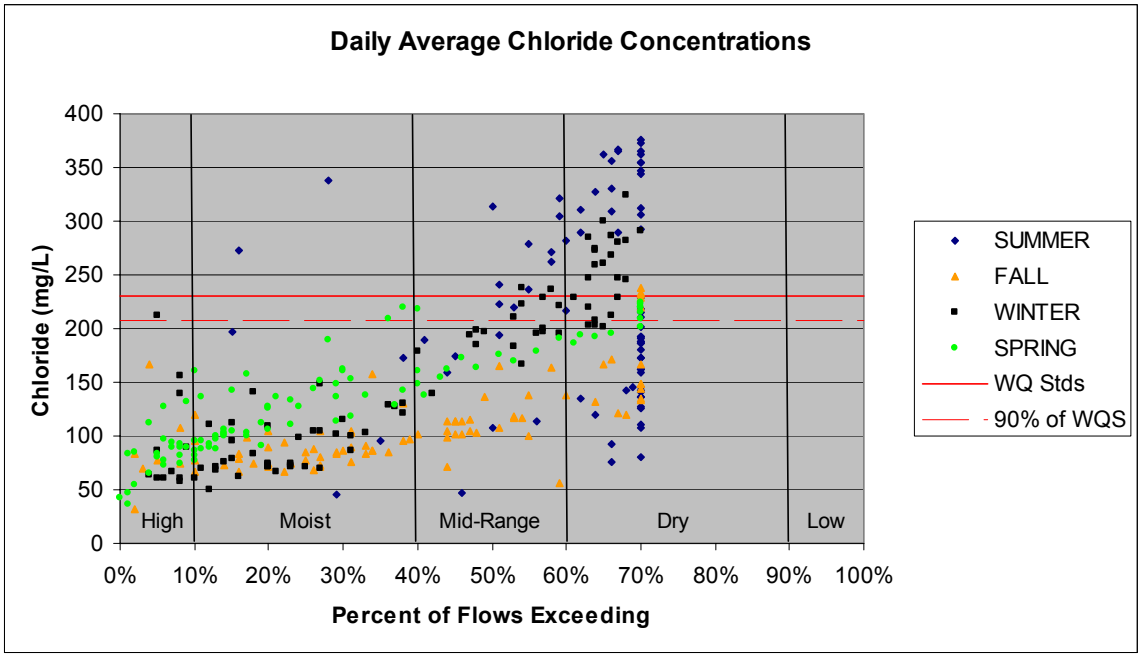


Data Source: DES (2007b)

The monitoring for the TMDL study detected violations of the chronic water quality standard. At station I93-NTC-01 (Figure 1) the water quality violated the chronic standard for 68.1 days of the year (18.7 percent). The location in the watershed at which violations of water quality standards have been detected is shown in Figure 1. The violations on this figure are from a compilation of all relevant data from 2002-2007 (DES, 2007b). The number of violations and the exact dates when these violations occurred are summarized in a data report (DES, 2007b).

Concentration-flow duration curves were used to document how the chloride concentration changed with stream flow (DES, 2007b). For these plots, the measured stream flow on a date was converted to the percent of the time when that flow level is exceeded. The methods for the historical flow duration calculations are provided in a data report (DES, 2007b). The concentration-flow duration plot for station I93-NTC-01 is shown in Figure 3. This figure indicates that the highest concentrations occur when stream flows are low (flow exceedence percentiles of 60-90 percent, "dry conditions"). Violations of the water quality standard occur in all seasons. Therefore, low stream flow is the critical condition for violations, regardless of season. It should be noted that the concentration-flow duration plot for this station is truncated at approximately 70 percent flow exceedence because there is no flow and only stagnant water in the stream 30 percent of the time.

Figure 3: Concentration-Flow Duration Plot for Station I93-NTC-01



Data Source: DES (2007b)

4. Source Characterization

Chloride in the form of salt is imported to the study watersheds from several major sources: Roadway deicing, food waste (e.g., sewage), water softeners, atmospheric deposition, and roadway salt pile runoff. DES estimated the mass of salt imported from each source. Details on how these estimates were made are provided in a data report (DES, 2007b). For the TMDL, groundwater was considered a pathway for chlorides, not an independent source.

All of the chloride imported to the watershed is eventually delivered to the impaired reach through stormwater runoff and groundwater flow. Stormwater flow through municipal storm sewer systems (MS4) covered by the Phase II stormwater program regulations will be considered a point source for this TMDL (EPA, 2002). The balance of the stormwater runoff will be considered a non-point source. One hundred percent of the watershed is covered by the MS4 Phase II program (Table 1); therefore, all of the chloride load will be considered a point source.

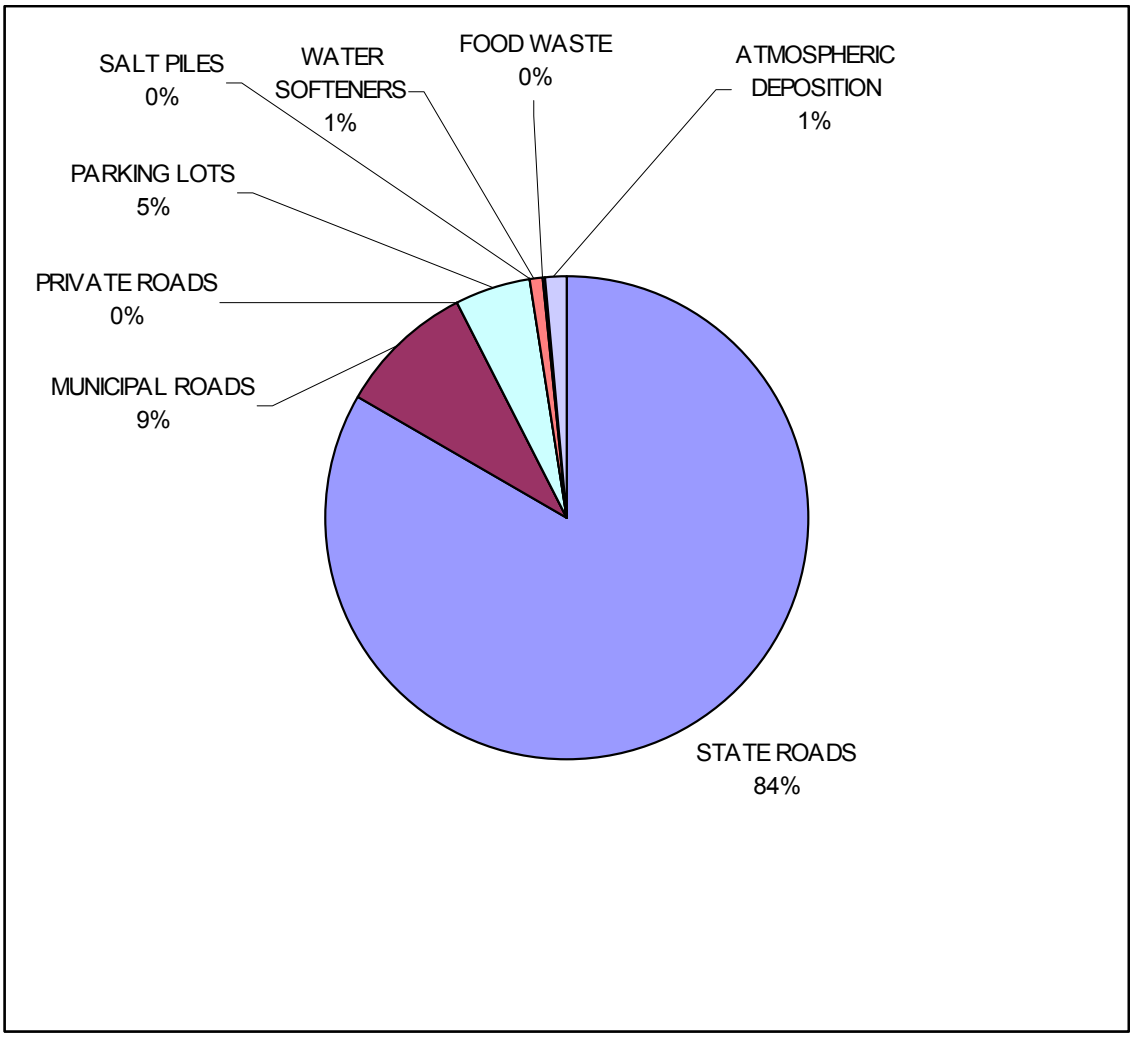
The salt imports for the period July 1, 2006 to June 30, 2007 are listed by source in Table 3. A total of 46.5 tons of salt was imported to the watershed at an average rate of 233.6 tons of salt per square mile of drainage area. The contribution of each source to the total load is shown in Figure 4. Deicing of roadways and parking lots accounted for 98 percent of the imports, with state roads being the single largest source (84 percent). There were no salt piles in the watershed. Water softeners, food waste, and atmospheric deposition were minor components. Water softeners were formerly a large source of salt to the watershed (approximately 55 tons per year) because of brine discharged from the W&E well field operated by Pennichuck Water Works. This discharge ceased in September 2005 (before the TMDL study) but some of the salt discharged is likely still in the groundwater.

Table 3: Sources of Salt to the North Tributary to Canobie Lake Watershed

Source	Agency/Town	Salt Imports (tons salt/yr)
State Roads	NHDOT PS 514	7.2
	NHDOT PS 528	31.6
Municipal Roads	Windham	4.2
Private Roads	Windham	0.0
Parking Lots	Windham	2.3
Salt Piles	Windham	0.0
Water Softeners	NA	0.4
Food Waste	NA	0.2
Atmospheric Deposition	NA	0.6
Total		46.5

Data Source: DES (2007b)

Figure 4: Relative Contribution of Each Source to the Total Salt Imports to the Watershed



Data Source: DES (2007b)

5. TMDL and Allocations

a. Definition of a TMDL

According to the applicable federal regulations, 40 CFR Part 130.2, the total maximum daily load (TMDL) for a waterbody is equal to the sum of the individual loads from point sources (i.e., waste load 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)
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 North Tributary to Canobie Lake TMDL will be expressed as a load duration curve following guidance from EPA (EPA, 2007). 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 are sufficient to account for the MOS.

b. Determination of TMDL

i. Seasonal Considerations/Critical Conditions

Section 303(d) of the CWA states that the TMDL must be established at a level necessary to attain the applicable water quality standards with seasonal variations. In Table 4, the factors which can influence chloride concentrations have been listed, along with how those factors will be manipulated to ensure that the TMDL will result in attainment of water quality standards during critical conditions.

Table 4: Factors for Determining Critical Conditions

Factor	Effect on Chloride Concentration	Selection of Critical Condition
Season	The effect of seasons on chloride concentrations is small. Figure 3 shows that violations occur at low flows regardless of season	None
Stream Flow	Figure 3 shows that chloride concentrations increase as stream flows decrease. The critical hydrologic condition is 60-90 percent flow exceedences ("dry conditions").	The TMDL will be expressed as a load duration curve to accurately describe the acceptable load at each stream flow.
Location	The proximity of salt sources can affect the chloride concentration in the waterbody.	Data from the year round station with the most violations of the water quality standard will be the basis for the TMDL.
Water Quality Standard	Either the acute or chronic water quality standard must be chosen to set the target for the TMDL.	The chronic standard will be the basis for the TMDL target because most of the violations in the watershed were of the chronic standard. The chronic standard is also lower than the acute standard.

ii. Margin of Safety

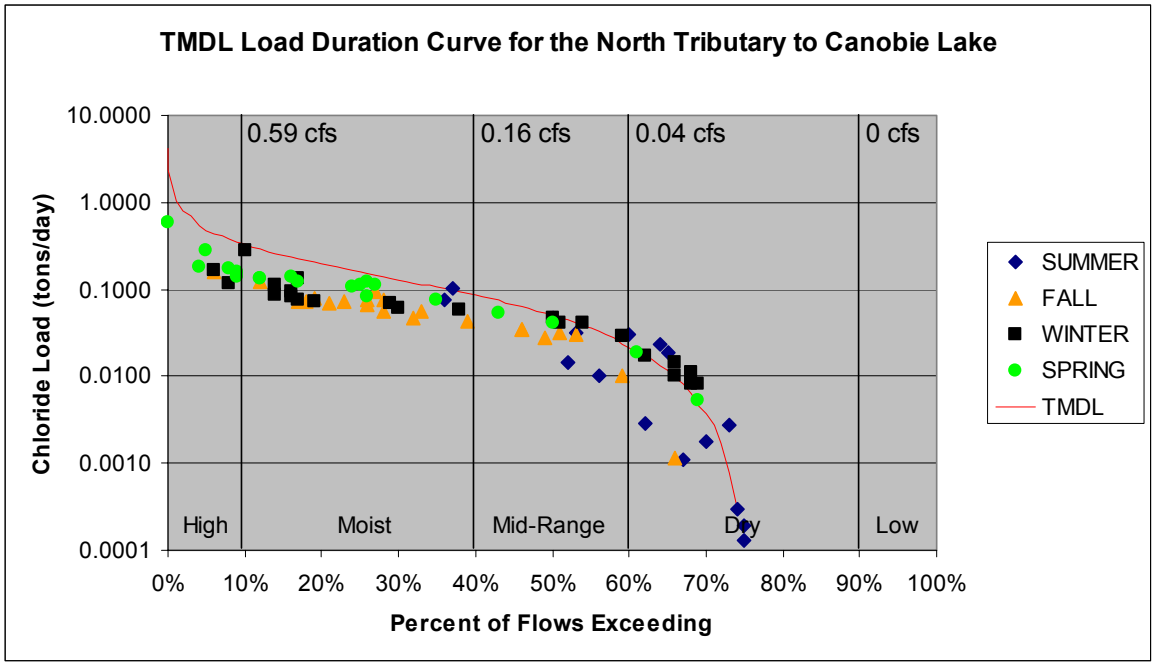
An explicit Margin of Safety (MOS) will be used in the TMDL calculation. The TMDL will be set at 90 percent of the chronic water quality standard (90%*230 mg C/L = 207 mg Cl/L). This assumption is equivalent to holding 10 percent of the loading in reserve to account for scientific uncertainty.

iii. TMDL Calculation

The TMDL will be expressed as a load duration curve following guidance from EPA (EPA, 2007) and in compliance with the approved Quality Assurance Project Plan (DES, 2006). The TMDL will be 90 percent of the chronic water quality standard (207 mg Cl/L) multiplied by each stream flow in the four-day average flow duration curve. The four-day average flow duration curve was used because the chronic water quality standard applies to four-day average concentrations. The TMDL will be set for the outlet station of the watershed, I93-NTC-01, because this is the only station in the watershed at which violations of the water quality standard have been detected. Figure 5 shows the TMDL load duration curve and the existing loads measured at I93-NTC-01 between July 1, 2006 and June 30, 2007. The units for the TMDL are tons of chloride per day. At each point on the TMDL curve, the waste load allocation for MS4 permittees is 100 percent of the TMDL and the load allocation for non-point sources is 0 percent of the TMDL (not

shown on figure). The margin of safety is explicit. The TMDL load duration curve is not expected to change; therefore, this TMDL is relevant to all existing and future impairments due to chloride in the North Tributary to Canobie Lake watershed. It should be noted that the TMDL load duration curve goes to zero near 70 percent flow exceendence because there is no flow and only stagnant water in the stream approximately 30 percent of the time.

Figure 5: TMDL Load Duration Curve at Station I93-NTC-01



The TMDL can be alternatively expressed as a percent reduction goal (PRG) to guide implementation. The method for calculating the PRG was described in the approved Quality Assurance Project Plan (DES, 2006). In summary, each individual chloride export value was compared to the TMDL. If the value was higher than the TMDL, the percent by which this value would need to be reduced to reach the TMDL was calculated. All of the individual PRGs calculated for the "dry" hydrologic condition were grouped and the 90th percentile value calculated (DES, 2007b). The four-day averaging period was used for this calculation to be consistent with the chronic water quality standard and the TMDL load duration curve. For the North Tributary to Canobie Lake watershed, the PRG was determined to be 39.6 percent for the July 1, 2006 to June 30, 2007 period. The total salt imports to the watershed during this period were 46.5 tons of salt per year. Therefore, salt imports to the watershed should be less than 28.1 tons of salt per year in order to attain water quality standards.

iv. Allocation of Loads

In 2006, DOT and DES established an interagency Salt Reduction Workgroup. The purpose of the workgroup is to advise DES and DOT on this TMDL study and all other

chloride TMDL studies in the I-93 corridor until these studies are completed, and then to advise and assist with implementation of required salt load reductions. The workgroup includes representatives from the following: DES; DOT; EPA; the Federal Highway Administration (FHWA); the selectmen's office of each town with area in a TMDL watershed; the public works department of each town with area in a TMDL watershed; the University of New Hampshire Technology Transfer (T2) Center; private winter road and parking lot maintenance companies; motorist associations; the State Police; the Southern New Hampshire Regional Planning Commission; the Nashua Regional Planning Commission; and the Rockingham Planning Commission. Representatives from pertinent watershed organizations and state-wide environmental organizations will be invited to join the workgroup in 2008.

In 2008, the Salt Reduction Workgroup will determine the final load allocations by sector in the implementation plan. There will be an opportunity for public comment on the implementation plan. However, <u>as a starting point</u>, draft allocations are presented in Table 5 based on the following assumptions:

- Ninety-eight percent of the salt imports to the watershed were for deicing activities. Therefore, essentially all of the salt import reductions will need to come from reduced deicing loads. The percent reduction in salt imports will be the same for state, municipal, and private roads and parking lots.
- The allocation for salt pile runoff will be zero because there were no salt piles in the watershed and any new salt and salt-sand piles should be covered.
- The existing loads from water softeners, food waste, and atmospheric deposition will be used as the allocation for these sources.

Table 5: Existing Salt Imports and Load Allocations

Source	Agency/Town	FY07 Salt Imports (tons salt/yr)	Allocation of Loads (tons salt/yr)
State Roads	NHDOT PS 514	7.2	4.3
	NHDOT PS 528	31.6	18.7
Municipal Roads	Windham	4.2	2.5
Private Roads	Windham	0.0	0.0
Parking Lots	Windham	2.3	1.4
Salt Piles	Windham	0.0	0.0
Water Softeners	NA	0.4	0.4
Food Waste	NA	0.2	0.2
Atmospheric Deposition	NA	0.6	0.6
Total		46.5	28.1

6. Implementation Plan

a. 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 are planned to abate water quality concerns in the North Tributary to Canobie Lake watershed.

b. Description of Activities to Achieve the TMDL

i. Implementation Plan

To implement this TMDL, salt imports to the watershed for deicing must be limited to the allocated loads in Table 5. State law (RSA 485-A:12.II) provides that "If, after adoption of a classification of any stream, lake, pond, or tidal water, or section of such water, including those classified by RSA 485-A:11, it is found that there is a source or sources of pollution which lower the quality of the waters in question below the minimum requirements of the classification so established, the person or persons responsible for the discharging of such pollution shall be required to abate such pollution within a time to be fixed by the department."

The details of an implementation plan will be developed by the Salt Reduction Workgroup in 2008 (see section 5(b)(iv) for information on the workgroup). The plan will require that owners of property on which salt is applied track and report the amount applied. This will be compared with allocations on an annual basis to determine compliance with RSA 485-A:12 and the load allocations of Table 5. It should be noted that the load allocations in the TMDL do not include an allowance for future growth, so any future construction of additional roads or parking lots in the North Tributary to Canobie Lake watershed would necessitate additional load reductions elsewhere in the watershed beyond the allocations in Table 5.

The draft implementation plan will be made available for public comment after it is developed by the workgroup.

ii. Monitoring

Pending the availability of resources, specific conductance will be monitored at 15-minute intervals with data loggers at the outlet station for the watershed, I93-NTC-01, from July 1, 2008 to June 30, 2016. Stream flow will be estimated using regression relationships with the USGS Beaver Brook gage. The data will be analyzed by DES for violations of the acute and chronic water quality standards and percent reduction for critical conditions following the procedures used in this report. The number of violations, the percent reduction goals during the critical conditions, and the salt imports to the watershed will be tracked for each year. DES will evaluate changes in these values using multivariate linear or logistic regression with climate variables (e.g., the DOT Winter

Severity Index, flow) as covariates. A trend will be considered significant if the coefficient of the year term in the equation is significant at the $p<0.05$ level. A minimum of five years of data (and most likely 10 years) will be needed before trend analysis can be performed. Biomonitoring should be completed after water quality standards for chloride have been met at station I93-NTC-01 to verify that there are no additional impacts to aquatic life from chlorides or other contaminants.

7. Public Participation

a. Description of the Public Participation Process

EPA regulations (40 CFR 130.7 (c) (ii)) require that calculations to establish TMDLs be subject to public review. The North Tributary to Canobie Lake TMDL was released for public comment on October 29, 2007. The comment period lasted until December 31, 2007. The report was posted on the DES (www.des.nh.gov/wmb/tmdl) and the Rebuilding I93 (www.rebuildingi93.com) websites. A letter announcing the release was distributed to 132 members of a stakeholder group, consisting of the Water Quality Standards Advisory Committee, the Lakes Management and Advisory Committee, the Rivers Management Advisory Committee, the Local River Management Advisory Committees, the New Hampshire Water Council, local and regional conservation organizations, and the Salt Reduction Workgroup. DES also issued a press release which generated stories in several local papers.

b. Public Comment and DES Response

DES received comments from six organizations or individuals by the deadline:

- U.S. Environmental Protection Agency
- New Hampshire Department of Transportation
- Federal Highway Administration
- Conservation Law Foundation and the New Hampshire Rivers Council
- Sierra Club
- New Hampshire Lakes Association

DES paraphrased the comments from each letter and provided responses in the following sections.

Comments from the Environmental Protection Agency

1. Figure 5 is a visual representation of the TMDL or Total Maximum Daily Load. As such, it is important that stream flow (in cubic feet per second) is represented on the x-axis so that on any given day and associated stream flow, a daily load can be determined.

Category: Accept
Response: The stream flow in cubic feet per second associated with the 10^{th}, 40^{th}, 60^{th}, and 90^{th} percentiles of the flow will be added to Figure 5.

2. We would consider the margin of safety to be explicit and not implicit.
Category: Accept
Response: The text of the TMDL will be changed.

Comments from the New Hampshire Department of Transportation

1.1 The applicable water quality standard for the TMDL should be 250 mg Cl/L, not 230 mg Cl/L.
Category: No change
Response: The assessment unit for this TMDL is impaired for the aquatic life use support designated use. The EPA and DES standard for the protection of aquatic life is 230 mg Cl/L. DES conducted a review of the toxicological literature related to road salt (DES, 2007c). The report concluded that 230 mg Cl/L was the appropriate standard for the TMDL to be protective of humans, wildlife, aquatic organisms, and most vegetation. Therefore, by setting the TMDL at the level necessary to achieve the 230 mg Cl/L standard, the TMDL addresses impacts associated with chlorides on the instream, benthic, and riparian communities. The secondary drinking water standard for chloride is 250 mg Cl/L. This standard is based on taste and odor issues, not human health. It is not appropriate for the TMDL because it is not the lowest applicable water quality standard and is not related to the impaired designated use.

1.2 The ten percent margin of safety is too high given the large amount of data collected for this study.
Category: No change
Response: A margin of safety is required for the TMDL to account for any lack of knowledge concerning the relationship between pollutant loads and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). DES selected ten percent as the margin of safety for the TMDL in the Quality Assurance Project Plan (DES, 2006), which was reviewed and approved by DOT, USGS, and EPA. There is not compelling evidence that the uncertainty in the relationship is greater than or less than ten percent. Furthermore, given the divergent comments on this topic (see CLF et al. comment 2.1), there is not consensus that a larger or smaller margin of safety should be adopted for policy reasons.

1.3 It is overly conservative to use the 90^{th} percentile statistic to calculate the percent reduction goal. An alternative approach based on the distribution of percent reduction values should be used.
Category: No change
Response: The method for calculating the percent reduction goals for the TMDL was set forth in the Quality Assurance Project Plan, which was approved by DES, DOT, USGS, and EPA. DES is hesitant to change the method for calculating the percent reduction goal in order to maintain consistency with the approved plan for the study.

In their comments, DOT argued that outliers in the dataset skew the percent reduction calculation. What may look like outliers, however, are actually real and representative measurements of water quality. The data used in the calculation were vetted by a QA/QC process, which included the identification and removal of outliers prior to calculation of the percent reduction goals. Moreover, there are no values more

than three standard deviations away from the mean, which is a common definition of an outlier.

DOT also presented an alternative method for calculating the percent reduction goal from the distribution of percent reduction goals during the critical flow regime. For the North Tributary to Canobie Lake TMDL, there were 7 unique, four-day periods during the "dry" flow condition during which the average chloride concentration exceeded the target (207 mg/L). The percent reduction needed to reach the target for each of these points was calculated. In order to aggregate these results into one percent reduction goal, DES calculated the 90th percentile of the distribution of 7 points (39.6%). This approach does not assume that the 7 points are normally distributed. As an alternative, DOT proposed to use the upper confidence limit of the mean value of the 7 points with a significance level of 0.003. The significance level of 0.003 was chosen because the water quality standard allows one violation every three years (1 in 273 unique, four-day periods or 0.003). DES has concerns about the method proposed by DOT for two reasons. First, the DOT method assumes that the individual percent reduction values are normally distributed. A histogram of the 7 values does not support this assumption. Moreover, DOT used the standard error of the mean to represent variability in the whole distribution. The probability of a water quality violation occurring should be calculated from the full distribution, not the distribution of the mean. If the standard deviation instead of the standard error of the mean is used in their calculation, the DOT method would predict that a 58.3 percent reduction goal should be used to protect against a 1 in 273 chance of a violation occurring. DES does not agree with the DOT method for the reasons stated above. The calculations provided in this paragraph are for illustration purposes only.

Ultimately, the goal of the TMDL is to eliminate water quality violations for chloride. The percent reduction goals stated in the TMDL are just a first approximation of what it will take to achieve water quality standards. As salt reduction efforts proceed in a phased way, the salt imports to the watersheds and the frequency of chloride violations will be monitored over time. When the water quality violations have ceased, the goal will be reached and no further reductions will be necessary.

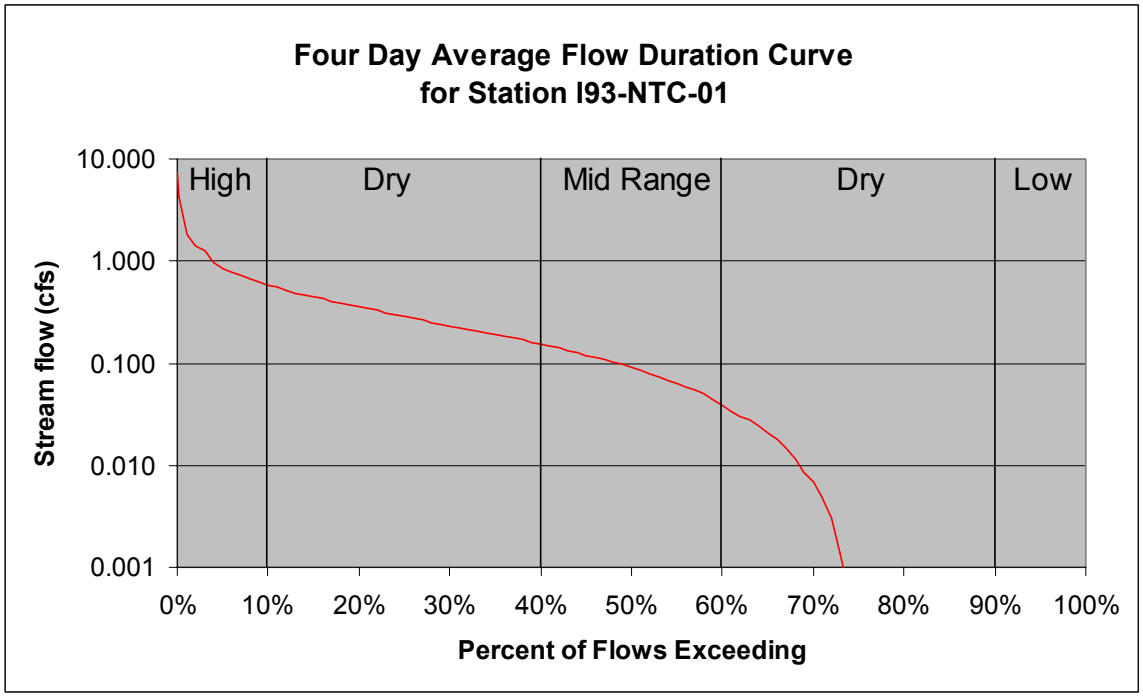
2.1 The flow duration curve for the North Tributary to Canobie Lake incorrectly assigns periods with zero flow (stagnant water) to the "dry conditions" category when they should be assigned to the "low flow" category.

Category: No change

Response: The North Tributary to Canobie Lake is very small. The average discharge from this watershed is 0.28 cfs. Groundwater withdrawals from the W&E wellfield and other factors result in stagnant water in this stream more than 25 percent of the time. For a stream with zero discharge for 25 percent of the time, the flow duration curve should be zero between 75 and 100 percent of flows exceeding (x axis on figure below). This period of zero flow spans the "dry" and "low" flow categories on the figure. Therefore, the question is whether chloride concentrations measured during periods of zero flow should be lumped with the "dry" or the "low" flow categories. This categorization of the results is important because it affects the overall percent reduction calculation.

Stream flow in the North Tributary to Canobie Lake was estimated from measured stream flow in Dinsmore Brook. Dinsmore Brook does not have periods of zero

flow; therefore, all of the flows can be assigned to the correct category. For the period from July 1, 2006 to June 30, 2007, the four-day average stream flows in Dinsmore Brook were all categorized as "dry" or higher. None of the four-day averages were in the "low" flow category. Since the stream flows in the North Tributary to Canobie Lake were generated from the Dinsmore Brook data, the same flow categorization should apply for both watersheds. Therefore, all of the chloride concentration measurements from the North Tributary to Canobie Lake made during stagnant water periods were correctly assigned to the "dry" flow category.



3.1 The effects of past discharges of salt brine from the Pennichuck Water Works well as well as current groundwater withdrawals from this well should be part of the TMDL.

Category: No change

Response: Discharges of brine from the Pennichuck Water Works wellfield ceased in September 2005, which was before the TMDL study began. The TMDL study quantified salt imports to the watershed for the period between July 1, 2006 and June 30, 2007. It would not be appropriate to include brine discharges which occurred before this period in the study. However, DES quantified the magnitude of the past discharge (55 tons per year) and acknowledged that some of the salt discharged is likely still in the groundwater in the TMDL report (Section 4). By including this anecdotal information in the TMDL report, DES has addressed the comment.

The effect of continuing groundwater withdrawals from this watershed was accounted for in the TMDL. In DES (2007b), the monthly average withdrawal from the wells was subtracted from the estimated stream flow to predict periods of stagnant water.

<u>Comments from the Federal Highway Administration</u>

1) Table of Contents, List of Figures, Pg i: Expand name of Figure 5 by adding "at I93-NTC-01".
2) Pg 1, 1 Introduction. In Line 1 spell out Environmental Protection Agency the first time you use the acronym "EPA".
3) Pg 1, 1 Introduction. In Line 3 is "water quality limited segments" correct?
4) Pg 1, 2a Waterbody Description, last sentence: Does Policy Brook actually discharge to the western embayment of Canobie Lake? It does not appear to do so in the figures in the I-93 FEIS.
5) Pg 1, Table 1: In the Data Source the acronym of "DES" is used before it is defined.
6) Figure 1: The "%" for "WQS Violation" in the Legend does not seem to be used. This is an important figure. Is it in color, which would help to identify details. I would recommend a larger scale for this figure.
7) Pg 3 second paragraph, Line 3: Shouldn't "State Statute" be capitalized? Also I would think it would be helpful to include excerpts from RSA 485-A about Class A and B waters in an appendix in this report. Use DES again without explaining. Shouldn't the CALM have the same web citation as used in the next paragraph?
8) Pg 3, third paragraph, Line 9, Use DES.
9) Pg 3, fifth paragraph, EPA is used twice without description.
10) Pg 3, fifth paragraph: Line 6 "… violations of for either …" is incorrect.
11) Pg 5, first paragraph: Give descriptions for DES and EPA but used acronyms previously.
12) Pg 5, first paragraph, Lines 5 and 6: Need footnote to describe "data loggers".
13) Pg 5, first paragraph, Line 6: Where is Station "NHRIV700061102-23" located on Figure 1?
14) Pg 5, second paragraph, Line 1: Change "the" to "this".
15) Pg 7, first paragraph, last three sentences: There is reference to multiple locations of violations, but isn't there only one (I93-NTC-01)?
16) Pg 7, Figure 3: Is this figure in color, as it is difficult to distinguish seasonal points. The label of the horizontal axis is not clear "Percent of Flows Exceeding" and should be clarified as it may be difficult for the public to understand.
17) Pg 8, second line: Add "roadway" before "salt".
18) Pg 8, Is "Food Waste" in Table 3 and elsewhere (Table 4, etc.) referring to septic system discharges?
19) Pg 10, first line: The acronym "TMDL" was explained on Page 1. Is it necessary to do it again here?
20) Pg 11, last paragraph: In the fourth and sixth lines, "four day" should be hyphenated.
21) Pg 12, Figure 5: Should the title of this Figure be "TMDL Load Duration Curve at I-93-NTC-01" to clarify its specific location?
22) Pg 12, last paragraph: The term "four day" in Line 7 needs to be hyphenated. Need to add another graph of % reduction and flows to illustrate where the PRG number of 39.4 is derived. We discussed possibly adding a figure to the appendix and referring to it.
23) Pg 13, 5th line: Add acronym of "FHWA".

24) Pg 13, second paragraph, first bullet and in Table 5: It indicates that the percent of salt imports will be the same for "private roads", but actually it is 0. Does that sentence apply because it was 0 and will remain 0?
25) Pg 14, second paragraph under "i. Implementation Plan", the last sentence says that future growth would necessitate additional load reductions. Would that reduction be expected to come from the same category (i.e., if a new municipal road was added, the allocation for municipal roads would stay the same, thus reducing the tons/ac/yr allowed at existing municipal roads?
26) Pg 14, last paragraph: hyphenate "15 minute".
27) Pg 14, last paragraph: This text discusses future monitoring. Aren't we going to perform the abatement actions (salt sheds, new salt spreader equipment, improved local storage and application practices,etc.) before this monitoring begins? If you know that you have violations and we do not institute some changes, won't there continue to be violations?

Response: All but two of the comments are editorial. Comments 25 and 27 are relevant to the implementation plan, which has not yet been drafted. These comments will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

Comments from the Conservation Law Foundation and NH Rivers Council

1.1 The TMDL does not address impacts that can be associated with chlorides including instream, benthic, and riparian communities.
Category: No change
Response: The assessment unit for this TMDL is impaired for the aquatic life use support designated use. The EPA and DES standard for the protection of aquatic life is 230 mg Cl/L. DES conducted a review of the toxicological literature related to road salt (DES, 2007c). The report concluded that 230 mg Cl/L was the appropriate standard for the TMDL to be protective of humans, wildlife, aquatic organisms, and most vegetation. Therefore, by setting the TMDL at the level necessary to achieve the 230 mg Cl/L standard, the TMDL addresses impacts associated with chlorides on the instream, benthic, and riparian communities. See also the response to CLF et al. comment 4.2.

1.2 The TMDL does not ensure that water quality standards will be met in all locations in the watershed.
Category: No change
Response: For the study design, DES established continuous monitoring stations at the outlets of each of the four watersheds. Two of the watersheds were small (Dinsmore Brook and North Tributary to Canobie Lake) and the outlet stations were considered to be representative of the whole watershed. For the Policy-Porcupine and Beaver Brook watersheds, DES chose additional locations in the watersheds to represent worst-case conditions based on monitoring data from 2002-2006. Water quality at these worst-case stations was monitored continuously during the TMDL study. In both watersheds, the water quality was worse at the outlet station than at the "worst-case" station. In Policy-Porcupine Brook, the chronic water quality standard was violated for a total of 87.7 days

at the outlet station (I93-POL-01V) compared to 66.0 days at the "worst case" station (I93-POL-04X) (DES, 2007b, Table 13). In Beaver Brook, water quality violations did not occur at either station; however, the average chloride concentration at the outlet station (09-BVR) was 67.58 mg/L compared to 55.86 mg/L at the "worst case" station (10A-BVR) (DES, 2007b, Table 10). Therefore, DES believes that attainment of the standards at the outlet stations should result in attainment of standards throughout the watershed.

1.3 The TMDL does not state when water quality standards will be met.
Category: Carry forward to implementation plan
Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

2.1 The ten percent margin of safety is inadequate. A more protective margin of safety is needed.
Category: No change
Response: The margin of safety is to take into account any lack of knowledge, or scientific uncertainty, concerning the relationship between the loading targets and water quality standards. Here, the official TMDL for this study is the load duration curve shown in Figure 5. The basis of this curve is a 20-year flow record and the water quality standard. Therefore we believe that the targets are reasonably accurate and there is no need for a margin of safety greater than ten percent. While CLF et al.'s comments identify a number of scientific uncertainties related to chloride loadings, those uncertainties are relevant to determining how the TMDL will effectively be implemented, not to the TMDL itself.

2.2 The study does not address the impacts of future development in the watershed.
Category: No change
Response: The TMDL for the watersheds was set at the total amount of road salt that the watershed can assimilate. Aside from a margin of safety, all of the TMDL was allocated to existing sources. However, in Section 6(b)(i) of the TMDL, it states that "any future construction of additional roads or parking lots in the TMDL watersheds would necessitate additional load reductions elsewhere in the watershed beyond the allocations in Table 5." Therefore, the provision for future growth in the watershed is a trading system between current and new sources.

2.3 The study should include an analysis of planned changes in drainages due to construction of the I-93 roadway.
Category: No change
Response: The official TMDL for this study is the load duration curve shown in Figure 5 which expresses the allowable load as the receiving stream flow multiplied by the chronic water quality criterion after reduction by a 10% safety factor. The TMDL targets are not dependent on drainage patterns due to construction of the I-93 roadway. Flow, drainage patterns and watershed salt loading are important considerations in determining

current/future loads, magnitude of required reductions and implementation plans but do not change the TMDL targets.

2.4 The final allocations of loads by sector should be made available for public review and comment.
Category: Accept
Response: The allocations of loads will be developed by the Salt Reduction Workgroup, which is a public process. In response to other comments (see CLF et al. comment 5.1), additional members will be added to this group. DES will add an opportunity to comment on draft allocations developed by this group. If necessary, DES will amend the TMDL to incorporate more specific wasteload allocations following public comment.

2.5 The allocations of loads should be split into more categories (e.g., by sector and by town or DOT patrol shed).
Category: Accept
Response: The Tables 3 and 5 in the TMDL will be revised to stratify both the salt import estimates for FY07 and the allocations of loads by town and patrol shed.

2.6 The TMDL should ensure that violations of the acute water quality standard for chlorides do not occur.
Category: No change
Response: The TMDL was based on the chronic standard for chlorides because this standard was violated far more frequently than the acute standard. The chronic standard is also lower than the acute standard (230 and 860 mg/L, respectively). Therefore, if the chronic standard is met, acute violations are unlikely. Of all of the stations monitored for the TMDL studies, there were only two where acute violations occurred but chronic violations did not (08-SHB and I93-BVRU03-01). These violations occurred for a total of 5 hours out of the 84,960 hourly average measurements made at all of the sites. Therefore, the 10 percent margin of safety for the TMDL should be sufficient to protect against the likelihood of this occurrence (0.006%).

2.7 The TMDL should be established with daily load allocations, not yearly.
Category: No change
Response: For this study, the TMDL, wasteload allocation, and load allocation are shown on the load duration curve shown in Figure 5. The units for this curve are tons of chloride per day, which meets the requirements of expressing the load allocations as daily loads.

3.1 The final implementation plan should be made available for public review and comment.
Category: Accept
Response: The final implementation plan will be developed by the Salt Reduction Workgroup, which is a public process. In response to other comments (see CLF et al. comment 5.1), additional members will be added to this group. DES will add an opportunity to comment on implementation plan developed by this group.

4.1 Monitoring in the watersheds should continue year-round to capture violations in the summer.
Category: Accept
Response: The design for the implementation monitoring in the North Tributary to Canobie Lake watershed will be changed to include year-round monitoring.

4.2 The implementation monitoring plan should include biomonitoring to detect direct impacts to aquatic life.
Category: Accept
Response: Until the water quality standards for chloride have been achieved in the TMDL watersheds, biomonitoring is not necessary because impacts to aquatic resources have already been demonstrated through water quality monitoring. However, DES agrees that biomonitoring should be completed after water quality standards for chloride have been met to verify that there are no additional impacts to aquatic life from chlorides or other contaminants. Aquatic life may be affected by sources other than road salt in these watersheds.

4.3 The implementation monitoring plan should include stations throughout the watershed to detect "hot spots" of chloride concentrations.
Category: No change
Response: See response to CLF et al. comment 1.2.

4.4 Implementation monitoring must not be "pending resources". A fully-funded monitoring program is critical.
Category: No change
Response: DES agrees that a fully-funded program is necessary. However, State and federal funding for water quality monitoring in the future cannot be guaranteed. Therefore, all programs must be considered to be "pending the availability of resources".

5.1 The Salt Reduction Workgroup should have members from pertinent watershed associations and state-wide environmental organizations.
Category: Accept
Response: DES agrees that representatives from pertinent watershed associations and state-wide environmental organizations should be invited to join the workgroup.

<u>Comments from the Sierra Club</u>

1.1 The boundaries of the stream segment should be justified based on monitoring data.
Category: No change
Response: In 2002, DES created assessment units for all stream segments in the state. The segments were developed using a standardized process described in the memorandum dated March 29, 2002. Monitoring in a variety of locations near the I-93 roadway in 2002-2006, detected chloride violations in the assessment unit for the North Tributary to Canobie Lake. The reported water quality violation triggered the need for a TMDL study of this assessment unit. For the TMDL study, DES delineated a watershed

which contributed to the impaired assessment unit. The outlet of the watershed was set at the point of discharge to Canobie Lake. All of the contributing drainage area upstream of the confluence was included as the TMDL study area. Therefore, monitoring data were used to select the assessment unit for the TMDL study and hydrology was used to define the watershed boundaries of the study area.

2.1 The TMDL should inventory NPDES permits for chloride discharges.
Category: No change
Response: DES obtained information on NPDES-permitted discharges in the study watersheds. None of the discharges had numeric limits for chlorides and none of the permittees were required to provide monitoring data on chloride loads. No municipal wastewater treatment facilities discharge in the study watersheds. Therefore, an inventory of NPDES permittees will provide no additional information about chloride loads to the watersheds.

4.1 The TMDL should not be based on the percent reduction goal relative to FY07 because FY07 was a mild year.
Category: Accept
Response: The official TMDL is the load duration curve in Figure 5. The TMDL is not based on FY07 conditions, but rather on a twenty-year flow record. The source of the confusion is Table 5. The allocation of loads in Table 5 is an alternative expression of the TMDL to aid in developing the implementation plan. The percent reduction values were added to Table 5 to provide a reference to FY07 conditions. DES agrees that including the percent reduction values on this table is confusing. The percent reduction values will be removed from Table 5.

5.1 The allocations of loads in the TMDL are only draft. There should be opportunity to comment on the final allocations.
Category: Accept
Response: See response to CLF et al. comment 2.4.

5.2 The TMDL should be established with daily load allocations, not yearly.
Category: No change
Response: See response to CLF et al. comment 2.7.

5.3 The TMDL does not have an implementation plan.
Category: Accept
Response: See response to CLF et al. comment 3.1.

5.4 The TMDLs do not provide for the expected growth from the I-93 expansion.
Category: No change
Response: See response to CLF et al. comment 2.2.

5.5 The TMDL does not include an enforcement plan for private chloride discharges.
Category: Carry forward to implementation plan

Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

Comments from the New Hampshire Lakes Association

1.1 Canobie Lake is a Class A waterbody. The North Tributary to Canobie Lake is a Class B waterbody. Can a Class B waterbody discharge to a Class A waterbody?
Category: No change
Response: The primary difference between a Class A and a Class B waterbody is that discharge of sewage or waste is prohibited in Class A waters. Given that runoff from the watershed for the North Tributary to Canobie Lake is not sewage or waste, it is not inconsistent for this Class B waterbody to discharge to Canobie Lake.

1.2 Are the units for chloride export shown on Figure 2 tons of salt per year or tons of chloride ion per year?
Category: No change
Response: The units for chloride export on this graph are tons of chloride ion per year.

1.3 Are the salt imports and exports in balance for the watershed?
Category: No change
Response: Table 31 in DES (2007b) shows that the estimated salt imports and salt exports are approximately in balance for the study period. A total of 28.22 tons of chloride were imported and 26.15 tons of chloride were exported from the watershed between July 1, 2006 and June 30, 2007.

1.4 Was the amount of salt imported from 7/1/2006 to 6/30/07 typical?
Category: No change
Response: See the response to comment 4.1 from the Sierra Club.

2.1 How long will it take for the waterbody to come into compliance?
Category: No change
Response: See response to CLF et al. comment 1.3.

2.2 The implementation plan should recommend a general reduction of salt use along I-93 and other state roads outside the TMDL study area.
Category: Carry forward to implementation plan
Response: This comment is relevant to the implementation plan, which has not yet been drafted. The comment will be carried forward to the Salt Reduction Workgroup to consider when developing the implementation plan.

2.3 The report should explicity acknowledge that major changes in land use are planned in the watershed and outline how that will be accounted for in implementing the compliance plan.
Category: No change
Response: See the response to CLF et al. comment 2.3.

2.4 Monitoring at the outlet station is critical and should not be "pending resources".
Category: No change
Response: See the response to CLF et al. comment 4.4.

2.5 Monitoring at the outlet station should occur in the summer as well as the winter.
Category: Accept
Response: See the response to CLF et al. comment 4.1.

2.6 Stakeholders such as the Canobie Lake Protective Association and the New Hampshire Lakes Association should be invited to join the Salt Reduction Workgroup.
Category: Accept
Response: See the response to CLF et al. comment 5.1.

8. References

DES. 2005. Section 305(b) and 303(d) Consolidated Assessment and Listing Methodology. NH Department of Environmental Services, Watershed Management Bureau, Concord, NH. November 2005. Available from: www.des.nh.gov/WMB/swqa/calm.html.

DES. 2006. Total Maximum Daily Loads for Chloride for Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: Quality Assurance Project Plan. NH Department of Environmental Services, Watershed Management Bureau, Concord, NH. June 30, 2006. Available from www.rebuildingi93.com/content/environmental/waterquality.

DES. 2007a. Total Maximum Daily Loads for Chloride for Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: Data Quality Audit. NHDES-R-WD-07-39. NH Department of Environmental Services, Watershed Management Bureau, Concord, NH. August 17, 2007.

DES. 2007b. Total Maximum Daily Loads for Chloride for Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: Data Report. NHDES-R-WD-07-40. NH Department of Environmental Services, Watershed Management Bureau, Concord, NH. September 2007.

DES. 2007c. Hazard Identification for Human and Ecological Effects of Sodium Chloride Road Salt. NH Department of Environmental Services, Watershed Management Bureau, Concord, NH. June 6, 2007.

EPA. 1991. Technical Support Document for Water Quality-based Toxics Control. EPA/505/2-90-001. US Environmental Protection Agency, Office of Water, Washington, DC. March 1991.

EPA. 2002. Establishing Total Maximum Daily Load (TMDL) Waste Load Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on those WLAs. Memorandum from Robert Wayland III, US Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Washington, DC. November 22, 2002.

EPA. 2007.An Approach for Using Load Duration Curves in the Development of TMDLs. EPA 841-B-07-006. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, D.C. August 2007. Available from: www.epa.gov/owow/tmdl/techsupp.html.

Hall, F.J. 1975. Chloride in Natural Waters of New Hampshire: New Hampshire Agricultural Experiment Station Bulletin 504, University of New Hampshire, Durham.

Sassan, D, and Kahl, S. 2007. Salt Loading Due to Private Winter Maintenance Practicies. Plymouth State University, Center for the Environment, Plymouth, NH. June 30, 2007.