CONNECTICUT FUND FOR THE ENVIRONMENT
SAVE THE SOUND

Petition to Review and Amend or Reissue the Long Island Sound Nitrogen TMDL to Mandate Further Enforceable Nitrogen Reductions

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Dear Administrators,

Connecticut Fund for the Environment and its bi-state program Save the Sound ("CFE/Save the Sound"), and supporting groups: Citizens Campaign for the Environment, Connecticut River Watershed Council, Environment Connecticut, Environmental and Natural Resources Law Clinic, Friends of the Bay, Rivers Alliance of Connecticut, and Soundkeeper, hereby petition the Regional Administrators of EPA Region I and Region II to develop a new or revised total maximum daily load ("TMDL") to meet water quality standards ("WQS") for dissolved oxygen ("DO") in Long Island Sound. This is required by Sections 303(d)(1)(C) and 303(d)(2) of the Clean Water Act ("CWA"),[1] and by the provisions of the TMDL itself.

A new or revised TMDL is required for Long Island Sound because: (1) available modeling predicts that WQS will not be met, and monitoring shows that WQS have and continue to be consistently violated by a large margin; (2) there is no reasonable basis to believe that WQS will be met following the completion of the few additional actions contemplated by the current TMDL; (3) non-treatment alternatives anticipated in the TMDL have not been implemented and there is no reasonable expectation that they will be in a manner that could meet WQS; and (4) emerging science demonstrates a need for additional nitrogen reductions because long-term observed climatic trends are in combination forcing greater water quality violations in the western Sound and recent monitoring strongly suggest that local embayments are also impaired for DO. A strategy to wait and see makes little sense unless there is a genuine question as to whether WQS will be met as a result of the current TMDL. And since there is no genuine question that we will still be far from achieving WQS, the time to act is now.

If EPA does not establish a new or revised TMDL, the CWA requires that every permit issued or renewed under the National Pollution Discharge Elimination System ("NPDES"), and each state-administered system, contain water-quality based effluent limitations ("WQBELs") that will ensure that such discharge will not cause, have the reasonable potential to cause, or contribute to the failure to attain WQS for DO in the Sound.[2] Because reductions from permitted point sources alone will be insufficient to attain WQS, permits would need to require sewage treatment plants to upgrade to the extent achievable by the limits of technology and offset the remaining discharge to ensure a net zero contribution of nitrogen to the impaired waterbody.

Upgrading all point sources to the limits of technology and offsetting the remaining discharge is an expensive and inefficient next step in addressing hypoxia in the Sound. As such, we urge the Agency to organize and facilitate the establishment of a *Memorandum of Understanding* between EPA and the five watershed states,[3] by June 15, 2015, to commit to: (1) amending or establishing a new Long Island Sound TMDL by June 15, 2016; and (2) establishing implementation plans and an accountability schedule that will ensure that WQS in Long Island Sound will be achieved by December 31, 2025. In the meantime, we request that the EPA review and implement the short-term measures highlighted in our prayer for relief that are available within EPA's existing regulatory authority.

For these reasons, we believe that a failure to issue a new or revised TMDL would not be in accordance with applicable law and would constitute an unreasonable delay with respect to a required agency action. More importantly, we believe timely and sustained action is required to restore Long Island Sound and the communities that surround it back to health.

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[1] *See* 33 U.S.C. § 1313 (d)(1)(C), (d)(2).
[2] *See* 40 C.F.R. § 122.44(d)(1)(i).
[3] Connecticut, Massachusetts, New Hampshire, New York, and Vermont.

I. Factual Background

a. Long Island Sound Becomes Hypoxic and Violates Connecticut and New York's Water Quality Standards Every Year Due to Human Activity

Hypoxia is the condition of low DO in water. As a general rule, concentrations above 5 mg/L are considered supportive of marine life, while concentrations below this are potentially harmful.[4] Hypoxia is caused, in part, by an overabundance of nutrients (nitrogen and phosphorus) present in the water.[5] The unique geographical characteristics of Long Island Sound contribute to complex circulation and mixing patterns, making some areas of the Sound particularly susceptible to seasonal hypoxia.[6]

The Federal Water Pollution Control Act, better known as the Clean Water Act, requires that every state develop WQS, to "establish the desired condition of a waterway."[7] The Sound is located within the territories of both Connecticut and New York; therefore, both states have created WQS for it.[8] Connecticut and New York have set an identical "acute toxicity" standard for the marine waters of the Sound (classified SA and SB) that the level of DO in the waters may not drop below 3.0 mg/L at any time.[9] Each state has also adopted a "chronic toxicity" standard to account for levels of DO that are hazardous to marine life over time. While the chronic

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[4] EPA Website, "Hypoxia in the Gulf of Mexico and Long Island Sound," http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewPDF&ch=50&lShowInd=0&subtop=315&lv=list.listByChapter&r=235290.
Chronic exposure to DO concentrations less than 4.8 mg/L has been shown to cause large-scale larval die-off and slowed growth rate of juvenile oxygen-breathing organisms such as fish, crustaceans, and shellfish. "At about 3 mg/L, bottom fish start to leave the area, and the growth of sensitive species such as crab larvae is reduced. At 2.5 mg/L, the larvae of less sensitive species of crustaceans may start to die, and the growth of crab species is more severely limited. Below 2 mg/L, some juvenile fish and crustaceans that cannot leave the area may die, and below 1 mg/L, fish totally avoid the area or begin to die in large numbers." Howell, P., and D. Simpson, Abundance of marine resources in relation to dissolved oxygen in Long Island Sound, Estuaries 17:394-402, 1994; *see also* Vaquer-Sunyer, R. and C. M. Duarte, Thresholds of hypoxia for marine biodiversity, P. Natl. Acad. Sci. USA 105:1545215457, 2008); *see also* Long Island Sound Study Website, "Water Quality: Hypoxia," http://longislandsoundstudy.net/issues-actions/water-quality/.

[5] *See* NYSDEC and CT DEP, A Total Maximum Daily Load Analysis to Achieve Water Quality Standards for Dissolved Oxygen in Long Island Sound, December 2000, http://www.dec.ny.gov/docs/water_pdf/tmdllis.pdf [hereinafter "2000 LIS Nitrogen TMDL"].
Nitrogen fuels excessive algae growth in surface waters. When the algae die, they sink to the bottom where they are consumed by bacteria. These bacteria, combined with the natural respiration of other oxygen-breathing organisms, use up the available oxygen in the lower water column, gradually reducing the dissolved oxygen concentration to unhealthy levels. The hypoxic water becomes trapped in the bottom waters due to naturally occurring density stratification of the water column, because the denser hypoxic water sinks to the bottom, while the less dense, oxygen-rich water remains above it. Warm weather and high sunlight exacerbate hypoxic conditions; therefore, they tend to occur during summer months.

[6] 2000 LIS Nitrogen TMDL at 4.

[7] *Arkansas v. Oklahoma*, 503 U.S. at 101, 112 S.Ct. at 1046, "A WQS for any given waterway, or "water body," has two components: (1) the designated beneficial uses of the water body and (2) the water quality criteria sufficient to protect those uses. Water quality criteria can be either numeric or narrative. Numeric criteria establish quantitative limitations on pollutant concentrations or levels, necessary to protect designated uses of the water body. When criteria are met, water quality will generally protect the designated uses of each water body."; *see also* 33 U.S.C. § 1313(a).

[8] *See* C.G.S. 22a-426-9(a)(1) Table 1 – Surface Water Criteria by Classification: "Nutrients;" *see also* 6 N.Y.C.R.R. Chapter X Subchapter B, Part 935: Upper East River and Long Island Sound Within Queens, Bronx and Westchester Counties; *see also* 6 N.Y.C.R.R. Parts 800-941; *see also* 6 N.Y.C.R.R. § 701.10-701.12, 703.2.

[9] C.G.S. 22a-426-9(a)(1) Table 1 – Surface Water Criteria by Classification: "Dissolved Oxygen".

standards differ slightly, both states' standards allow DO levels between 3.0 and 4.8 mg/L for a period of time specified by regulation—two to thirty days.[10]

In 1985, the Long Island Sound Study ("LISS"), an EPA-led, bi-state national estuary program consisting of federal and state agencies, user groups, concerned organizations, and individuals, was formed to study and monitor the condition of the Sound, and to plan for the protection of it and its abundant resources. LISS has been monitoring water quality during summer months since 1987, and has tracked the size, duration, and severity of hypoxic zones each year.

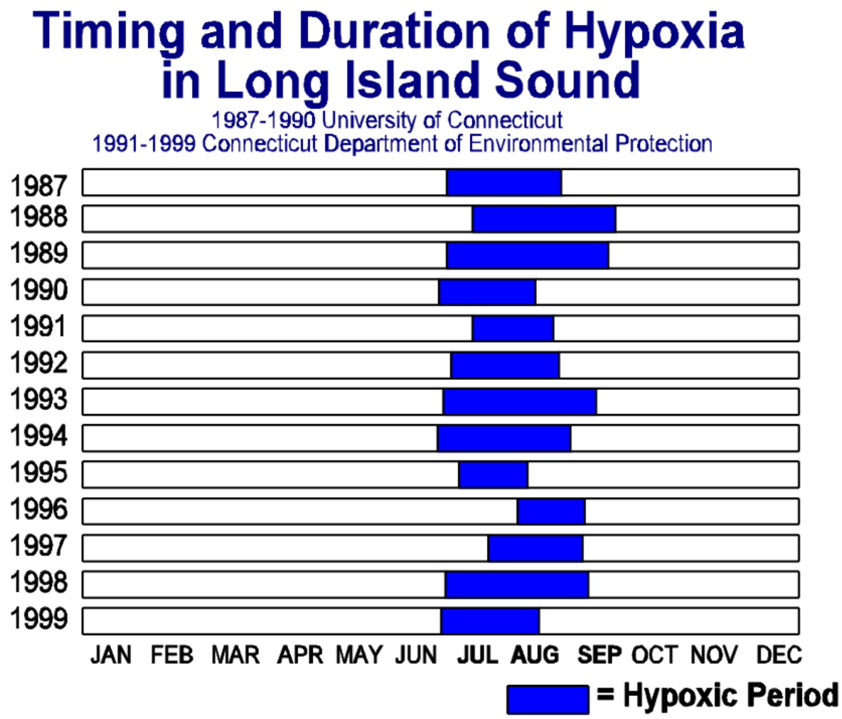

Figure 1 [11]

Figure 1, above, shows the duration of hypoxia in the Sound every year from 1987, when monitoring began, until the TMDL was created in 1999. While the hypoxic period has varied in duration from year to year, it typically starts in late June and ends in late August or early September.

The size of the hypoxic zone can also vary greatly from year to year. Figure 2 (below), depicts the frequency of hypoxia (below 3.0 mg/L) occurring in the Sound based on EPA-funded

[10] *See* CGS Section 22a-426-9(a)(1) Table 1, Note 1, "Cumulative Dissolved Oxygen exposure parameters," Table A: (Levels less than 4.8 mg/L to 4.5 mg/L may not exceed a period of 30 days; levels less than 4.5 mg/L to 4.0 mg/L may not exceed 14 days; levels less than 4.0 mg/L to 3.5 mg/L may not exceed 7 days; levels less than 3.5 mg/L to 3.0 mg/L may not exceed 2 days); *see also* 6 N.Y.C.R.R. § 703.3, ("The DO concentration may fall below 4.8 mg/L for a limited number of days, as defined by the formula: $DO = \frac{13.0}{2.80 + 1.84e^{-0.1t}}$ where DO = DO concentration in mg/L between 3.0-4.8 mg/L and t = time in days. This equation is applied by dividing the DO range of 3.0-4.8 mg/L into a number of equal intervals. DO is the lower bound of each interval (i) and t is the allowable number of days that the DO concentration can be within that interval. The actual number of days that the measured DO concentration falls within each interval (i) is divided by the allowable number of days that the DO can fall within interval (t). The sum of the quotients of all intervals (i...n) cannot exceed 1.0: *i.e.*")
[11] 2000 LIS Nitrogen TMDL, Figure 1 at 1.

consistent monitoring during summer hypoxic seasons, 1991-2011. As the map shows, the hypoxic zone occurs most frequently in the western Sound. It occasionally remains localized in the west, but some seasons it can reach east past New Haven, Connecticut.

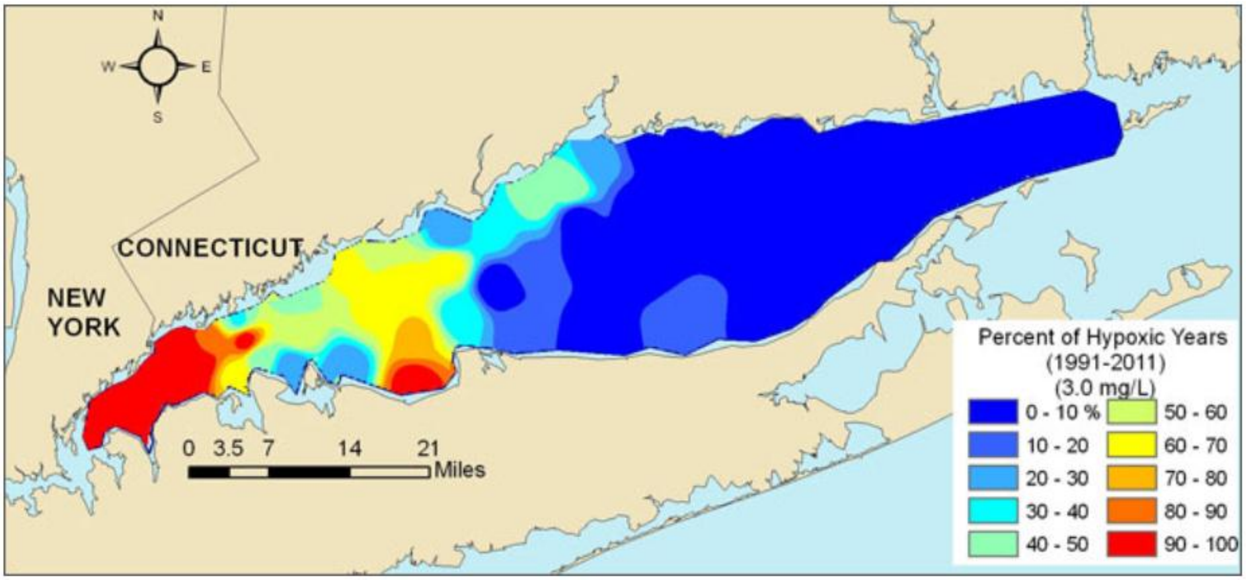

Figure 2 [12]

The Sound has not always suffered from hypoxia. LISS has concluded that hypoxia in the Sound is driven by the massive increase of human sewage (and wastewater treatment effluent) that has occurred since the colonial population and industrialization of the Long Island Sound watershed.

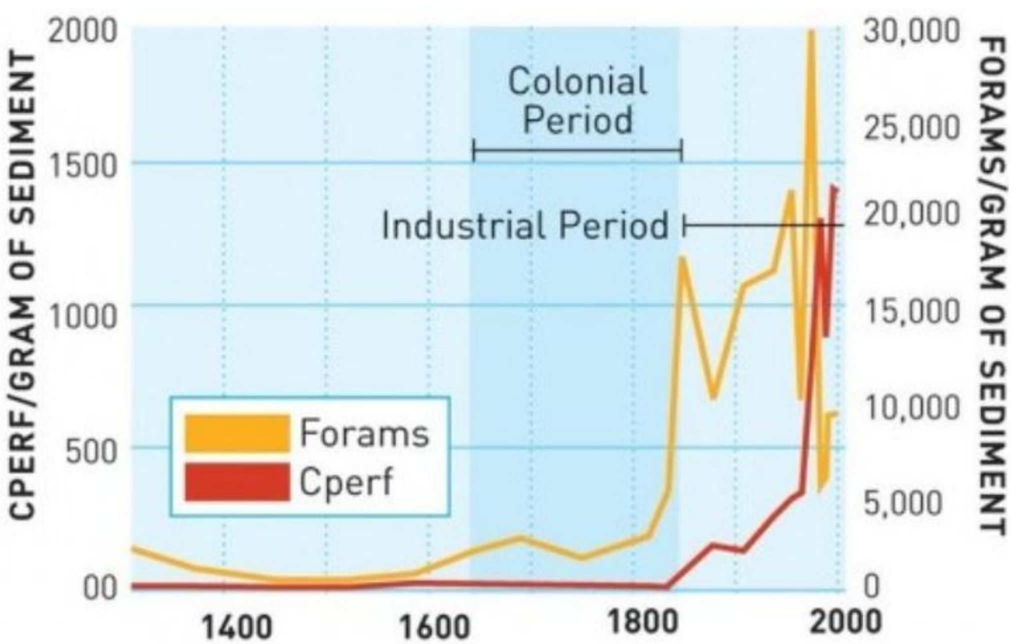

Figure 3 [13]

[12] EPA, LISS Website, "Frequency of Hypoxia," http://longislandsoundstudy.net/2010/07/frequency-of-hypoxia/.
[13] EPA: LISS Website, "Status and Trends: LISS Environmental Indicators," Increases in Population and Sewage, http://longislandsoundstudy.net/2010/07/increases-in-population-and-sewage/.

The above chart shows two measurable indicators of raw and treated human sewage, and clearly displays the increase in each since the early 1800s. *Clostridium perfringens* ("Cperf") are bacterial spores that live in the gut of mammals, and *Foraminifera* ("Forams") are microscopic plants that feed on nitrogen-rich sewage. LISS has concluded that the increase in Forams is an indicator of more eutrophication, the process that causes hypoxia.[14]

We have attached a white paper by Johan Varekamp, Professor of Earth and Environmental Studies at Wesleyan University, who has studied historic hypoxic conditions in Long Island Sound and confirms that hypoxia is not a natural condition of Long Island Sound; instead, it is the result of human impacts.

b. <u>The TMDL, Without Further Action, will not Meet Water Quality Standards for Dissolved Oxygen</u>

In 2000, Connecticut and New York completed *A Total Maximum Daily Load Analysis to Achieve Water Quality Standards for Dissolved Oxygen in Long Island Sound* ("the 2000 LIS Nitrogen TMDL" or "the TMDL"), which EPA formally approved in 2001. A TMDL is "a calculation of the maximum amount ("load") of a pollutant that a waterbody can receive and still meet WQS, and an allocation of that load among the various sources of that pollutant."[15] In 1992, both New York and Connecticut included the Sound on their CWA Section 303(d) list[16] of "impaired" waterbodies ("those waters . . . for which effluent limitations . . . are not stringent enough to implement any water quality standard applicable to such waters").[17] The 303(d) listing triggered the requirement that the states or EPA establish the TMDL.[18]

The TMDL agreement instituted three new phases of a Hypoxia Management Program intended to meet and attain WQS by 2014 – Phases III, IV, and V.[19] Phases I and II were completed prior to the formation of the TMDL. In 1990, Phase I froze nitrogen point source and nonpoint source loadings at their 1990 levels in key geographic areas.[20] In 1994, Phase II reduced nitrogen loads through the implementation of low cost actions and retrofits to high-priority wastewater treatment plants.[21] Phase III, the centerpiece of the 2000 TMDL, required a 58.5 percent reduction in nitrogen loading from point sources and terrestrial nonpoint sources in Connecticut and New York.[22] Phase IV focused on out-of-basin sources,[23] requiring nitrogen

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[14] *Id.*
[15] EPA Website, "Water: TMDL 303(d), What is a TMDL?," http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/overviewoftmdl.cfm.
[16] 33 U.S. Code § 1313 (d)(1)(A): Each State shall identify those waters within its boundaries for which the effluent limitations … are not stringent enough to implement any water quality standard applicable to such waters. The State shall establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters.
[17] 2000 LIS Nitrogen TMDL at 9.
[18] 33 U.S.C. § 1313 (d)(1)(C).
[19] Specifically, Phase III established a WLA from in-basin point sources of 15,556 tons per year and a LA for terrestrial nonpoint sources of 8,410 tons per year. Together these loads amounted to a 58.5 percent reduction from the 1990 baseline. Phase IV established a WLA for out-of-basin point sources of 2,243 tons per year, a 25 percent reduction from the 1990 baseline, and a LA for out-of-basin terrestrial nonpoint sources of 10,574 tons per year. Phase IV also envisioned an 18 percent reduction of atmospheric nitrogen deposition from Clean Air Act implementation throughout the basin. *See* 2000 LIS Nitrogen TMDL at 27, 34-36, 40, 43-46.
[20] 2000 LIS Nitrogen TMDL at 2.
[21] *Id.* at 2.
[22] *Id.* at 42.

reductions of 25 percent from point sources, 10 percent from terrestrial nonpoint sources, and 18 percent from atmospheric deposition.[24] Finally, Phase V required reevaluation and revision of the TMDL every five years to keep it on pace to meet WQS by 2014, and implementation of non-treatment alternatives to make up for any shortfall in the ability to meet WQS through effluent reductions.[25]

The measurable and enforceable reductions of Phase III and IV are nearly complete and it is clear that the modest remaining reductions (which are scheduled to be implemented by 2017) will not lead to the attainment of WQS. Phase V has not been pursued or implemented in a manner that could achieve WQS, there are no credible plans to do so in the foreseeable future, and the required five year reassessments of the TMDL have not occurred.

1. The Nitrogen Reductions Required by Phases III and IV are Unable to Meet Current Water Quality Standards

Even if we assume that Phases III and IV will be completed in the near future, it is clear that WQSs will not be met without significant further nitrogen reductions and other actions to cure low-DO areas. This conclusion is supported by (i) EPA modeling, (ii) the fact that most of the enforceable nitrogen reductions have been implemented or will be by 2017, and (iii) current monitoring results.

i. Available Modeling Predicts that Phases III and IV will not Meet Water Quality Standards

In its review of the TMDL in 2001, EPA recognized that the reductions required by the TMDL would not meet WQS: "[T]he LIS 3.0 model predicted that after executing Phase III and Phase IV reductions, approximately 125 model segments would still not meet water quality standards for DO criteria."[26] EPA then approved the TMDL, but noted that only with reevaluation and implementation of non-treatment alternatives (under Phase V) could WQS be met.

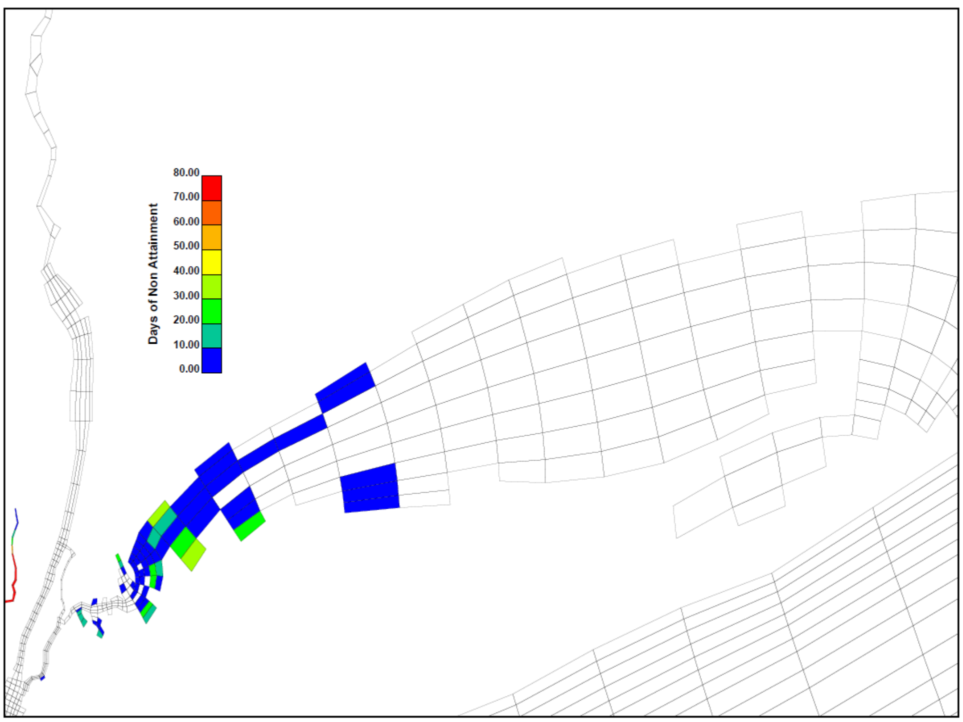
> The TMDL recommends the use of non-treatment alternatives to attain water quality standards. One of the alternatives identified is mixing/aeration. Based on an analysis of this alternative, it was estimated that the addition of at least 10,000 lbs/day of oxygen to each of the 125 model segments, combined with the nitrogen and associated carbon reductions identified in Phase III and Phase IV of the TMDL, could attain DO standards.[27] … EPA agrees that the nitrogen loading capacity identified for each phase … in combination with Phase V non-treatment alternatives (e.g., mixing/aeration), will ultimately achieve water quality standards for the Long Island Sound. … EPA especially recognizes CTDEP's and NYDEC's commitment to evaluate and implement Phase V non-treatment alternatives to attain water quality standards.[28]

While nitrogen and hypoxia modeling in Long Island Sound has run into some problems due to complexity of the ecosystem, the modeling we have consistently shows that we will not meet WQS under the current TMDL. Moreover, we know of no model or scientific evidence that predicts WQS will be met. LISS has further evaluated expected DO improvements since

[23] The TMDL refers to "in-basin" and "out-of-basin" sources of nitrogen. "In-basin" refers to sources from within Connecticut and New York, and out-of-basin refers to sources from outside of Connecticut and New York, i.e. from Massachusetts, New Hampshire, Vermont, the Atlantic Ocean, and the atmosphere.
[24] *Id.* at 43.
[25] *Id.* at 46.
[26] EPA: The Long Island Sound Office, *EPA New England and EPA Region 2 TMDL Review* at 7.
[27] *Id*. at 7.
[28] *Id.* at 7.

adoption of the TMDL, using an updated System-wide Eutrophication Model ("SWEM"). In a 2007 SWEM report, LISS concluded: "Based on modeling simulations performed with SWEM, it is unlikely that WQS for dissolved oxygen in Long Island Sound will be achieved by the mandated Phase 3 and Phase 4 nitrogen TMDLs limits, even if credit is taken for associated, but not mandated, reductions to carbon loadings."[29] It should be noted that the updated model predicts significantly lower resulting DO following implementation of the TMDL than the TMDL's modeling did. The red segments in Figure 6 show that SWEM predicts that some segments will still reach very low DO levels, below 1.0 mg/L, while the several red-orange and orange segments show the area below 3.0 mg/L of DO. Whereas, the TMDL's modeling predicted no areas below 3.0 mg/L following just the Phase III nitrogen reductions.[30]

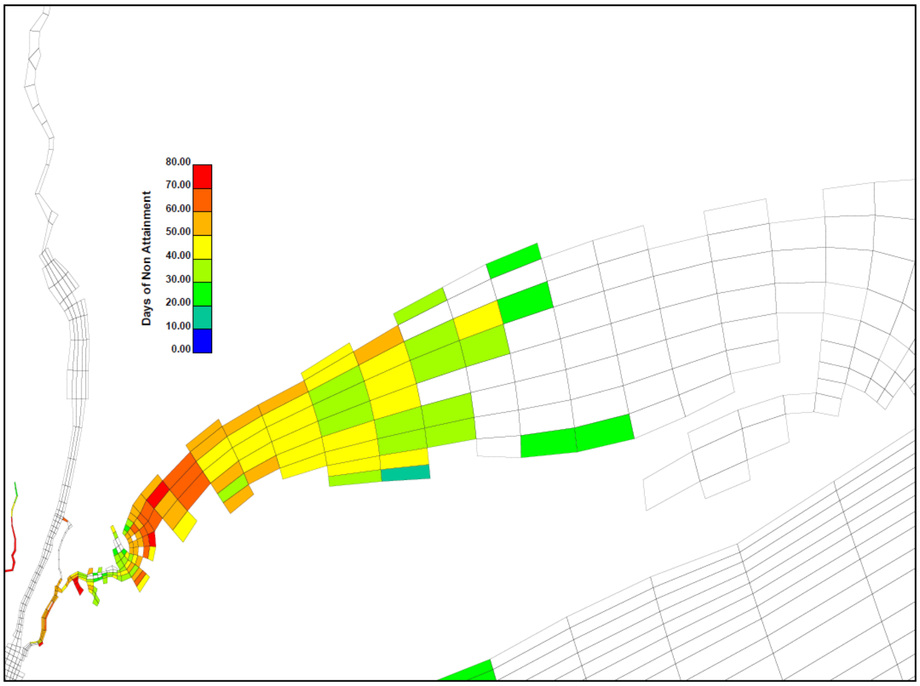
Figures 4 and 5, taken from the above-mentioned SWEM report, illustrate SWEM's prediction that neither the acute or chronic New York criteria for dissolved oxygen will be met following the completion of Phases III and IV of the TMDL. Figure 4 shows the areas that will drop below 3.0 mg/L of DO following full implementation of the TMDL's nitrogen reductions, and Figure 5 is an approximation of areas that will exceed the permitted number of days that DO levels can be below 4.8 mg/L.



LIS Nitrogen TMDL, Phase IV, 1988 Hydrodynamic Conditions
New York State Acute Criteria

Figure 4 [31]

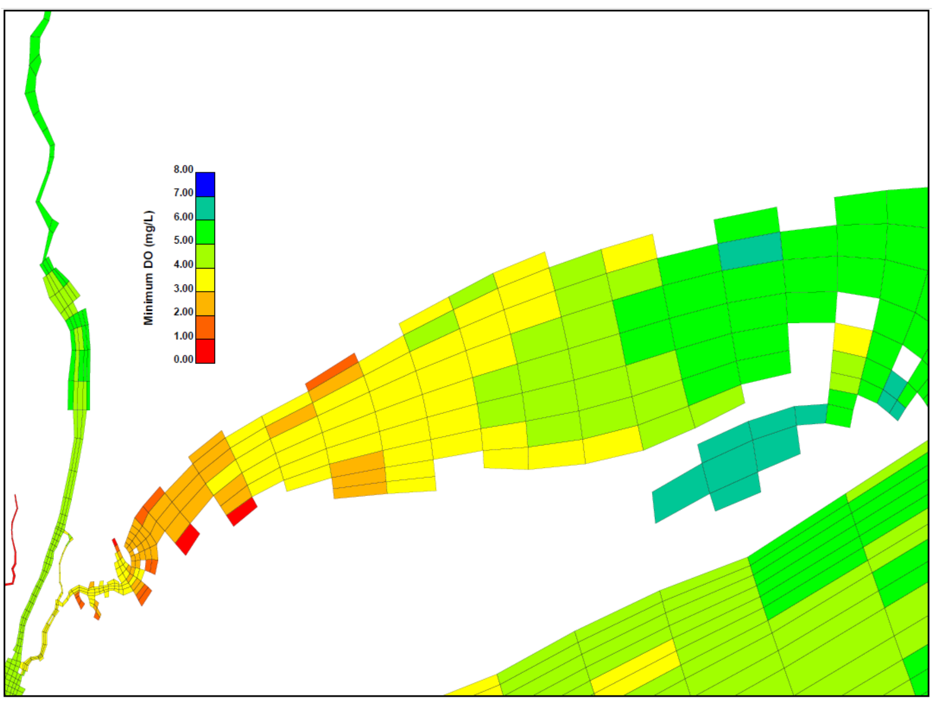
[29] EPA, LISS, *Additional SWEM Scenarios to Identify Dissolved Oxygen Responses to Load Reductions in Between TMDL and Pastoral Loadings Summary Findings Report*, September 2007 at 1.
[30] 2000 LIS Nitrogen TMDL, Table 8 at 30.
[31] *Id.*, Appendix 5 at 99.



LIS Nitrogen TMDL, Phase IV, 1988 Hydrodynamic Conditions
New York State Chronic Criteria

Figure 5 [32]

Figure 6, below, shows the predicted minimum DO level that will be reached following the TMDL's nitrogen reductions and associated carbon reductions.



LIS Nitrogen TMDL, Phase IV + Carbon Adjustments, 1988 Hydrodynamic Conditions
Absolute Minimum Dissolved Oxygen

Figure 6 [33]

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[32] *Id.* at 103.

ii. Nitrogen Reductions Required by the TMDL are Nearly Complete

The measurable nitrogen reductions required by Phase III of the current TMDL are nearly complete. Other significant nitrogen reductions anticipated by Phase IV of the TMDL have largely been unnecessary after a study found that the loads called for in the TMDL were already being met. Nonpoint source reductions called for by the TMDL are very difficult to measure and their effectiveness may have been countered by increases in developed land.

Phase III of the 2000 LIS Nitrogen TMDL required significant, measurable reductions of nitrogen from point sources in Connecticut and New York. According to 2013 data reported to LISS by CT DEEP and NYSDEC, Connecticut has already met its reduction requirements for point sources. In 2013, Connecticut point sources discharged 8,446 transfer equalized ("TE") lbs/day; this is *less* than the allocated load in the TMDL of 9,507 TE lbs/day.[34] In 2013, New York point sources discharged 18,702 TE lbs/day; this is *more* than the allocated load in the TMDL of 13,267 TE lbs/day.[35] While New York point sources still exceed the current TMDL's wasteload allocation ("WLA"),[36] it is predicted that New York's targets will be met by 2017, when currently in-progress construction is completed and nitrogen removal technology comes on-line.[37]

Phase IV of the 2000 LIS Nitrogen TMDL anticipated reductions of nitrogen from point sources in the rest of the Long Island Sound watershed: parts of Massachusetts, Vermont, and New Hampshire. NEIWPCC has concluded that Phase IV point source reduction targets have been met based on a monitoring study undertaken by the USGS and a subsequent NEIWPCC modeling effort. The USGS study measured the level of nitrogen present at several points in the Connecticut River, and concluded that the levels of nitrogen reaching the Connecticut-Massachusetts border on the Connecticut River were already below TMDL-required levels.[38] The total point and nonpoint source loads crossing the Connecticut-Massachusetts border was roughly 59,000 lbs/day; less than the combined Phase IV requirement of 59,741 lbs/day. [39]

These loads are compared in Figure 9 below, which shows the baseline, the TMDL's allocation, and the results of the USGS study. Because of how the data was collected, the USGS study did not distinguish between point and nonpoint sources of nitrogen.

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[33] *Id.* at 222.

[34] EPA LISS, *TE WLA 2013 Master File final*, based on data reported by CT DEEP and NYS DEC, updated Spring 2014.

[35] *Id.*

[36] A "wasteload allocation" is "the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution (e.g., permitted waste treatment facilities)." *See* EPA Website, "Water: TMDL 303(d), Glossary, http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/glossary.cfm.

[37] NEIWPCC, *An Overview of the Long Island Sound Total Maximum Daily Load for Dissolved Oxygen and the Connecticut River Workgroup*, August 2010 [hereinafter "NEIWPCC, *An Overview* 2010"] at 31.

[38] *Id.*, Figure 8 at 41-54.

[39] *Id.*

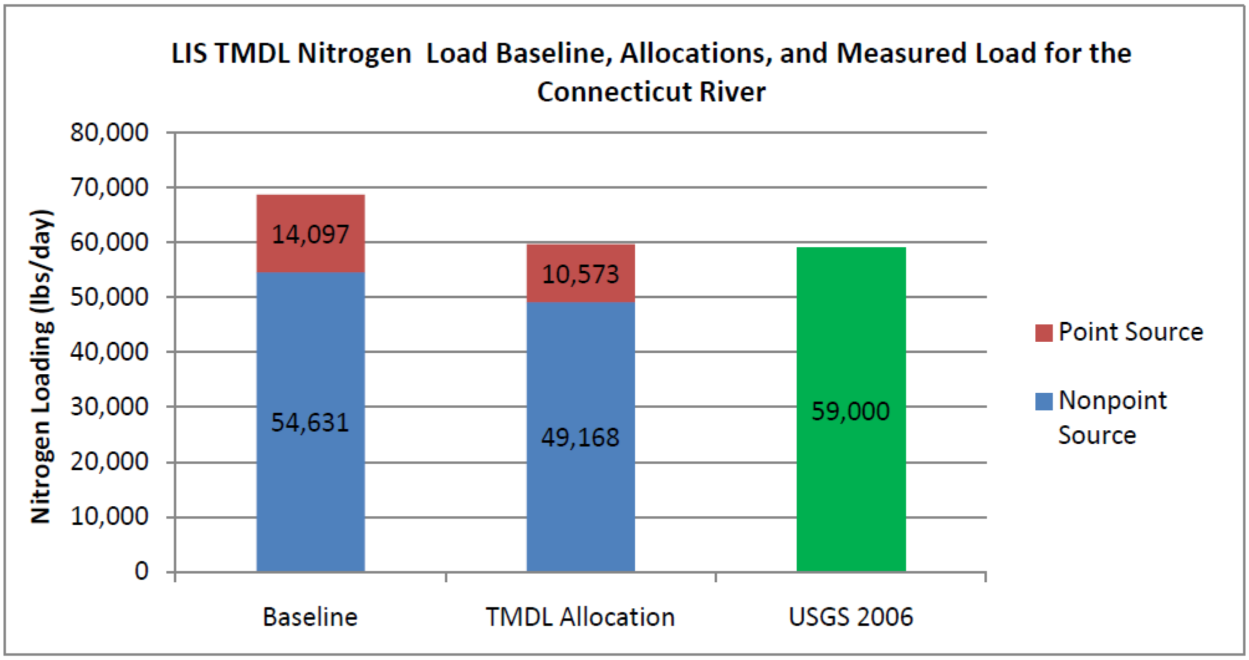

Figure 7 [40]

NEIWPCC's predictive model, "Northeast AVGWLF," was recalibrated for the Connecticut River watershed using the monitoring data collected by USGS and utilized nitrogen attenuation rates to determine the rate of loss of nitrogen as water flows down the Connecticut River. This model estimated that the amount of nitrogen that *reached the Sound* from the out-of-basin states was only 57,916 lbs/day.[41]

A 2014 NEIWPCC report is inconclusive about whether the TMDL's required 10 percent reduction to terrestrial nonpoint sources has been achieved for either the in or out-of-basin areas. The report notes that there have been significant increases in developed land, impervious cover, and population, which has likely increased nitrogen loading, and several regulatory and non-regulatory programs have been implemented and are likely to have reduced nitrogen loads.[42] The report concludes that more analysis is needed to determine whether the programs have been effective at reaching the required 10 percent reductions.[43]

Finally, the 2014 report by NEIWPCC concluded that the expected 18 percent reduction from atmospheric deposition from Clean Air Act implementation has likely been met.[44] National Atmospheric Deposition Program ("NADP") data from monitoring sites within or near the Long Island Sound watershed show that mean concentrations of nitrate have decreased by approximately 50 percent since 1990, while the Clean Air Status and Trends Network ("CASTNET") 2011 Annual Report cites a 26 percent reduction in total nitrogen deposition (wet and dry, nitrate and ammonium) between 1990 and 2011. NEIWPCC concludes, "[w]hile the actual amounts of nitrogen deposition throughout the Long Island Sound watershed may vary

[40] *Id.* at 12.
[41] *Id.* at 41-42.
[42] NEIWPCC, *Watershed Synthesis Section: A Preliminary and Qualitative Evaluation of the Adequacy of Current Stormwater and Nonpoint Source Nitrogen Control Efforts in Achieving the 2000 Long Island Sound Total Maximum Daily Load for Dissolved Oxygen*, August 2014 [hereinafter "NEIWPCC, *Synthesis* 2014"] at 59-60.
[43] *Id.*
[44] *Id.* at 62.

from these two estimates, in combination they strongly suggest that implementation of the CAA achieved at least the 18 percent reduction estimated in the TMDL."[45]

In summary, Connecticut is considered to have met and surpassed its Phase III nitrogen loading targets.[46] As of 2013, New York point sources discharged 5,434 TE lbs/day more nitrogen than its target WLA, but has several upgrades in progress, and is projected to meet its targets by 2017.[47] There is less concrete data available regarding current out-of-basin point source loads, but a USGS monitoring study indicates that TMDL levels have likely already been achieved. Reports regarding nonpoint source reductions indicate that there simply is not enough data to conclude whether nonpoint source reductions have been achieved. Finally, it is generally believed that required atmospheric reductions have been met.

iii. Current Monitoring Shows Water Quality Standards will not be Met

Despite the fact that Connecticut and New York have nearly achieved the enforceable and measurable reductions, monitoring in the Sound shows that WQS are still far from being attained. Annual LISS water quality monitoring throughout the summer months shows that WQS for DO are still violated every year. Figure 8 below shows the area and duration of the Sound below 3.0 mg/L (the acute standard) every year since monitoring began in 1987 until 2013. The blue line indicates the duration of days out of each year that the WQS for DO were violated. For example, even in the three "best years" (1995, 1996, and 2000), WQS were violated for over 30 days. The green column graphs represent the area of the Sound (depicted in square miles) that experienced DO below the acute standard, as reflected by the values in the left hand vertical axis. While 2013 was the best year in the post-TMDL era, more than 75 square miles of the Sound still fell below the acute standard. Moreover, these figures do not even address the chronic standard, which we believe is violated far more frequently.

[45] *Id.* at *62*.
[46] EPA LISS, *TE WLA 2013 Master File final*, based on data reported by CT DEEP and NYS DEC, updated Spring 2014.
[47] *Id.*

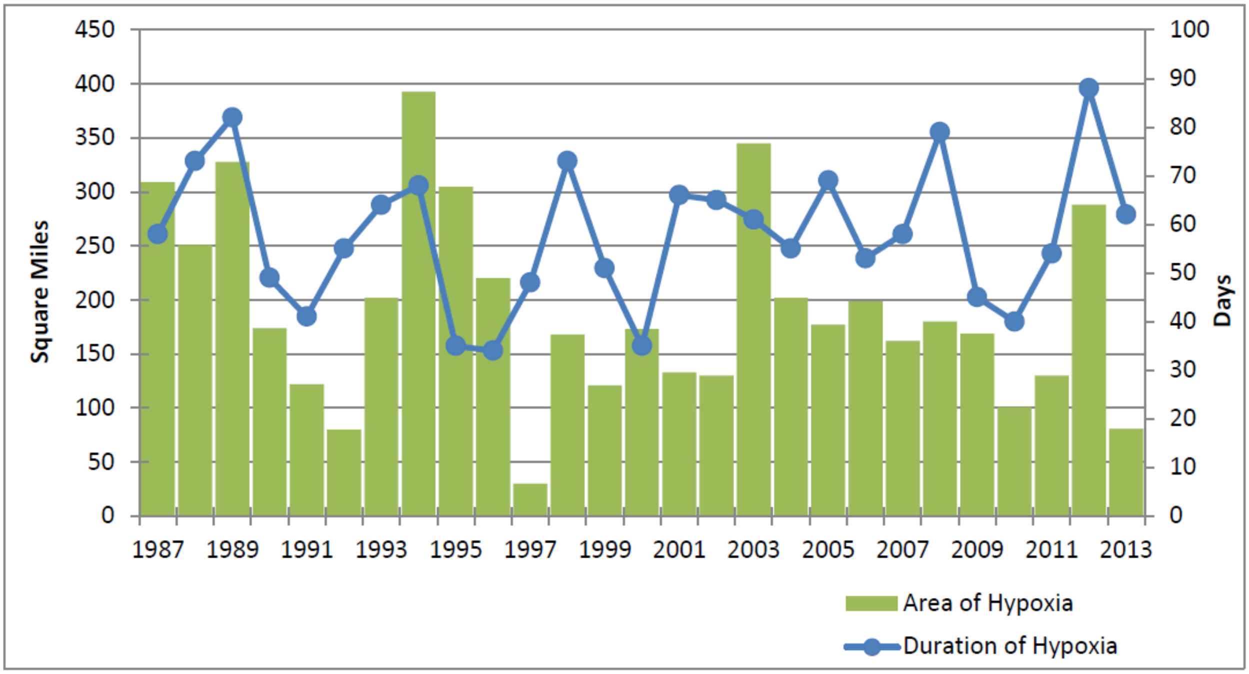

Figure 8 [48]

This monitoring shows only a slight trend toward the hypoxic zone shrinking in total area and no appreciable trend in shortening its duration. In its 2014 Synthesis Report, NEIWPCC notes: "while [monitoring] has substantially contributed to our understanding of hypoxia and variability within the system, analyses have not revealed an upward trend in DO." [49] As recently as 2012, a particularly bad year, an area of 18 square miles became anoxic (reached below 1.0 mg/L).[50] Figure 9, below, shows the extent of the anoxia in black and the rest of the hypoxia (below 3.0 mg/L) in red and orange.

[48] *Id.* at 14.
[49] *Id.* at 63.
[50] CT DEEP, *2013 Long Island Sound Hypoxia Season Review* at 16.

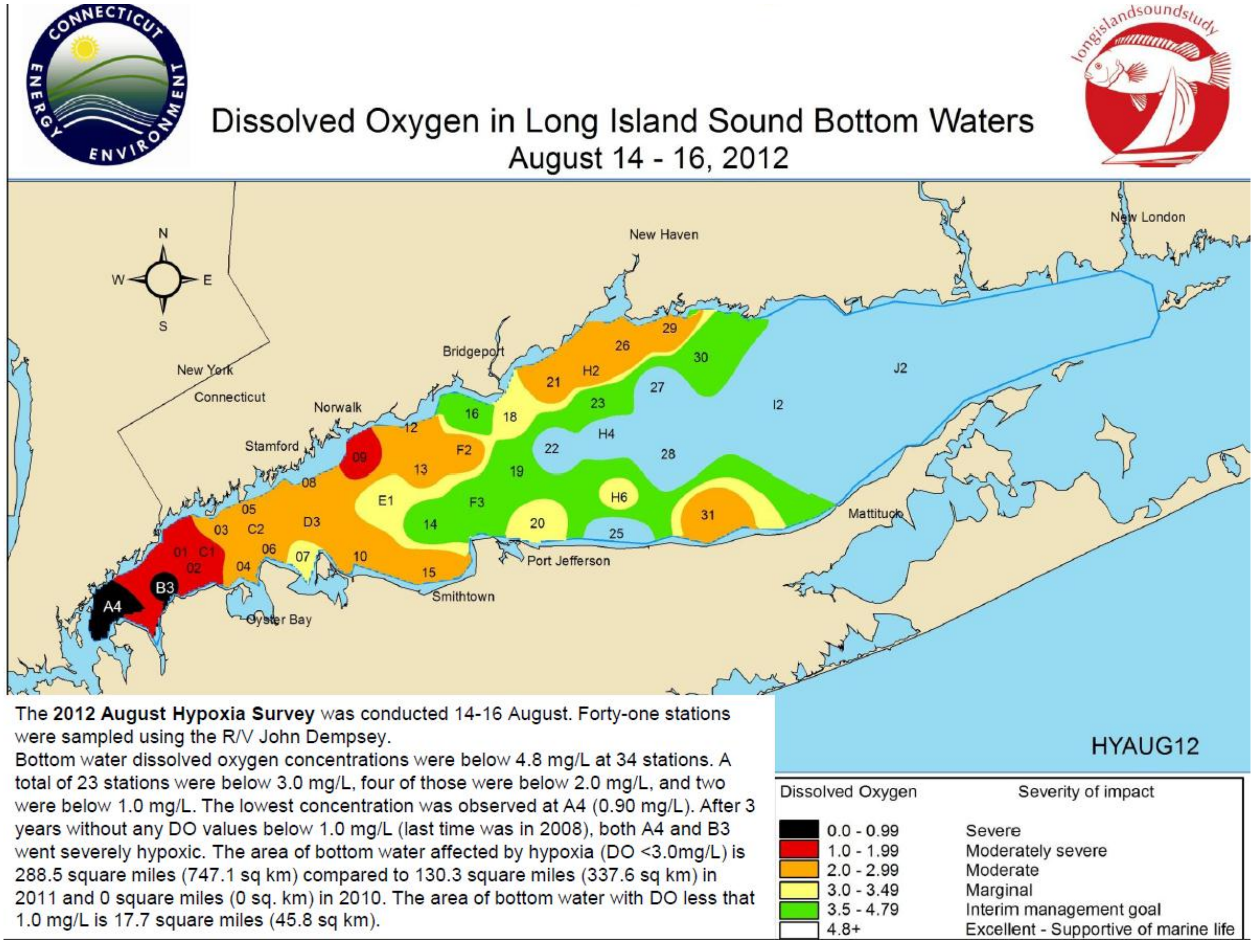

Figure 9 [51]

Even in the particularly good years of 2013 and 2014, DO criteria were still violated by a large margin. In 2013, the minimum DO recorded reached as low as 1.05 mg/L, and dropped below 3.0 mg/L for a total of 23.49 cumulative days.[52] In 2014, the LISICOS buoy at Execution Rocks recorded a low of 1.07 mg/L, and the area of bottom water affected by hypoxia (below 3.0 mg/L) was 87.1 square miles.[53] Considering that all of the required nitrogen reductions under the TMDL are nearly complete and that DO levels still nearly reach anoxic levels in a "good" year, these results clearly demonstrate that the Sound is still far from meeting WQS.

This wide variation in the extent of water quality violations is likely related to significant year-to-year variations in wind, temperature, and precipitation. We consider this short-term variability as mere weather variability, which should not be confused with the long-term, multi-decade observed and predicted changes to our climate conditions. Key observed and predicted multi-decade climatic shifts that are associated with greater duration and extent of hypoxia in and around the Sound's region are discussed in section (I)(b)(4).

[51] CT DEEP Website, "Dissolved Oxygen Maps for Summer 2012," August 14-16, http://www.ct.gov/deep/lib/deep/water/lis_water_quality/monitoring/2012/narrative_map_hyaug12.pdf.
[52] CT DEEP, *2013 Long Island Sound Hypoxia Season Review* at 9.
[53] E-mail from Katie O'Brien-Clayton, CT DEEP, *CTDEEP WQAUG14 survey summary* (August 26, 2014).

2. Non-Treatment Alternatives Necessary to Meet Water Quality Standards Have Not Been Implemented and there is No Reason to Believe they will be in a Manner that will Achieve Water Quality Standards

Pursuant to EPA regulation, non-treatment alternatives may be used to meet WQS on a case-by-case basis when technology-based treatment requirements are not sufficient.[54] Thus, the TMDL included Phase V, which intended to make up for any shortfall in attaining WQS through future revisions to the TMDL requirements and/or the implementation of non-treatment alternatives.[55]

The TMDL lists several potential non-treatment alternatives that could help meet WQS in the Sound, including mixing/aeration of bottom waters, artificial wetlands, relocation of sewage treatment plant outfalls, tide gates, and seaweed farms (bio-extraction).[56] However, instead of choosing specific alternatives, the TMDL states: "there is still an inadequate basis for determining which one(s) would be the preferred environmental and economic alternative(s) to employ as part of the overall hypoxia management effort. Additional study is needed to assess the utility, feasibility, consequences, and economics of the different alternatives."[57]

The TMDL therefore required assessment, pilot testing, and the inclusion of non-treatment alternatives into future revisions of the TMDL to meet WQS.[58] The TMDL predicted that an hourly minimum DO concentration of 5.0 mg/L would be achievable through Phase V non-treatment alternatives, although the TMDL does not explain how it reached this conclusion.[59] In addition to non-treatment alternatives, the TMDL called for reassessment of the TMDL, and the progress made under it, every five years, with revision to the TMDL "as appropriate" to meet WQS.[60] The first reassessment and revision was supposed to be completed by August 2004.[61]

But Phase V non-treatment alternatives have neither been chosen nor implemented and the schedule in the TMDL has not been followed. The TMDL indicates that the August 2004 revision to the TMDL was supposed to "include an assessment of the degree to which Phase V actions are required and a more detailed schedule for implementation." [62] Pilot testing was to begin immediately following this, as appropriate, and finish by August 2006. Final design engineering was to be completed by August 2007, and non-treatment alternatives were to be implemented starting August 2008.[63]

Neither the revision required in 2004, nor the subsequent testing, engineering, and implementation of non-treatment alternatives have taken place. Many of the alternatives mentioned in the TMDL are generally considered to be infeasible, such as mixing/aeration of the bottom waters of the Sound and relocation of the sewage treatment plant outfalls from the East River to New York Harbor or the Atlantic Ocean.

[54] 2000 LIS Nitrogen TMDL at 34 [*citing*] 40 CFR 125.3(f).
[55] *See Id.* at 34-37.
[56] *See Id.* at 35-37.
[57] *Id.* at 34.
[58] *Id.* at 36, 47.
[59] *See Id.*, Figure 8 at 30.
[60] *Id.* at 46-48.
[61] *Id.*, Table 14 at 48.
[62] *Id.* at 47.
[63] *Id.*

LISS is currently investigating one of the non-treatment alternatives, called "nutrient bioextraction."[64] Bioextraction is the process of farming certain plants or animal species that absorb nitrogen and then removing them from the environment. Phytoplankton (algae) can absorb nitrogen from a variety of sources. Shellfish consume and filter the phytoplankton, and nitrogen from the phytoplankton is incorporated into the shellfish's tissues and shell. When the shellfish are harvested, the nitrogen is removed from the local environment.[65] Increased shellfish farming in the near-shore environment would remove excess nutrients from the water without any of the deleterious effects that would be expected from other non-treatment alternatives.[66] Other bioextraction techniques include seaweed farming or direct algae removal.

But bioextraction has yet to be recommended, funded, or implemented on a large scale in the Sound. And "[I]ndividual farms may have environmental impacts locally, but large-scale implementation is necessary to be effective at the ecosystem scale."[67] And even large-scale implementation of bioextraction projects serves more as a complement to a solution, rather than a solution itself. "The scale of the coastal eutrophication problem worldwide is such that, while shellfish aquaculture holds promise as an additional tool for coastal and estuarine nutrient management, it functions most effectively as a complement, not a replacement, for existing nitrogen source control efforts."[68]

3. The Reassessments of the TMDL, Required to Take Place Every Five Years, have not been Timely or Complete.

The TMDL also required reassessment and revision as appropriate in order to meet WQS.[69] Reassessment was to occur every 5 years; the first was to be completed by February 2003, and the second by February 2008. In addition, the TMDL was to be revised, "as appropriate" following each reassessment—by August 2003, and again by August 2008.[70]

To date there have been no revisions. In 2012, 9 years after the 2003 deadline, the "Five State/EPA Total Maximum Daily Load Work Group" along with the LISS Management Committee approved a framework for TMDL assessment called the "Enhanced Implementation Plan for the Long Island Sound Total Maximum Daily Load" ("EIP"). [71] The EIP, signed by EPA and the five states, detailed the future steps to be taken in furtherance of achieving the current TMDL.

The three main elements of the EIP are:

> (1) Continue with implementation of nitrogen reductions from wastewater treatment plants (upgrades and optimization work in the lower basin and capping loads and monitoring in the upper basin), (2) Complete a preliminary evaluation of current stormwater and nonpoint source control efforts with a goal of qualitatively assessing their adequacy for meeting the

[64] NEIWPCC, *An Overview* 2010 at 11.
[65] Rose, Julie M., Suzanne B. Bricker, Mark A. Tedesco, and Gary H. Wikfors, A Role for Shellfish Aquaculture in Coastal Nitrogen Management, Environmental Science and Technology, ACS Publications, http://pubs.acs.org/doi/abs/10.1021/es4041336 at 2,519.
[66] *Id.* at 2,521.
[67] *Id.* at 2,522.
[68] *Id.* at 2,522.
[69] 2000 LIS Nitrogen TMDL at 41.
[70] *Id.* at 41-48.
[71] LISS Management Committee, Five State/EPA Total Maximum Daily Load Work Group , Enhanced Implementation Plan for the Long Island Sound Total Maximum Daily Load, http://www.neiwpcc.org/neiwpcc_docs/LIS%20TMDL%20Enhanced%20Implementation%20Plan.pdf.

> 2000 TMDL load allocations, and (3) Develop and implement a feasible tracking system to evaluate attainment of load allocations for nonpoint sources and wasteload allocations for regulated stormwater sources.[72]

These measures are largely evaluative of current progress. They do not require any qualitative assessment of the ability of the current TMDL or other measures to meet WQS upon completion. Significantly, it also does not call for any substantive revisions to the requirements of the current TMDL, despite overwhelming evidence that the current TMDL will never meet WQS.[73] Nor does the EIP call for any evaluation or recommendation of the implementation of Phase V non-treatment alternatives, as was required by Phase V of the TMDL to occur by 2008.[74]

4. Recent Science Suggests a Combination of Long Term Climatic Changes Will Exacerbate Hypoxia and Related Water Quality Violations

Changes to the climate in and around the Long Island Sound watershed may make it more difficult to meet WQS in the Sound. Therefore, additional nitrogen removal and management techniques may be required to offset the changing climatic forces that are predicted to increase the frequency of water quality violations as cited below.

The concept of "adaptive management" attempts to incorporate new scientific understandings and field observations into management decisions.[75] In the context of watershed management, it is the process by which new information about the health of a watershed is incorporated into the management plan. This idea was incorporated into the TMDL's implementation schedules, which built into it periodic reevaluation and revision of the TMDL nitrogen targets.[76]

The monitoring data, reflected in Figure 8 above, suggests that Long Island Sound is recovering more slowly than EPA's modeling predicted, and that it is recovering in a non-linear pattern.[77] The recently published synthesis of a quarter-century of scientific study of Long Island Sound documents long-term, multi-decade climatic shifts underway in the Sound that fuel additional hypoxia. These climatic shifts are thought to be exacerbating stratification in the western Sound, thus setting up conditions for longer duration and larger areas of hypoxia.[78]

Perhaps the strongest climatic shift that is forcing greater stratification and longer duration hypoxia is a gradual change in the Sound's wind regime. Since 1946, the mean wind direction has gradually been shifting westward by approximately 30 degrees over a 70-year observed time frame.[79] The mean wind direction shifting westward is now approaching 203

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[72] NEIWPCC, *Synthesis* 2014 at 19.
[73] *See supra* section (I)(b)(1) at 9; LISS Management Committee, Five State/EPA Total Maximum Daily Load Work Group , Enhanced Implementation Plan for the Long Island Sound Total Maximum Daily Load, http://www.neiwpcc.org/neiwpcc_docs/LIS%20TMDL%20Enhanced%20Implementation%20Plan.pdf.
[74] *See supra* section (I)(b)(2) at 17; *see also* 2000 LIS Nitrogen TMDL, Table 13 at 47; LISS Management Committee, Five State/EPA Total Maximum Daily Load Work Group, Enhanced Implementation Plan for the Long Island Sound Total Maximum Daily Load, http://www.neiwpcc.org/neiwpcc_docs/LIS%20TMDL%20Enhanced%20Implementation%20Plan.pdf.
[75] Franklin, Thomas M. et al., Using Adaptive Management to Meet Conservation Goals, https://www.fsa.usda.gov/Internet/FSA_File/chap_7.pdf.
[76] 2000 LIS Nitrogen TMDL at 42-48.
[77] NEIWPCC, *Synthesis* 2014 at 14.
[78] Latimer, James, et al., Long Island Sound, Prospects for the Urban Sea, Springer, 2014 [hereinafter "Latimer"] at 135-140, 501-509.
[79] *Id.* at 140.
[79] *Id.* at 503-504.

degrees T, which is the optimal direction for producing vertical stratification in the western Sound.[80] There is a strong statistical correlation between southerly and westerly winds and long duration of hypoxia. In contrast, easterly quadrant winds are strongly associated with diminished hypoxia duration.[81] Easterly winds are thought to mitigate hypoxic conditions by pushing the stratified layer of top-waters westward and causing greater mixing and less stratification.[82] Not only is the wind direction shifting westward (resulting in conditions conducive to hypoxia formation), but long-term observations also reflect that the vigor of the easterly winds is diminishing during our warm hypoxic season. Strong easterly winds have the greatest mixing benefits, and these winds, going forward, may have diminished potential to curb hypoxia.[83]

An additional and related long-term oceanographic shift in the Sound is an observed 1.5˚C increase in temperature differential between summer-averaged surface and bottom waters between 1946 and 2006. This is thought to be largely related to the previously mentioned long-term shifts in regional wind direction.[84]

Finally, hypoxia is also exacerbated by the climatic shift toward increased precipitation and warmer springs, causing earlier snowmelt and generating an overall greater flow of freshwater into the Sound.[85] Less dense freshwater in the Sound tends to sit on top of the denser seawater, contributing to the density stratification that leads to hypoxia. As the amount of freshwater increases, stratification becomes more severe.[86] The Sound's local climate has experienced a 13 percent increase in average annual precipitation over the past twenty years, and perhaps as much as a 20 percent increase over 40 years.[87] The U.S. Government's most recent regional climate projections predict continued increases in overall precipitation in the northeast region coupled with higher spring temperatures and continued earlier snowmelt.[88]

Moreover, observed climatic trends suggest earlier seasonal water column stratification in the western Sound—the pre-condition for seasonal hypoxia.[89] A trend toward warmer regional winters has produced long-term trends toward earlier spring snowmelt and freshets originating in the northern watershed areas of the Hudson and Connecticut Rivers.[90] Seasonally, the western Sound's hypoxia typically commences when the spring riverine freshet occurs followed by warm spring weather.[91] Thus, these climatic shifts generally accelerate the conditions for both a longer period of hypoxia and perhaps a greater areal extent of hypoxia.

To summarize, a synthesis of the observed conditions coupled with long-term climate predictions suggests troubling patterns. First, long-term, multi-decade observed climate-related changes are predicted to continue. And these observed and predicted changes in wind direction and precipitation amounts, combined with earlier and warmer spring conditions and earlier snowmelt freshets, create challenging management implications. These shifts suggest that over

[80] *Id.* at 140.
[81] *Id.* at 135.
[82] *Id.* at 133-136.
[83] *Id.*
[84] *Id.* at 503.
[85] *Id.* at 505-506.
[86] *Id.* at 506.
[87] *Id.* at 505.
[88] Kunkel, K.E, *et al*., U.S. NOAA Technical Report NESDIS, *2013: Regional Climate Trends and Scenarios for the U.S. National Climate Assessment. Part 1. Climate of the Northeast*.
[89] Latimer at 506-507.
[90] *Id.*
[91] *Id.* at 505-508.

the next several decades, these climate patterns will push the western Sound's hydrodynamic stratification system into patterns of larger areas of hypoxia and water quality violations lasting for longer periods of time.

Thus, a new or revised TMDL must respond to conditions as we understand them now, which are substantially different to how we understood them when the TMDL was implemented.

5. Preliminary Results from Recent EPA-Supported Research Indicate that Hypoxia is a Common Condition in Embayments throughout the Sound

We are increasingly finding hypoxic conditions in embayments throughout the Sound. While these were not the subject of the original TMDL, these are certainly conditions that must be addressed moving forward. When the 2000 LIS Nitrogen TMDL was proposed, virtually no research that was underway focused on DO conditions within local harbors and embayments around Long Island Sound. Over the past three years, LISS has focused substantial efforts on researching local embayment health at 50 embayments, including modeling flow exchange and monitoring dissolved oxygen conditions within ten of these coastal embayments.

As part of this effort, Assistant Professor Jamie Vaudrey of the University of Connecticut has been examining the DO levels in Long Island Sound's bays and harbors. She stated: "I was surprised that [hypoxia] was in almost all of them."[92] While this condition is most prevalent during late summer nights, it is critical to remember that our acute standards are designed to prevent known, substantial impacts to marine life from short-term exposure to very low oxygen conditions. Professor Vaudrey's co-researcher, Professor Charles Yarish of the University of Connecticut, is quoted as stating: "Some embayments are large, some are small and they also have different levels of exchange … So we have to be really careful how these embayments are managed and have to minimize the introduction of these nutrients, which are causing the hypoxia."[93] The early results of this emerging research suggest another critical reason to act aggressively now to identify and control local sources of nitrogen.

c. Excess Nitrogen also Contributes to Other Harmful Conditions in the Sound and its Many Embayments

1. Excess Nitrogen is Causing Harmful Algae Blooms that Make Shellfish Toxic to Humans

Excess nitrogen contributes to other pressing ecological problems in the Sound in addition to hypoxia. "Harmful algal blooms occur when a single species of phytoplankton grows to a density that has a direct negative impact upon other organisms or an ecosystem through production of toxins, mechanical damage, or by other means."[94] Since 2006, harmful algal blooms have occurred annually within some parts of the Sound.[95] Dense blooms of *Alexandrium fundayense*, which produce "saxitoxin," a paralytic toxin responsible for the human illness known as paralytic shellfish poisoning, have emerged in Northport and Huntington every spring since 2006.[96] These blooms, which last for approximately two months, cause shellfish to become

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[92] Zaretsky, Mark, "Low oxygen levels present even in bays in eastern estuary, UConn researchers find" *New Haven Register* (August 4, 2014), http://www.nhregister.com/general-news/20130804/low-oxygen-levels-present-even-in-bays-in-eastern-estuary-uconn-researchers-find.
[93] *Id.*
[94] Latimer at 338.
[95] *Id.*
[96] *Id.*; *see also* Blunden, Gerald, "Review: Biologically Active Compounds from Marine Organisms," *Phytotherapy Research 15* (2001) at 89.

highly toxic to humans, and resulted in the closure of nearly 10,000 acres of shellfish beds during five of six years from 2006 to 2012.[97]

A study investigating factors promoting toxic *A. fundayense* blooms in Northport Bay found a strong correlation between available nitrogen, particularly ammonium, and increased densities of *A. fundayense* and high saxitoxin concentrations.[98] "These findings suggest that *A. fundayense* growth was supported by a source of wastewater, such as the sewage treatment plant that discharges into Northport Harbor or on-site septic systems."[99]

Blooms of *A. fundayense* are not an isolated phenomenon limited to the Huntington Bay and Northport Bay harbor either. Surveys of Long Island Sound from 2008 to 2011 have demonstrated that undetected blooms of *A. fundayense* occurred at multiple near shore regions of the Sound in both New York and Connecticut, and elevated levels of *A. fundayense* have been confirmed at 25 sites around the Sound.[100] The widespread distribution of *A. fundyense* highlights the potential for this species to create toxic blooms in many other embayments around the Sound if similar conditions are present – excess available nitrogen from a source of wastewater combined with poor flushing of the embayment.[101]

A. fundayense is only one of several species of toxic algae that has been recently begun forming in large, persistent annual blooms.[102] Additional harmful algae blooms in and around several Long Island embayments include toxic blue green algae ("cyanobacteria"), the "red tide" producing *Cochlodinium polykrikoides*, and *Ulva lactuca* (sea lettuce). A report published by the NYSDEC concluded that all are fueled by excess nitrogen, and can be harmful to humans, other animals, or ecosystems.[103]

2. <u>Excess Nitrogen is a Significant Driver of Tidal Marsh Loss throughout the Coastal Zone of Long Island Sound</u>

Excess nitrogen is also a significant contributor to the deterioration of tidal marshes throughout Long Island Sound. Tidal salt marshes are "highly productive coastal wetlands that provide a wide array of ecosystem services, including storm surge protection for coastal communities, nutrient removal, carbon sequestration, and habitat for numerous fish, shellfish, and wildlife species."[104] A recently-released report by NYSDEC detailed how excess nitrogen drives the high rates of tidal wetland loss that has been observed along the coasts of the Long Island Sound.[105] The report states:

> Recent scientific studies have focused on excess nutrient nitrogen as a significant driver of tidal marsh loss. Nitrogen enrichment increases above-ground leaf biomass, yet decreases the dense below-ground biomass of bank-stabilized roots. There is also an increase in microbial

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[97] Latimer at 339, [*citing*] Hattenrath, Teresa, *et al*., "The influence of anthropogenic nitrogen loading and meteorological conditions on the dynamics and toxicity of *Alexandrium fundyense* blooms in a New York (USA) estuary," *Harmful Algae* 9 (2010) at 402-412.
[98] *Id.*
[99] Latimer at 339.
[100] *Id.* at 340.
[101] *Id.*
[102] *Id.*
[103] NYS DEC; NY Works; NY Rising; NYS Environmental Facilities Corporation, *Coastal Resiliency and Water Quality in Nassau and Suffolk Counties: Recommended Actions and a Proposed Path Forward* (2014) at 13.
[104] *Id.* at 7.
[105] *Id.* at 7-9.

> decomposition of organic matter within the soils that underlie the marsh biomass than can cause marshes to subside.[106]

Moreover, this report documents the substantial levels of tidal wetland area loss along the North Shore of Long Island since 1974, as illustrated in Figure 10 below.

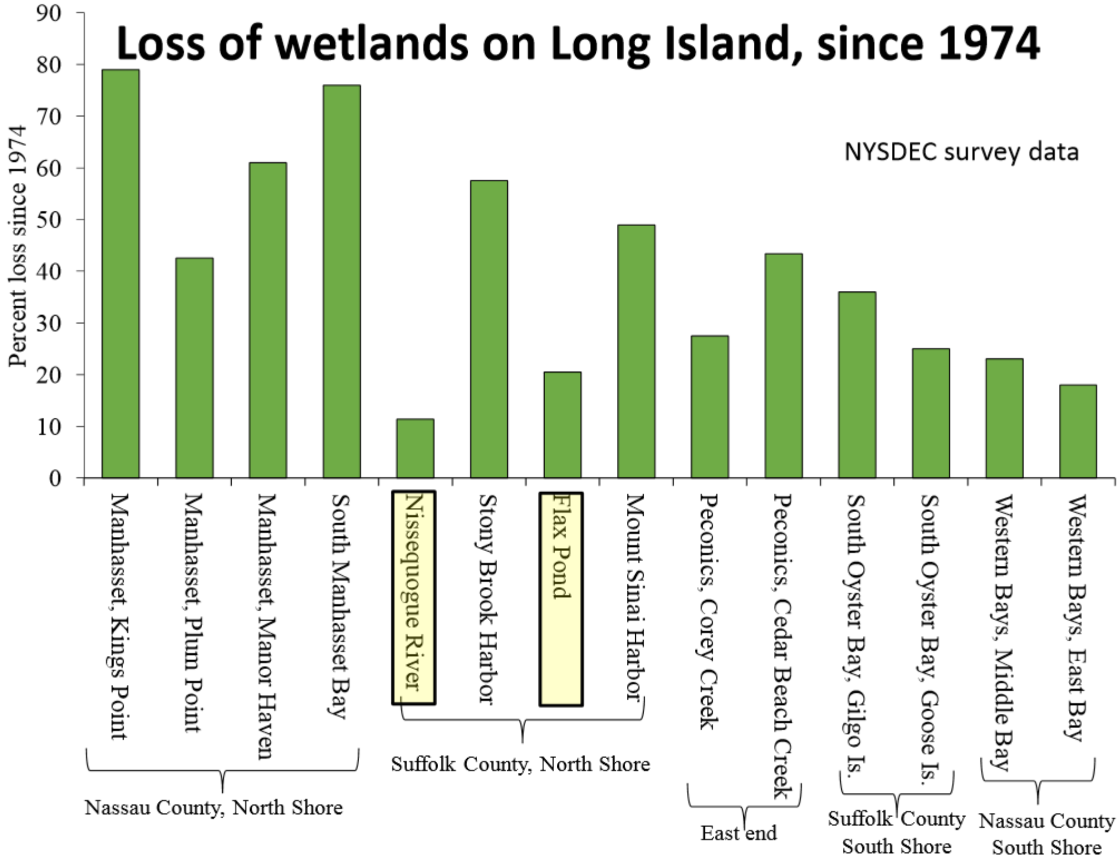

Figure 10 [107]

Tidal marsh loss along the Connecticut coast is also an issue of concern. A 2013 report by the U.S. Fish and Wildlife Service noted a loss of more than 50 acres of salt marsh in southwestern Connecticut from 1974 to 2004.[108] The report then gave a conservative estimate of a net loss of 11 salt marsh acres from1990 to 2010.[109]

While a main focus of the nitrogen TMDL must be to attain WQS for dissolved oxygen, nitrogen pollution clearly contributes to the deterioration of tidal marshes, which help remove excess nitrogen, further perpetuating the nitrogen problem in the Sound. Therefore, further reductions to nitrogen loading will likely result in important auxiliary benefits, such as curbing the loss of tidal marshes.

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[106] *Id.* at 8.
[107] *Id.* at 7.
[108] Tiner, Ralph, *et al.*,U.S. Fish and Wildlife Service, *Changes in Connecticut Wetlands: 1990 to 2010* (July 2013), http://aswm.org/wetlandsonestop/connecticut_wetland_trends_1990-2010_final_report_2013.pdf at 25.
[109] *Id.*

d. Significant Potential for Nitrogen Reductions Remain

Even after completion of the nitrogen reductions that the 2000 LIS Nitrogen TMDL required, significant potential for future nitrogen reduction remains from both point and nonpoint sources.

Further reduction of nitrogen from in-basin point sources is possible by continuing the process of upgrading nitrogen reduction technologies in wastewater treatment plants ("WWTP"). The 2000 TMDL required 58.5 percent reduction from in-basin point sources instead of requiring upgrades to the limit of technology. This decision was based on a "cost-sensitive" scenario, where model programmers tried to maximize the increase in DO levels relative to the expected cost of the implementation.[110] The formula used to evaluate cost effectiveness found that 58.5 percent reduction of nitrogen from in-basin point sources was achievable for roughly $650 million, down from the expected $2.5 billion cost to reach the Limits of Technology ("LOT") – considered by LISS to be an effluent nitrogen concentration of 3.0 mg/L.[111] While the difference in cost led the TMDL developers to choose a cost-sensitive option, further reductions are technically achievable, and the cost of implementation has likely dropped since it was evaluated prior to the last TMDL.

Also, the adoption of a nitrogen trading program in Connecticut allowed some WWTPs to buy credits instead of updating their technologies. This led to most of the upgrades occurring at larger facilities concentrated near the shore, while smaller, farther-away facilities chose to buy credits. This means that many in-basin facilities employ no nitrogen-removal technology at all.

Reductions of nitrogen from out-of-basin point sources are also achievable. Many water treatment facilities north of the Connecticut-Massachusetts border lack any nitrogen removal technology since the reductions required by the TMDL did not lead to substantial action. This means that there is still significant potential for nitrogen removal from out-of-basin point sources. A 2008 report by Barry Evans concluded that significant reductions to out-of-basin point sources are technically attainable. "[T]he point source loads in the upper part of the Connecticut River Basin (i.e., in areas above Connecticut) could be reduced by approximately 3,385,941 lb/yr if all plants were upgraded to discharge no more than 3 mg/L of nitrogen. This would equate to a reduction of about 74.7 percent when considering the current point source delivered by sources upstream of Connecticut (4,531,090 lb/yr).[112] NEIWPCC has noted the need for a "5-state TMDL," meaning that all five states would participate in the re-evaluation and revision process and sign on to the revised TMDL in order to achieve these necessary reductions from out-of-basin sources.[113]

Throughout much of the Long Island Sound watershed, nonpoint sources contribute considerably higher nitrogen loads than point sources,[114] and many significant nonpoint sources of nitrogen remain to be addressed. According to NEIWPCC, there is not enough available data

[110] 2000 LIS Nitrogen TMDL at 22-24.
[111] *Id.* at 23.
[112] Evans, Barry M., *An Evaluation of Potential Nitrogen Load Reductions to Long Island Sound from the Connecticut River Basin* (March 18, 2008) at 28.
[113] NEIWPCC, *An Overview* 2010 at 13.
[114] Evans, Barry M., *An Evaluation of Potential Nitrogen Load Reductions to Long Island Sound from the Connecticut River Basin* (March 18, 2008) at 28 ("[T]he current nitrogen load delivered to Long Island Sound via the entire Connecticut River basin is about 28,710,233 lb per year. Of this amount, approximately 35.3 percent originates from point sources (primarily municipal wastewater treatment plants), with the remainder (64.7 percent) coming from nonpoint sources.")

to conclude that a 10 percent reduction from terrestrial nonpoint sources has been achieved from the actions taken pursuant to the TMDL.[115] But the original TMDL did not evaluate or focus on local and important sources of nitrogen contribution, especially in the coastal sections of Connecticut and New York. Instead, several sources were grouped under the heading of "nonpoint source" and given a single estimated loading factor.[116]

Terrestrial nonpoint source nitrogen primarily comes from urban and suburban stormwater and agricultural run-off. Urban and suburban stormwater carries nitrogen originating from urbanized impermeable surfaces, residential lawns, and commercial turf (including golf courses) to the Sound. Run-off from agricultural operations can contribute nitrogen from fertilizers or animal wastes directly to tributaries that lead to the Sound. In order to make any substantial progress on the reduction of nitrogen loads from nonpoint sources, the relative contributions of each must be accounted for individually. Until this occurs, there is simply not enough information to understand how to reduce nitrogen from these various nonpoint sources.

Human waste sources reach the Sound from deteriorating, leaking sanitary sewer conveyance structures through what is commonly labeled excess "inflow and infiltration," and through groundwater inputs from cesspools and septic systems in areas without sewers. Nitrogen from septic systems and leaking sewer infrastructure was not addressed in the TMDL. Recent research has greatly expanded our knowledge of the nitrogen contributions of from septic systems. In fact, modeling advances now allow us to identify the localized contribution of on-site cesspools and septic systems on a sub-watershed basis.

An examination of these local contributions for all sub-watersheds within Cape Cod was recently released as part of the Section 208 Cape Cod draft report.[117] Moreover, the Nature Conservancy ("TNC") is currently undertaking such a sub-watershed modeling effort for all of Long Island Sound. Preliminary results indicate very high nitrogen contributions from septic and cesspools for sub-watersheds along Long Island and parts of eastern Connecticut. TNC's April 2014 report, entitled "Southern New England and New York Seagrass Research Toward Restoration – Phase II," previewed their findings in many embayments along the Connecticut and Long Island shores of the Sound. For example, septic systems and cesspools account for 72 percent of the nitrogen loaded to Wading River, 68 percent to Huntington Harbor, 77 percent of the nitrogen loaded to Centerpoint Harbor, 75 percent of the nitrogen loaded to the Nissequogue River, 49 percent of the nitrogen loaded to the lower Saugatuck River, and 36 percent of the nitrogen loaded to the Ram Island Embayments.[118] Moreover, rising ground waters due to wetter climate conditions have caused a greater amount of nitrogen from septic systems and cesspools to seep into surface waters through a hydrological connection and reach the Sound. The previous TMDL does not address septic systems at all, but the data shows that they contribute a significant and growing load of nitrogen to the Sound, which must be addressed.

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[115] NEIWPCC, *Synthesis* 2014 at 59-60.
[116] *See* 2000 LIS Nitrogen TMDL at 26-33.
[117] *See* Cape Cod Commission, *DRAFT Cape Cod Area Wide Water Quality Management Plan Update* (August 2014).
[118] The Nature Conservancy, *Southern New England and New York Seagrass Research Towards Restoration – Phase II*, April 2014 at 15-67.

II. EPA Must Establish a New or Amended TMDL for Long Island Sound

As we have stated, the 2000 LIS Nitrogen TMDL is not effectively serving as a tool to achieve WQS in Long Island Sound. In order to come into compliance with the Clean Water Act and regulations, EPA must amend the 2000 LIS Nitrogen TMDL or establish a new TMDL.

a. TMDLs are Required when Water Quality Standards Cannot Be Met

Under the Clean Water Act, TMDLs are triggered when WQS are not met through the regulation of point source pollution and voluntary measures. States are first required to set WQS for all waters within their boundaries, regardless of the sources of pollution. If the states do not set WQS, or EPA determines that the state standards do not meet the requirements of the Act, EPA must promulgate standards for the state.[119] The first objective of the CWA is to ensure that technology-based controls on point sources are established and maintained. These controls are established through the application of the "best practicable control technology" effluent limitations for most point source discharges.[120]

When those controls are insufficient to meet and maintain WQS, water quality-based controls are required under Section 303(d) of the CWA. Section 303(d)(1)(A) requires each state to identify waters within its boundaries for which the effluent limitations required by section 301(b)(1)(A) and section 301(b)(1)(B) are not stringent enough, and to implement any water quality standard applicable to such waters.

Each state then "shall establish for [impaired] waters . . . the total maximum daily load, for those pollutants which the Administrator identifies . . . as suitable for such calculation."[121] A TMDL is a specification of the maximum amount of a particular pollutant that can pass through a waterbody each day without WQS being violated.[122] Such "load shall be established at a level *necessary to implement the applicable water quality standards* with seasonal variations and a margin of safety which takes into account any lack of knowledge..."[123] If EPA does not approve the state's submission, EPA must establish the TMDL.[124] Once the 303(d) list and any TMDLs are approved by the EPA, the state must incorporate the list and TMDLs into its continuing planning process. From a practical standpoint, the establishment of watershed-based or multijurisdictional TMDLs has followed a cooperative approach whereby EPA acts as an intermediary in the implementation process of TMDLs and strengthens states' efforts to implement TMDLs as necessary.

b. A New or Amended TMDL is Required for Long Island Sound Because the 2000 TMDL Expired in 2014, and will not Meet Water Quality Standards

The compliance schedule of the 2000 LIS Nitrogen TMDL expired in August 2014, necessitating the establishment of either amendments to the TMDL or a new TMDL. TMDLs are required when the regulation of point source pollution and other voluntary measures do not result in the attainment of WQS.

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[119] 33 U.S.C. § 1313(b), (c)(3)-(4).
[120] 33 U.S.C. § 1311(b)(1). (Note that POTWs are exempted from BPCT requirements under the CWA and instead must meet federal "primary" and "secondary" treatment standards).
[121] 33 U.S.C. § 1313(d)(1)(C).
[122] 33 U.S.C. § 1313(d)(1)(C).
[123] *Id.* (Emphasis added).
[124] 33 U.S.C. § 1313(d)(2).

As discussed above, even full implementation of the 2000 LIS Nitrogen TMDL will not achieve WQS because the required Phase III and IV nitrogen reductions were not set at a level that was predicted to meet WQS. EPA concluded this in its report approving the TMDL.[125] The TMDL relied on the implementation of non-treatment alternatives to make up for the predicted shortfall DO improvement below WQS. But many of these alternatives were never seriously considered or researched, or are considered to be clearly infeasible, with the exception of nutrient bioextraction. However, even this alternative has not been recommended or implemented on a large scale and is certainly not projected to achieve WQS.

The few remaining reductions required to New York point sources under Phase III cannot reasonably be expected to cure the seasonal hypoxia monitored annually in the Sound. Beyond that, there are no further affirmative reductions to existing nitrogen sources required by the current TMDL. There simply in no reasonable expectation that WQS can be met based on the loads and requirement set forth in the 2000 LIS Nitrogen TMDL.

In addition, new information in the form of better predictive modeling, increased understanding of nitrogen inputs from septic systems, consistent monitoring data, and new scientific projections based on changing climate patterns, each discussed above, suggest that we are even farther from achieving WQS than the TMDL predicted. The 2000 LIS Nitrogen TMDL was prepared to deal with new data. It contemplated future changes to the TMDL and reduction allocations upon advances in monitoring, modeling, research, implementation, water quality criteria, and other factors as new information is acquired. The TMDL specifically included commitments to reevaluate nitrogen reduction targets in 2003 and 2008.[126] However, despite EPA's and the states' knowledge that WQS will not be met, and the significant body of new knowledge and data that is available, no significant reassessment or revision of the adequacy of the TMDL to meet WQS has been performed or is forthcoming.

The 2012 EIP began the process of reevaluating the TMDL, but added no new or substantive reductions to the TMDL, and clearly will not contribute to meeting WQS. These efforts serve only to delay further reductions to nitrogen sources, and are insufficient because there is no reasonable basis to believe that this process will result in meeting WQS. Although a phased approach while gathering more information for a multijurisdictional TMDL is acceptable, EPA "cannot classify its action as an 'interim' or phased approach in order to get around the fact that the current calculations included in the TMDL are insufficient to return the impaired waterways to meeting water quality standards."[127]

We believe that the reassessment and revision process to date, including the EIP is: (1) not in accordance with federal law as reflected in the CWA and the terms of the TMDL itself; (2) arbitrary and capricious in not finding that revision to the current TMDL is appropriate in light of new information, modeling, and science, and the clear inability of the current TMDL to meet WQS; and (3) constitutes an unreasonable delay of required agency action.

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[125] EPA: The Long Island Sound Office, *EPA New England and EPA Region 2 TMDL Review* at 7.
[126] *See* 2000 LIS Nitrogen TMDL at 42-48.
[127] *Minnesota Center for Environmental Advocacy v. U.S. E.P.A.*, No. 03-5450, 2005 U.S. Dist. Lexis 12652, at 14-16 (D. Minn. June 23, 2005) [*quoting*] *Chlorine Chemistry Council v. EPA*, 206 F.3d 1286, 1291 (D.C. Cir. 2000).

c. The Long Island Sound TMDL must be Set at a Level that will Meet Water Quality Standards and must Include Reasonable Assurances that Actions will be Taken to Meet those Water Quality Standards

A threshold requirement of a TMDL is that the loads set will result in achieving WQS.[128] A second key requirement is that the TMDL provide reasonable assurances that it will be implemented.

1. Section 303 of the Clean Water Act and the TMDL Regulations are Clear; TMDLs *Shall* be at a Level Necessary to Implement the Applicable Water Quality Standards

The Clean Water Act plainly states that each state "shall establish for [impaired waters] . . . the total maximum daily load, for those pollutants which the Administrator identifies . . . as suitable for such calculation."[129] There is no question that the states and EPA are required to establish TMDLs when triggered by the CWA.[130]

In addition, such "load *shall be established at a level necessary to implement the applicable water quality standards* with seasonal variations and a margin of safety which takes into account any lack of knowledge…"[131] These requirements apply to both point sources and nonpoint sources of pollution.[132]

As discussed in detail above, WQS will not be met under the previous TMDL because the nitrogen loading requirements in the TMDL were not set at a sufficient level to meet WQS, relied on future amendments to these levels or non-treatment alternatives to meet WQS, and no amendment or implementation of non-treatment alternatives has occurred or can be reasonably expected in the immediate future.

Furthermore, each state "shall have a [management plan]" that is consistent with the Clean Water Act and contains the "total maximum daily load for pollutants" and a provision for "adequate implementation, including schedules of compliance, for revised or new water quality standards."[133]

It must also be noted that the 2000 LIS Nitrogen TMDL incorrectly categorized all stormwater as being "nonpoint source" pollution. It therefore did not distinguish discharges from municipal separate storm sewer systems ("MS4s") from other categories of stormwater runoff. Due to this misclassification, the TMDL includes nitrogen loaded from MS4s as part of the load allocation ("LA") instead of the point source wasteload allocation ("WLA"). The functional difference between the two is that a WLA is directly enforceable though permits, while a LA must be achieved through state action independent of CWA enforcement mechanisms. The next TMDL must fix this issue by distinguishing stormwater loads from nonpoint sources, and by accounting for stormwater in the WLAs.

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[128] 33 U.S.C. § 1313(d)(1)(C).
[129] 33 U.S.C. § 1313(d)(1)(C).
[130] *See Natural Resources Defense Council v. Fox*, 909 F. Supp. 153 (S.D.N.Y. 1995) (EPA must establish TMDLs based on Congress' use of the word "shall" in section 303); *Alaska Center for the Environment v. Reilly*, 762 F. Supp. 1422 (W.D. Wa. 1991) (EPA has a mandatory duty to promulgate TMDLs).
[131] 33 U.S.C. § 1313(d)(1)(C) (Emphasis added).
[132] *Pronsolino v. Nastri*, 291 F.3d 1123, 1139 (9th Cir. 2002).
[133] 33 U.S.C. § 1313(e)(3)(C), (F).

2. TMDLs must Include Reasonable Assurances that Control Measures will Achieve Expected Load Reductions

The goal of the Clean Water Act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[134] Without question, these congressional goals will only be advanced if there are "reasonable assurances" that TMDLs will be implemented to improve water quality. Courts have recognized this principle as well. For example, in Sierra Club v. Hankinson, 939 F. Supp. 872, 873 (N.D. Ga. 1996), the Court stated that to obtain goals of the CWA, EPA must ensure that TMDLs are implemented. In American Canoe Ass'n, Inc. v. EPA, the Court-ordered schedule for the Virginia TMDL case "in no way violates either the letter or the spirit of the CWA. Rather, it ensures that the CWA shall not be reduced to empty formalism."[135]

As early as 1991, EPA has issued guidance requiring that TMDLs include "reasonable assurances" that steps would be taken to meet the TMDLs. "*Guidelines for Water Quality-Based Decisions: the TMDL Process*," were issued in April of 1991 under Martha G. Prothro, Director of the Office of Water Regulations and Standards. The guidelines state in pertinent part:

> When establishing permits for point sources in the watershed, the record should show that in the case of any credit for future nonpoint source reductions, (1) there is reasonable assurance that nonpoint source controls will be implemented and maintained or (2) that nonpoint source reductions are demonstrated through an effective monitoring program. Assurances may include the application or utilization of local ordinances, grant conditions, or other enforcement authorities.[136]

On August 8, 1997, EPA issued guidance entitled, "*New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs)*." In this document, Assistant Administrator Bob Perciasepe states: "It is now time to move towards the next stage of our strategy to achieve water quality standards – to make sure that TMDLs are established for all listed waters, and that the load allocations established by TMDLs are implemented by point and nonpoint sources alike."[137] In this guidance document, EPA states that implementation plans should include "reasonable assurances that the nonpoint source load allocations established in TMDLs (for waters impaired solely or primarily by nonpoint sources) will in fact be achieved. These assurances may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs."[138]

Most importantly, the 2002 Guidelines call for "reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable" where the waters are impaired by both point and nonpoint sources.[139] The 2002 Guidelines go on to state that this "information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to

[134] 33 U.S.C. § 1251(a).
[135] 54 F. Supp. 2d 621, 628 (E.D. Va. 1999); s*ee also, Natural Resources Defense Council, Inc. v Texaco Refining & Mktg, Inc.*, 20 F. Supp. 2d 700, 709 (D. Del. 1998) (Court concluded that the public interest, as revealed by the "spirit and intent" of the Clean Water Act, would best be served by mandating the implementation of a monitoring program for the TMDL).
[136] EPA Guidance, *Guidelines for Water Quality-Based Decisions: the TMDL Process*, EPA 440/4-91-001 (April, 1991) at 6.
[137] Perciasepe, Robert, EPA Memorandum, *New Policies for Establishing and Implementing Total Maximum Daily Loads (TMDLs)* (August 8, 1997) at 1.
[138] *Id.* at 6.
[139] EPA Guidance, *Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992* at 3.

implement water quality standards."[140] The TMDL Review Checklist, attached to the 2002 Guidelines, also lists "Reasonable Assurances: through NPDES permits or if WLAs depend on LAs" as one of the Review Elements for the document.[141]

Having established that reasonable assurances will be required in amendments to the Long Island Sound TMDL or in a new TMDL, it is important to note that voluntary measures alone do not satisfy the reasonable assurance required.

The evidence suggesting that "purely voluntary" plans generally do not work is overwhelming.[142] In fact, the futility of voluntary measures is routinely recognized by courts in the context of a number of environmental statutes. For example, in *Sierra Club v. EPA*, 99 F.3d 1551 (10th Cir. 1996), the Court held that before EPA could redesignate an area from nonattainment to attainment under the Clean Air Act, it must "determine that the improvement in air quality is due to permanent and enforceable reductions in emissions" and not to voluntary compliance measures.[143]

Distrust of voluntary compliance is also evident in cases involving the National Environmental Policy Act ("NEPA"), 42 U.S.C. §§ 4321-4370e. To avoid having to prepare an environmental impact statement ("EIS"), agencies often outline future mitigation measures to be undertaken to lessen the impact of a particular project. To ensure that these proposed mitigation measures actually occur, courts routinely require more than mere voluntary compliance. There must be a guarantee that the proposed mitigation measures will be utilized.[144]

Further, in the context of the Endangered Species Act ("ESA"), 16 U.S.C. §§ 1531-1544 (1973), numerous courts have held "purely voluntary" programs to be inadequate because they offer no assurances that species protection will occur.[145] With regard to the above-mentioned environmental protection laws, the courts have rightly been concerned that purely voluntary measures do not result in appreciable changes in environmental quality and do not reflect the intent of the scope of laws passed to protect and restore our environment. The same principles apply to the Clean Water Act, and specifically to TMDLs.

The 2000 LIS TMDL does not establish a nitrogen load calculation that will meet WQS and does not include sufficient reasonable assurances to satisfy the requirements of the CWA and

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[140] *Id.* at 3.
[141] *Id.* at 5.
[142] *See: Putting the Pieces Together: State Nonpoint Source Enforceable Mechanisms in Context*, ELI Project No. 970302 (June, 2000).
[143] *Id.* at 1557; *see also Environmental Defense Fund v. EPA*, 167 F.3d 641, 656 (D.C. Cir. 1999) [*citing*] (CAA requirement that state implementation plans contain "enforceable control measures.").
[144] *See Cabinet Mountain Wilderness v. Peterson*, 685 F.2d 678 (D. C. Cir.1982) (Forest Service ensured that affirmative mitigation measures would occur); *Sierra Club v. Peterson*, 717 F.2d 1409, 1411 (D.C. Cir. 1983) (Stipulations attached to oil and gas leases were not adequate because while the Department of the Interior could impose conditions, they could not preclude the proposed activity.).
[145] *See Bennett v. Spear*, 520 U.S. 154 (1997) (ESA decisions may not be based on "speculation or surmise"); *Biodiversity Legal Foundation v. Babbitt*, 943 F. Supp. 23 (D.D.C. 1996) (Agency cannot use "promises of proposed future action" as an excuse); (*National Wildlife Federation v. Coleman*, 529 F.2d 359, 374 (5th Cir. 1976) (Reliance on proposed, unenforceable actions insufficient); *Sierra Club v. Marsh*, 816 F.2d 1376 (9th Cir. 1987) (Corps violated ESA by relying on speculation that activities will occur); *Oregon Natural Resources Council v. Daley*, 6 F. Supp. 2d 1139 (D. Or. 1998) (Future, voluntary, and untested habitat measures are inadequate) [*citing*] *Save Our Springs Legal Defense Fund, Inc. v. Babbitt*, Civ No. 96-168-CA (W.D. Tex. 1997) (Voluntary actions provide "no assurances that measures will be carried out."); *Natural Resources Defense Council v. U.S. Dept. of the Interior*, 113 F.3d 1121 (9th Cir.1997) (California's "purely voluntary program" offered "no substantive protection.").

its implementing regulations. The lack of these requirements in the 2000 LIS TMDL and the failure of the states to implement and revise the TMDL in 2003 and 2008 as was required has led us to the current scenario whereby the TMDL expired and the waterbody is not meeting WQS. EPA must therefore amend the 2000 TMDL or establish a new TMDL that will achieve WQS and includes reasonable assurances from the states that the TMDL will be implemented.

d. A Comparative Approach to Multijurisdictional TMDLs: The Chesapeake Bay TMDL

When there are numerous states associated with a waterbody, it makes sense to have all of the states included in the establishment of a TMDL for that waterbody and for EPA to coordinate the effort. With regard to the LIS TMDL, the New England Interstate Water Pollution Control Commission and the Connecticut River Workgroup acknowledge that as "the revised TMDL may include new allocations for the upper basin states, it is important to have their input in the process."[146] A five-state TMDL—or a watershed approach—is advisable and has been successful for other waterbodies wherein numerous states impact and have a stake in the establishment and implementation of a TMDL. One example of this effective cooperative approach is the Chesapeake Bay TMDL (or "the Bay TMDL").

EPA established the Bay TMDL in 2010. The TMDL is comprised of 92 smaller TMDLs for individual tidal segments, which identify pollution reductions from major sources of nitrogen, phosphorous, and sediment across the District of Columbia and large sections of Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia. The Bay TMDL set a 25 percent reduction in nitrogen, 24 percent reduction in phosphorous, and 20 percent reduction in sediment, and required that practices be in place to meet 60 percent of these reductions by 2017 and full restoration of the Bay and its tidal tributaries by 2025.[147] In the four years since the Bay TMDL was established, the Bay states have developed and started implementing Phase I and Phase II Watershed Implementation Plans ("WIPs") with Phase III WIPs due in 2017 that are expected to provide additional details of restoration actions to ensure that the 2025 goals are met.

The Bay TMDL is "unique because of the extensive measures EPA and the jurisdictions have adopted to ensure accountability for reducing pollution and meeting deadlines for progress. The accountability framework includes the WIPs, two-year milestones, EPA's tracking and assessment of restoration progress and, as necessary, specific federal actions if the jurisdictions do not meet their commitments."[148]

During the drafting phase of the Bay TMDL, EPA established an accountability framework in part to "implement the reasonable assurance provisions of the Bay TMDL."[149] As part of this framework, EPA provided for "backstops," should the Bay's jurisdictions fail to meet EPA's expectations in a timely manner.[150] These backstop actions, which were more specifically tailored to states during the drafting of the Phase I WIPs, included:

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[146] NEIWPCC, *An Overview* 2010 at 13.
[147] *See* U.S. E.P.A., Region 3, *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorous and Sediment*, (December 29, 2010) at ES-1.
[148] Fact Sheet, Chesapeake Bay Program, *Chesapeake Bay Total Maximum Daily Load, Driving Actions to Clean Local Water and the Chesapeake Bay*, http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/BayTMDLFactSheet8_26_13.pdf at 2.
[149] U.S. E.P.A., Region 3, Letter to The Honorable L. Preston Bryant, Virginia Secretary of Natural Resources, chair of the Principal's Staff Committee of the Chesapeake Executive Council (December 29, 2009) at 2.
[150] *Id.* at 2.

- Expand NPDES permit coverage to currently unregulated sources;
- Object to NPDES permits and increase program oversight;
- Require net improvement offsets;
- Establish finer scale wasteload and load allocations in the Bay TMDL;
- Require additional reductions of loading from point sources;
- Increase and target federal enforcement and compliance assurance in the watershed;
- Condition or redirect EPA grants; and
- Federal promulgation of local nutrient WQS.[151]

The Bay jurisdictions have now completed their Phase I and Phase II WIPs, and EPA remains committed to take necessary actions if the states demonstrate insufficient WIP implementation, pollution reductions, or fall behind on the 2017 midpoint assessment.[152]

Another important feature of the Chesapeake Bay TMDL is EPA's willingness to continually oversee the state programs through the Chesapeake Bay TMDL Tracking and Accountability System. Progress in meeting cleanup commitments will be tracked on this website so that the Bay partners and public have a transparent means of tracking, accounting, and verifying pollution reductions.

While the Long Island Sound TMDL process has differed from the Chesapeake Bay TMDL process in many ways, some of the tools utilized by EPA in coordinating, establishing, monitoring, and ensuring the success of the Bay TMDL should be applied in amending or reestablishing the LIS TMDL. Specifically, there should be involvement from every state in the watershed in establishing each state's required actions, but EPA should rigorously ensure that these plans are sufficient and provide for specific backstop actions that are within the jurisdiction of the federal government if the state's plans are not sufficient.

e. The Amended or New Long Island Sound TMDL must be Established by a Target Date, Include a Nitrogen Load that will Achieve WQS, and Include Reasonable Assurances of Implementation

TMDLs are the last line of defense, used when permits for point sources and best management practices ("BMPs") for nonpoint sources fail to protect water quality.[153] As such, and as required by the Clean Water Act, the LIS TMDL must be amended (or a new TMDL must be developed) by a target date, established at a level necessary to meet WQS, and include reasonable assurances that it will be implemented for both point and nonpoint sources.

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[151] *Id.* at 4.

[152] EPA lists the following as potential actions it may take if necessary:

- Expanding coverage of NPDES permits to sources that are currently unregulated;
- Increasing federal oversight of state-issued NPDES permits;
- Requiring additional pollution reductions from federally regulated sources;
- Increasing federal enforcement and compliance;
- Prohibiting new or expanded pollution discharges;
- Redirecting EPA grants;
- Revising water quality standards to better protect local and downstream waters; and Discounting nitrogen, phosphorous and sediment reductions progress if jurisdictions cannot verify proper installation and management of controls.
  http://www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/EnsuringResults.html?tab2=5 (November 9, 2014).

[153] *See* 33 U.S.C. § 1313(d)(1); 40 C.F.R. § 130.7(b)(1).

While the particular factors affecting Long Island Sound are unique, EPA should draw on the tools used in the establishment of other multi-state watershed based TMDLs like the Chesapeake Bay TMDL. Progress since the establishment of the LIS TMDL has lagged well beyond the initial timetables set by Connecticut and New York and approved by EPA in 2000. It is well recognized that the TMDL process across the country has lagged since Congress' original goal of eliminating pollutant discharges into navigable waters by 1985, and courts have acknowledged that because TMDLs provide a basis for developing pollution control measures, TMDLs must be developed quickly if they are to serve their intended purpose.[154]

III. EPA should Utilize its Residual Designation Authority to Regulate Stormwater

In addition to amending or establishing a new TMDL, EPA should utilize its Residual Designation Authority ("RDA") to require permits for as much of the total stormwater point source discharge in the Long Island Sound watershed as is feasible.

EPA has jurisdiction over any discharge to the waters of the U.S. through a discernable conveyance. Under the Clean Water Act, EPA or the authorized state agency may designate any such discharge of stormwater as requiring a NPDES permit if it "contributes to a violation of water quality standards."[155] This authority, commonly called the RDA, was expanded in the Phase II Rules regarding stormwater discharges to "include a 'category of discharges within a geographic area' that contributes to the violation of a water quality standard or is a significant contributor of pollutants."[156]

EPA's regulatory notes explain that this broader permitting authority would help facilitate an overarching goal of watershed planning: "In promoting the watershed approach to program administration, EPA believes NPDES general permits can cover a category of discharges within a defined geographic area. Areas can be defined very broadly to include political boundaries (i.e., county), watershed boundaries, or State or Tribal land."[157]

Considering the well-documented contributions of nitrogen to the Sound from stormwater that is conveyed through MS4s, the disproportionately large load of nitrogen from stormwater runoff in the northern watershed states, and the growing knowledge of the correlation between impervious surface cover and failing WQS, it is clear that stormwater does indeed cause or contribute to the violation of WQS in Long Island Sound. We specifically request that EPA and the designated states in the Long Island Sound watershed examine the impact that nitrogen from currently unregulated categorical sources of stormwater has on the failure of the Sound to attain WQS for DO. With regard to stormwater discharges from commercial, industrial and institution sites (CII), Region 1 already stated that it "intends to evaluate individual watersheds, focusing on the nature of the impairment and the extent to which stormwater discharges from CII sites are contributing to such impairment, to determine whether and the extent to which exercise of RDA

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[154] 33 U.S.C. § 1313(d)(1)(C); *see also Friends of Wild Swan v. U.S. E.P.A.*, 74 Fed. Appx. 718, 722-724 (9th Cir. 2003).
[155] 33 U.S.C. § 1342(p)(2)(E).
[156] *In re Stormwater NPDES Petition*, 910 A.2d 824 (Vt. 2006) at 827-828, [*citing*] 40 C.F.R. 122.26(a)(9)(i)(D).
[157] *National Pollutant Discharge Elimination System: Regulations for Revision of the Water Pollution Control Program Addressing Storm Water Discharges: Final Rule*, 64 Fed. Reg. 68,721, 68,736 (Dec. 8, 1999) (codified at 40 C.F.R. 9, 122, 123, 124); *see also, In re Stormwater NDPES Petition*, 910 A.2d 824 (Vt. 2006).

is appropriate."[158] Many currently unregulated sources of stormwater remain impediments to the restoration of Long Island Sound and EPA and the states should use RDA to address this.

IV. **If the Long Island Sound TMDL is not Amended, or a New TMDL is not Established, EPA must Move Forward with Modifying Permits to Comply with Lower Water Quality Based Effluent Limitations so that they do not Violate Water Quality Standards**

a. NPDES Permits for Point Sources in the Long Island Sound Watershed are Required to include Water Quality Based Effluent Limitations Sufficient to Meet Water Quality Standards

An NPDES permit is required for any discharge of a pollutant from a point source to any navigable water of the United States.[159] First, the permittee must comply with any technology-based effluent limitations ("TBELs"), which are limitations based on the available technology for reducing the pollutant.[160]

When those technologies are not sufficient to control pollution and meet WQS, states are required to take action, and permittees must then comply with more stringent water quality-based effluent limitations ("WQBELs") whenever "necessary to meet water quality standards, treatment standards, or schedules of compliance, established pursuant to any State law or regulations."[161] WQS establish the desired condition of a waterway and supplement effluent limitations "so that numerous point sources, despite individual compliance with effluent limitations, may be further regulated to prevent water quality from falling below acceptable levels."[162]

Because both New York and Connecticut have listed Long Island Sound as impaired for not meeting WQS, NPDES permits issued within the region must include WQBELs that will achieve WQS.

b. The Allocations Established in the 2000 Long Island Sound TMDL will not Achieve Water Quality Standards and the Water Quality Based Effluent Limitations Used in NPDES Permits to Date are Insufficient

As we have stated, there is no total loading allocation for nitrogen established by the 2000 LIS TMDL that will meet WQS.

The regulations that establish requirements for establishing WQBELs state that these WQBELS must be set at levels necessary to achieve WQS.[163] Indeed, the requirement to meet WQS is identified as one of the Clean Water Act's central objectives.[164] To be lawful, WQBELs

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[158] U.S. E.P.A., Region 1, Letter to Odefy, Kilian and Devine in Response to Petition for Determination that Stormwater Discharges Contribute to Water Quality Standard Violations Throughout Region 1 (March 11, 2014) at 1.
[159] 33 U.S.C. § 1311(a); 33 U.S.C. § 1342.
[160] 33 U.S.C. § 1311(b)(1)(A).
[161] 33 U.S.C. § 1311(b)(1)(C).
[162] *EPA v. California ex. Rel. State Water Resources Control Board*, 426 U.S. 200, 205, n. 12 (1976); *see also* 33 U.S.C. § 1313.
[163] 40 C.F.R. § 122.44(d).
[164] *Arkansas v. Oklahoma*, 503 U.S. 91, 106 (1992), [*citing*] 33 U.S.C. § 1251(a).

used in NPDES permits must be consistent with the requirements of Section 301(b)(1)(C) of the Clean Water Act and the regulations at 40 C.F.R. § 122.44(d)(1).

This means that, even if it were fully implemented, the 2000 LIS TMDL will continue to be impaired for DO. NPDES permits in Connecticut and New York have been issued with WQBELs that are based on the WLAs in the TMDL and therefore will not achieve WQS. For this reason, EPA must either: (a) develop a new or revised TMDL which will meet WQS, as discussed in Section I; or (b) modify each permit to contain a WQBEL that will meet WQS, in order to come into compliance with the Clean Water Act.

c. Without an Amended or New TMDL within a Reasonable Timeframe, EPA must Modify NPDES Permits to Require More Stringent WQBELs

The effective implementation of a NDPES permitting program in the Long Island Sound watershed cannot be stalled if an amended or new TMDL is not established (or if that process takes too long). Since 1973, "EPA regulations have provided that an NPDES permit *shall not be issued* '[w]hen the imposition of conditions cannot ensure compliance with the applicable water quality requirements of all affected states.'"[165]

If an amended or new LIS TMDL is not established, EPA must move the program forward by modifying permits to more stringent WQBELs than currently required by the TMDL. The Clean Water Act and regulations provide the procedures for such modifications where EPA finds that a change is warranted.[166]

EPA has utilized this authority effectively. For example, in *Upper Blackstone Water Pollution Abatement District v. EPA*, 690 F.3d 9 (1st Cir. 2012), EPA determined that efforts being made by the Upper Blackstone Water Pollution Abatement District ("District") under its NPDES permit were not sufficient to meet WQS; EPA therefore issued a new NPDES permit for the District that required more stringent levels of control of its nitrogen, phosphorous, and aluminum.[167] EPA determined that a seasonal reduction to no more than 5.0 mg/L concentration of nitrogen was required to achieve WQS and that there was no realistic likelihood of meeting WQS with a less stringent nitrogen limit (the previous permit had not included nitrogen limits but discharges of 8.0 – 10.1 mg/L were expected with future controls).[168] With regard to phosphorous, EPA found that the old permit's 0.75 mg/L was inadequate to ensure WQS as they related to controlling eutrophication.[169]

The District petitioned for a review of the permit with the Environmental Appeals Board claiming, among other things, that EPA's decision to tighten the nitrogen and phosphorous limits in the Permit was not reasonable because the District had not yet completed its facility upgrades and the completion of a new computer model of the Blackstone River (then under development by the District), and that EPA did not have enough information on nutrient impairment in the Narragansett Bay.[170] EPA had determined that even with the fully completed upgrades, the

[165] *Arkansas v. Oklahoma*, 503 U.S. 91, 105, 112 (1992); 40 C.F.R. § 122.4(d).
[166] 33 U.S.C. § 1342(a)(4), (b)(1)(C); 40 C.F.R. § 122.62(a) (2), 124.5.
[167] *Upper Blackstone Water Pollution Abatement District v. EPA*, 690 F.3d 9 (1st Cir. 2012).
[168] *Id.* at 17-20.
[169] *Id.*
[170] *Id.* at 18-19.

District's discharge would *still* "cause, have the reasonable potential to cause, or contribute to a violation of water quality standards."[171]

The First Circuit held that EPA did not err by issuing the new permit without waiting for additional information.[172] The Court stated that "neither the CWA nor EPA regulations permit the EPA to delay issuance of a new permit indefinitely until better science can be developed, even when there is uncertainty in existing data." [173] Indeed,

> In almost every case, more data can be collected, models further calibrated to match real world conditions; the hope or anticipation that better science will materialize is always present, to some degree, in the context of science-based agency decision making. Congress was aware of this when it nonetheless set a firm deadline for issuing new permits.[174]

The scenario in the Upper Blackstone case is comparable to the status of NPDES permits in Long Island Sound. Even though the 2000 LIS TMDL is currently being reevaluated by the Long Island Sound Study Management Committee and the five watershed states, there is no reasonable likelihood that the limits set in current Long Island Sound watershed NPDES permits will meet WQS. Therefore, if an amended or new TMDL is not established for Long Island Sound in a timely manner, EPA must update permits to bring them into compliance without the benefit of a true TMDL calculation and associated WLA for nitrogen, or a plan that adequately accounts for the nitrogen loaded to the Sound from other sources.

d. The 2000 TMDL Cannot Act as a Shield to Meeting Water Quality Standards

The overarching goal of the CWA is to achieve WQS. When WLAs included in a TMDL are insufficient to meet WQS, as they are here, NPDES permits must be given stronger WQBELS that are sufficient to meet WQS.

TMDLs are "primarily informational tools that allow the states to proceed from the identification of waters requiring additional planning to the required plans."[175] In fact, the development "of TMDLs … is not a necessary prerequisite to the adoption or enforcement of water quality standards."[176]

The 2000 LIS TMDL does not include a calculation of a total load of nitrogen that Long Island Sound can receive and still meet WQS, and even if it were to be fully implemented, will not achieve WQS. The 2000 LIS TMDL, therefore, cannot act as a shield to EPA and the states' obligation to abide by the Clean Water Act and its implementing regulations and to set the WQBELs in NPDES permits at levels that will achieve WQS.

e. In the Absence of a New TMDL, Permits must Require WQBELs Equal to the Limits of Technology, and Require Other "Net Zero" Offsets so as not to Contribute to the Violation of Water Quality Standards

We know that if the 2000 LIS TMDL is left as it stands, WQS in Long Island Sound will not be achieved. As explained above, in order for NPDES permits in the region to comply with

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171 *Id.* [*citing*] 40 C.F.R. 122.44(d)(1)(i).
172 *Id.* at 21.
173 *Id.* at 22.
174 *Upper Blackstone Water Pollution Abatement Dist. V. U.S. E.P.A.*, 690 F.3d 9, 15 (1st Cir. 2012) *cert. denied*, 133 S. Ct. 2382 (2013).
175 *Pronsolino v. Nastri*¸ 291 F.3d 1123, 1129 (9th Cir. 2002); *see also Alaska Center for the Environment v. Browner*¸ 20 F.3d 981, 984-985 (9th Cir. 1994).
176 43 Fed. Reg. 60,662, 60,665 (Dec.28, 1978).

the Clean Water Act, they must include new lower WQBELs than currently required. Since it has been shown that the reduction of nitrogen from WWTPs alone is insufficient to meet WQS, the permits' new WQBELs must be set at a level that will have a "net zero" discharge. In order to achieve a net zero discharge, WWTPs would be required to upgrade their nitrogen removal processes to the "limits of technology" and take other significant actions to mitigate their remaining nitrogen discharge.[177] While this approach has been taken by EPA before,[178] this is not a desirable outcome for the region, or even a feasible means of meeting WQS. It is, however, what would be required if the 2000 LIS TMDL is not amended or reestablished with a nitrogen load that will achieve WQS and the inclusion of requirements on other sources to do their part in eliminating the remaining load.

V. <u>Prayer for Relief</u>

In summary, the current LIS Nitrogen TMDL does not establish a load for nitrogen that will achieve WQS. While revisions were required in 2003 and 2008, those are just getting under way and are not being done in a manner that will achieve required nitrogen reductions. Thus, EPA must issue a new or revised TMDL that will require additional reductions throughout the watershed to achieve WQS. The alternative is that individual NPDES permits for sewage treatment plants will have to achieve limits of technology plus offsets to ensure no net impact, which is expensive and will not ultimately bring Long Island Sound back to health.

For these reasons, and all of the reasons stated in this Petition, CFE/Save the Sound and the undersigned organizations implore EPA[179] to take the following actions:

1. Organize and facilitate the establishment of a *Memorandum of Understanding* by June 15, 2015 between EPA and the five watershed states to commit to: (1) amending or establishing a new Long Island Sound TMDL by June 15, 2016; and (2) establishing implementation plans and an accountability schedule that will ensure that WQS in Long Island Sound will be achieved by December 31, 2025.
2. Amend the current TMDL or establish a new TMDL for Long Island Sound to meet WQS for DO, that includes the following:[180]
    a. An identification of local sources / loads of nitrogen and their localized effects within the five-state watershed;
    b. Controls that will lead to attainment of WQS including controls on:
        i. Point Sources;
        ii. Septic systems;
        iii. Stormwater;
        iv. Agriculture and turf; and

[177] *See* U.S. E.P.A. Region III, Letter to The Honorable L. Preston Bryant, Virginia Secretary of Natural Resources, chair of the Principal's Staff Committee of the Chesapeake Executive Council (December 29, 2009) at 9-10, [*referencing*] 40 C.F.R. 122.44(d)(1)(vii).
[178] *See*, *EPA Proposes to Modify a NDPES Permit to Discharge Pollutants Pursuant to the CWA, West Boise Wastewater Treatment Facility, City of Boise, Idaho*, ID0023981-091312, 2012.
[179] Indeed the LIS TMDL recognizes that EPA will have to take the lead on future interstate WLA/LA needs. *See* 2000 LIS Nitrogen TMDL at 33.
[180] This list is not meant to be exhaustive of all the items that should be included in a revised or amended LIS TMDL, rather a starting point for elements that must be included in order to create an effective LIS TMDL.

v. Bioextraction;

c. A series of 5 and 10 year target reduction levels for implementation with midpoint assessments;

d. Reasonable Assurances that actions will be taken to achieve implementation and the maintenance of the TMDL;

e. Enforceable backstops if the states do not comply with meeting commitments in a timely manner;

f. An identification of existing and potential funding sources;

g. An explanation of how trading may be utilized if and when appropriate; and

h. A clear requirement for the use of offsets to account for load increases due to growth.

3. Establish technical guidelines explaining the most effective methods available to reduce nitrogen loads in the Long Island Sound region and update those guidelines as new information becomes available.

4. Utilize Residual Designation Authority for currently non-regulated sources of stormwater.

5. In the event that the 2000 LIS TMDL is not amended or reissued within a reasonable period of time, modify NPDES permits within Long Island Sound to comply with the Clean Water Act and Regulations.

6. Take any and all other actions available to EPA to require the Long Island Sound states to come into compliance with the Clean Water Act and Regulations.

The following are more specific measures that should be included in the TMDL, but can also be implemented immediately with EPA's existing authority. While the revised TMDL is ultimately necessary to have a long-term enforceable plan to achieve WQS, many of the proposed measures are also necessary in the short term to make progress and prevent backsliding.

1. Require, upon renewal, that MS4 permits mandate a substantial reduction of nitrogen from urbanized and sewered portions of the Long Island Sound watershed during the next five-year permit period. We urge EPA to mandate the implementation of restoration efforts for at least ten percent of the focus areas' impervious surface area.

2. Establish that a discharge of sewage from groundwater via a hydrological connection to surface water is a direct discharge to a water of the United States subject to regulation by the EPA, and enforcement under the Clean Water Act.

3. Seek cooperation from Connecticut and New York to delegate regulatory authority for nitrogen control over on-site sewage disposal systems, including septic systems and cesspools, to the state agency with jurisdiction over CWA implementation and enforcement.

4. Establish cost-effective nitrogen reduction mandates for Massachusetts, New Hampshire, and Vermont sewage treatment plants that do not currently employ nitrogen removal technology, and contribute significant amounts of nitrogen to Long Island Sound. At the

same time, continue with additional cost-effective opportunities in Connecticut and New York. EPA can directly incorporate these nitrogen discharge limits into its NPDES permits in Massachusetts and New Hampshire, where EPA directly administers Clean Water Act permits.

5. Focus its enforcement efforts, in collaboration with Connecticut and New York, on the best strategies for reducing high levels of inflow and infiltration of stormwater, which cause sewer overflows and nitrogen pollution in many coastal communities.
6. Focus its enforcement efforts in collaboration with Connecticut, New York, and Massachusetts on combined sewer overflows ("CSO") reduction strategies, mandating aggressive five-year actionable reduction targets that incorporate cost-effective, green infrastructure-related, flow reduction opportunities. Consider a uniform, long-term CSO reduction target for all of the municipalities within the Long Island Sound watershed with documented CSO problems.
7. Direct Connecticut and New York to develop updated Section 208 plans for Long Island Sound by June 2016, with support from EPA. Such plans should identify:
    a. local nonpoint source contributions;
    b. untreated point source contributions;
    c. associated loads of nitrogen;
    d. known localized impacts; and
    e. western Sound hypoxia impacts.

We appreciate the efforts EPA has made with the Long Island Sound states and stakeholders to date, and we are hopeful that EPA will promptly consider and implement the actions that we have requested. As an environmental organization with members who use and enjoy Long Island Sound and have a sincere interest in the restoration of this waterbody, CFE/Save the Sound and its allies will pursue all legal opportunities available to facilitate the establishment of a new or amended LIS TMDL (and the implementation thereof) to ensure the restoration of Long Island Sound. We would appreciate a written response to this Request within 90 days and welcome an opportunity to meet to further discuss the issues raised in this Request.

Dated: February 09, 2015 Respectfully submitted,

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Hypoxia in Long Island Sound: Facts and Comparisons

Johan C. Varekamp, E&ES, Wesleyan University and CFE/STS

Many estuaries in the world show evidence of hypoxia over the last 100 years, ranging from the Chesapeake Bay and the Mississippi Delta coast line to the Baltic Sea and parts of the Mediterranean and Asian marginal seas (Figure 1).

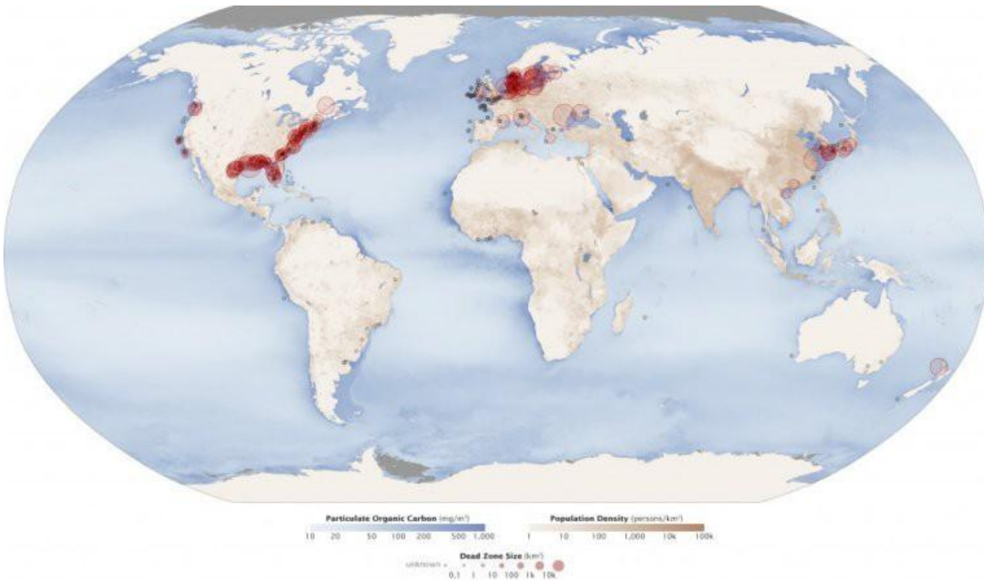

Figure 1. Distribution of dead zones on the globe today.

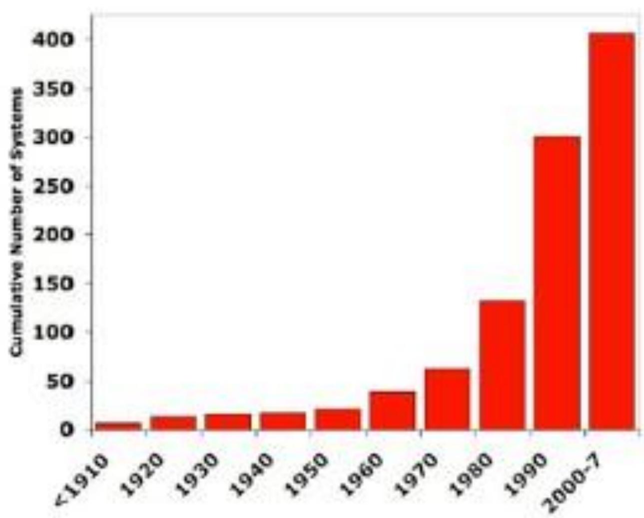

Figure 2. Increase in hypoxic waters in the world over the last 100 years. Shown as cumulative numbers of hypoxic zones.

The number of dead zones and their surface area has increased greatly over the last few decades (Figure 2).

What are hypoxic zones and how do they form?

Water can hold a limited amount of dissolved oxygen (DO) gas, which is critical for many animals such as fish, lobsters, shellfish, and squid. Fresh water can hold more oxygen than seawater, and cold water can hold much more oxygen than warm water (Figure 3). Usually, waters with less than 3 mg/L O2 are not conducive to most animals, especially active swimmers. These waters are considered hypoxic. Waters with less than 1 mg/L O2 are "anoxic", and are only suitable for bacteria and certain creatures that live in the deep oceans.

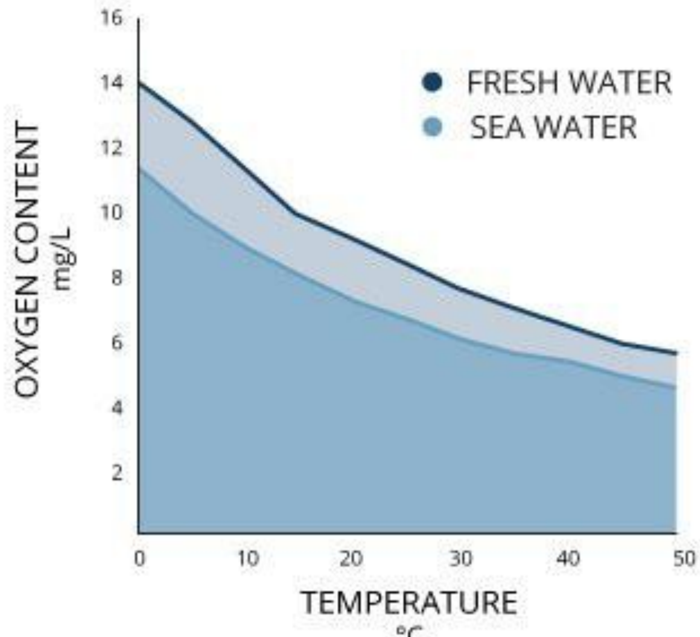

Figure 3. Solubility (in mg O2/L water) of O2 in sea water and fresh water.

The oxygen in the water is either derived from the atmosphere (~20% by volume is O2) or through photosynthesis in the upper water layer, where light can penetrate, simplified as follows:

CO2 + H2O + N + P + light ==> C(org) + O2 (reaction 1)

The N and P (dissolved nitrogen and phosphorus) are the essential nutrients (fertilizer) for photosynthesis. The C---organic is the "tissue" of unicellular algae (such as diatoms) or plants, and will ultimately make its way to the bottom. In the lower water column and on the sea floor, the C(org) is metabolized in a reverse mode from reaction 1:

C(org) + O2 ==> CO2 + H2O (reaction 2)

The bottom waters are usually too dark for photosynthesis. The oxidation of the C(org) also releases the essential nutrients N and P, fuelling a new cycle of photosynthesis according to reaction 1 once the bottom waters mix again with the surface waters. Reaction 2 is the main O2 consumption reaction in natural waters, although the activity of marine animals such as fish, lobsters, and sea urchins also consumes O2 (just like people and animals do on land). See Figure 4 for illustration.

The main mechanisms that explain how water becomes depleted in oxygen thus are:

- Higher salinity and warmer water have less dissolved O2
- More abundant C(org) leads to higher O2 consumption rates through enhanced oxidation (reaction 2)

Surface water remains well oxygenated because they can obtain O_2 from the atmosphere and through photosynthesis. Bottom water in density stratified estuaries cannot replace its oxygen as quickly and becomes anoxic in many estuaries. When bottom waters become hypoxic or anoxic, we can say that the rate of oxygen consumption there is higher than the rate of oxygen supply.

The rate of O2 consumption is largely determined by reaction 2, while the salinity and temperature of the water determine the original amount of O_2 in that water layer. The rate of O2 supply to the bottom water relates to the rate of exchange with the surface waters, which tend to be well oxygenated generally (see above). If waters in an estuary are well mixed through currents and winds, there is usually no O_2 problem. As an example, the 'dead waters' in the Mississippi Delta were totally re---oxygenated during Hurricane Katrina, and fall storms mix the waters in Long Island Sound and end summer hypoxia.

Once the bottom waters are devoid of oxygen, the C(org) is no longer oxidized according to reaction 2 (no O2 left), and more of the C(org) is deposited in the bottom muds. Alternative reactions then may occur such as C(org) reactions with dissolved sulfate in seawater, creating H2S gas with the smell of rotten eggs. Accumulations of this toxic gas in bottom waters make the environment even less hospitable to higher life forms (a condition called euxinic), whereas the gas will again consume O2 during re---oxidation to sulfate if it moves to shallower waters.

Most dead zones occur during the summer, and from the above we see why: in the spring and summer, snowmelt water and rainfall are most intense, leading to a layer of less salty water at the surface of many coastal embayments. This less dense, fresher water layer does not mix as easily with the colder, dense saline bottom waters, effectively forming a cap that prevents vertical mixing, thus impeding supply of O2 to the bottom waters. The sun warms the surface waters, and these warmer surface waters are also less dense than the colder bottom waters, providing another factor to isolate the bottom waters from the sources of oxygen (atmosphere and shallow water). So this leads to two factors that set the stage for seasonal hypoxia (usually mid to late summer):

- Stratification of the water column due to fresh water run---off and seasonal high temperatures in the surface waters. We thus expect natural conditions in many estuaries that may lead to hypoxia: poor ventilation of bottom waters as a result of stratification of the waters
- With the higher summer temperatures at the surface and more sunlight, more photosynthesis will occur, producing more C(org). This provides the fuel for the O2 consumption according to reaction 2, once the material reaches the deeper waters.

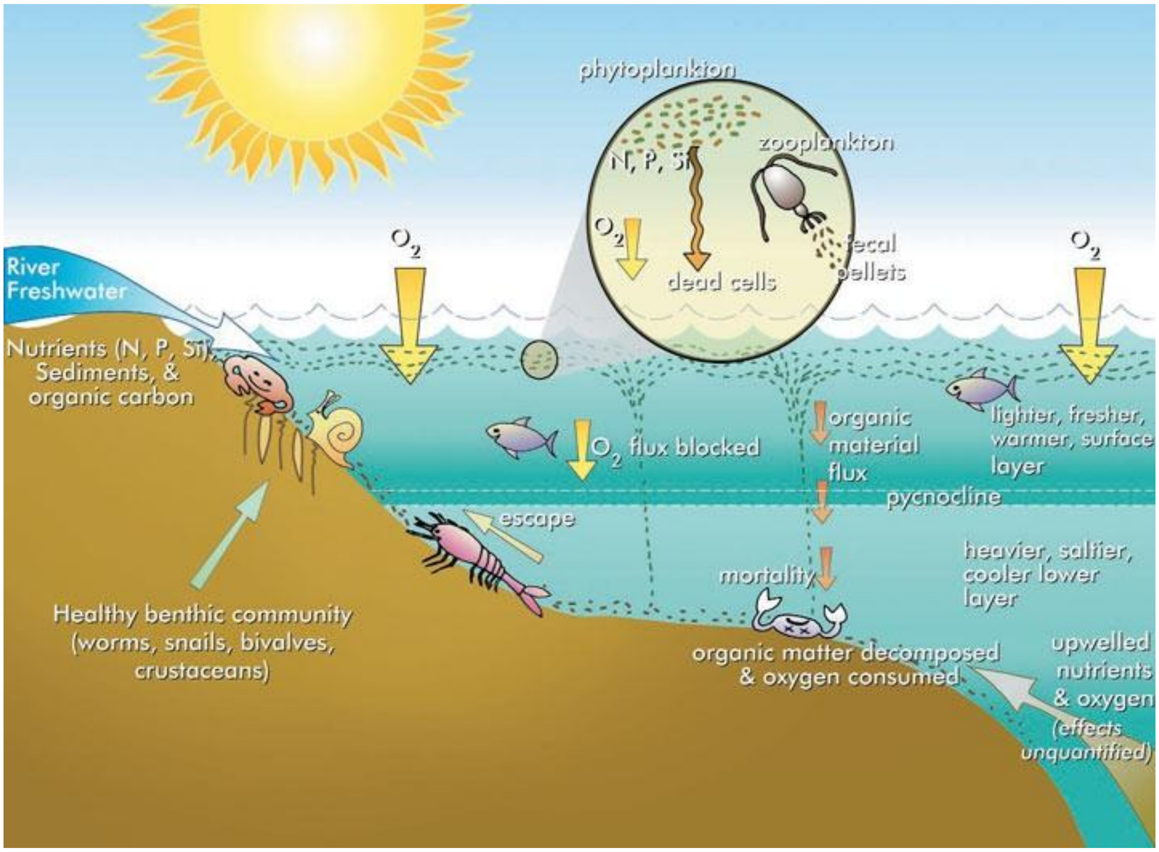

Figure 4. Simplified cross section through an estuary with potential dead zone bottom waters.

Some estuaries had periods of hypoxia during geological history, through combinations of changing climate and productivity by algae, and layers of C(org)--- rich muds, so---called sapropels (black mud layers), that were deposited.

The main cause of the modern dead zones is the run---off from land, carrying excess N (and P) from fertilizer and/or waste water treatment plants, as well as dead organic matter, into the coastal oceans. In heavily urbanized regions, the outflow of sewage treatment plants is the main input of nitrogen, while in more agricultural regions fertilizers are the main input. These nutrients fuel the growth of algae, and dead C(org) is oxidized once it reaches the deeper water column. The extent of the dead zone can be along shore or lateral from the river outflow, as seen in the Gulf of Mexico.

The influence of climate change on the dead zones is many fold: increasing temperatures lead to warmer waters (less O2 in them), enhanced stratification, increased productivity if sufficient nutrients are available (more C(org)), and more intense respiration and oxidation of C(org). More rainfall would lead to enhanced influx of nutrient---rich waters and increased stratification as well. More stormy weather, on the other hand, would resupply the deep water with O2 through more efficient mixing.

Looking at Long Island Sound, the main hypoxic areas are found in the narrow western section, so it appears that O2 re---supply is poor in this sluggishly--- ventilated part of the Sound. Then again, this is also a very populous region with many sewage treatment plants, providing a large influx of nutrients (with the waste water flux from NY city similar in size to the water flow in the

Housatonic River). Ultimately, it is important to realize that neither Long Island Sound nor Chesapeake Bay were hypoxic in the recent past (pre---1800). It is especially significant that neither was suffering from hypoxia during the warm period about 1000 years ago (Mediaeval Warm Period), a 200 year epoch considered almost as warm as today.

An ongoing study of relative levels of a specific stable isotope of carbon ("^{13}C") present in seashells (calcium carbonate) in many different sediment layers beneath the Sound shows that oxygen was relatively abundant in the bottom-waters of the Long Island Sound prior to the industrial era and that the current hypoxic condition is likely a result of human activity (Figure 5).

A lower relative abundance of this ^{13}C isotope (carbon isotope ratio) correlates with lower levels of oxygenation in the water column in the modern environment. By radiocarbon-dating the sediment layers, scientists have been able to reliably map the relative abundance of this isotope ratio in the sediment since 800 AD. This ratio remained unchanged from 800 AD until roughly 1800 AD, including throughout the "Medieval Warm Period" ("MWP"). Starting around 1800 AD, this isotope ratio became drastically lower, reflecting the processes that led to lower oxygen levels in the Sound's waters. This change has progressed until today, in direct correlation with the increase in nutrient pollution in the Sound's watershed.

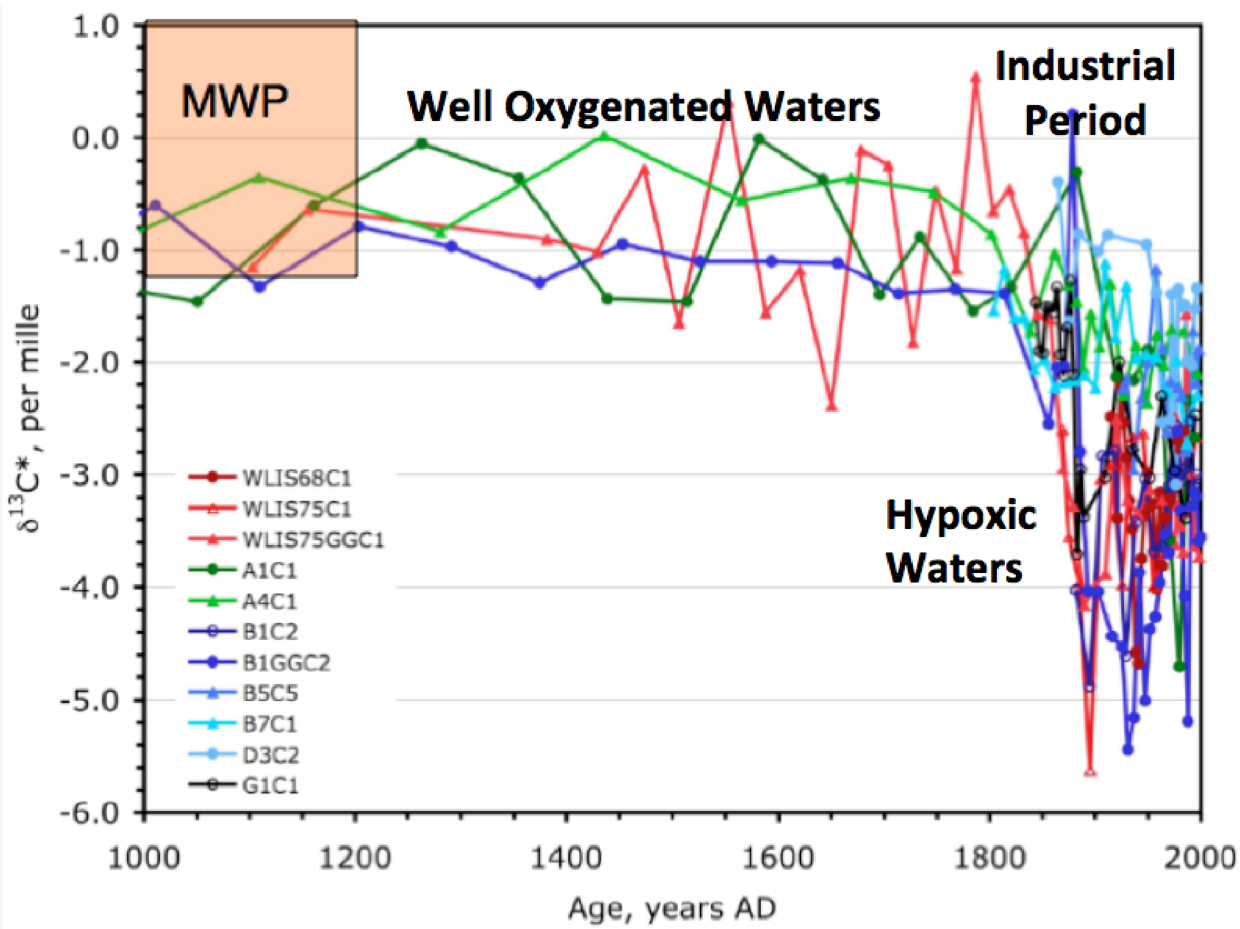

Figure 5. A graph of the relative level of the ^{13}C isotope over time. The y-axis is the ^{13}C isotope ratio in shells from bottom dwelling Long Island Sound organisms, and the x-axis is a

timeline from 1000 AD to the present. Each colored line represents measurements on samples from a different sediment core from beneath the Sound. The ratio of this isotope dropped markedly in many of these samples during the industrial period. The stable carbon isotope ratio in calcium carbonate shells is a proxy for the level of dissolved oxygen in the bottom waters of the Sound. It shows that from 1800AD on, the oxygen balance in the Sound changed dramatically, which goes hand in hand with increases in the levels of nutrients and organic carbon loaded to the Sound, primarily from human waste and changes in land use. These nutrient flows overwhelmed the equilibrium in the Sound, leading to the seasonal hypoxia cycle that we see today.

This data lends some of the greatest scientific support to the theory that hypoxia in the Sound is a product of human impact and not something that is part of the natural condition of the Sound. Hypoxic zones form when the rate of oxygen consumption exceeds the rate of oxygen resupply to bottom waters. The increase of algal matter (Corg) because of N fertilization drives the oxygen consumption, while climate change may enhance the water stratification of the estuaries, leading to a reduced O2 supply as well. The core studies show that hypoxia is not a natural condition of the Sound.