CONSERVATION COMMISSION

MEMORANDUM

TO: DEP Northeast Region Project Reviewer

CC: Ben Stevens, Trask Development/The Fields at Sherborn LLC
Alan Rubenstein, Sherborn ZBA
David Williams, Sherborn Town Administrator

FROM: Sherborn Conservation Commission
Steve Gaskin, Chair; Allary Braitsch, Agent

DATE: March 11, 2016

RE: **The Fields at Sherborn (DEP File No. 283-0366) - Overcoming the Presumption That Title 5 Compliance Protects Interests of the Wetlands Protection Act: Follow-up to 1/12/2016 Memo**

Summary

The state wetland regulation 310 CMR 10.03(3) states that "credible evidence from a competent source" can overcome the presumption that a sewage disposal or septic system constructed in compliance with Title 5 protects the interests of the Wetlands Protection Act ("WPA" or "Act"). While again noting that, as of the writing of this memo, the project does not have an approved Title 5 wastewater discharge permit, were one to be issued for the project as currently proposed, the Commission's stance is that it would not protect the interests of the Act related to protection of water supplies, prevention of pollution, protection of wildlife habitat and flood control.

The ability to overcome the presumption in the WPA is intended to cover projects where, though Title 5 regulations are met, there is still a likelihood of significant adverse impacts to wetland resources. Specifically, a septic system may be deemed Title 5 compliant by local boards of health, and may meet stormwater and other septic setback standards in the WPA, yet still adversely affect wetland resources. Golet et al. (1993), in extensively documenting the function and values of red maple/forested swamps in New England—the predominant wetland type adjacent to the project site—characterize the concern this way: "Septic systems sited close to wet-lands in soils with excessively high permeability also represent a significant water-quality threat because of the speed with which effluent can flow toward the wetland, even if the system is properly maintained" (p. 121).

The work presented in this memo argues that the current septic system design (as of December 11, 2015) will adversely affect the wetlands adjacent to the project site. This is true even though the applicant ("Applicant") states that the system meets all applicable Title 5 requirements. This memo is based on "credible evidence" from multiple "competent sources" and, though it necessarily includes some simplifying assumptions (mostly standard), even a conservative analysis has shown that the large magnitude of nitrate loadings (and other septic-related contaminants) will have adverse impacts on the functioning of the adjacent wetlands. In turn, the subsequent functioning of these wetlands will significantly lessen their ability to contribute to the interests of the Act related to protection of water supplies and wildlife habitat as well as pollution prevention and possibly flood control.

In summary:

• Though the septic soil absorption system (SAS or leachfields) lies outside the wetland buffer zone, the effluent from the system is predicted to primarily migrate into the wetlands adjacent to the project site. This is based on analysis of groundwater gradients and soil characteristics (sandy) by both the Applicant's engineer and other hydrologists. The closest wetland area has been estimated by the Applicant to be 27,825 square feet (0.64 acre) in size and has been labeled "impacted wetland" in its submittal to the Sherborn Board of Health (BOH) dated 12/11/2015. This wetland area is about 200 feet downgradient from the leachfields. A larger wetland area, "Dirty Meadow Swamp" (about 13 acres) is also located downgradient of the leachfields and is expected to receive the septic effluent both via ground water and surface water from a stream discharging from the "impacted wetland". This Swamp lies partially inside of the neighboring town of Holliston's Zone II Wellhead Protection Area.

• The septic effluent eventually entering the wetlands is estimated to contain about 400 kg nitrate annually (along with other septic system related contaminants). This is based on a proposed septic system producing 8,360 gpd of effluent with nitrate concentrations of 35 mg/L at the point of discharge (and standard assumptions as discussed below).

• The resulting estimate for nitrate loadings annually to the "impacted wetland" area is about 1,600 kg/ha/yr (Nobis and Applicant). Some of this loading will be borne by the larger Dirty Meadow Swamp over time via both surface and ground water. An end point calculation by Nobis is an annual loading of about 70 kg/ha/yr if averaged over a larger wetland area of about 13 acres, which is inclusive of the "impacted wetland" and the larger Dirty Meadow Swamp. Though of less importance for wetland impacts, the estimated nitrate concentration levels range from 31 mg/L at the edge of "impacted wetland" to about 23 mg/L at the edge of Dirty Meadow Swamp using a Title 5 estimation approach (Nobis). Another estimation of the nitrate levels is a concentration approximation of 10 mg/L in the Swamp if the effluent is diluted by stormwater recharge from the entire 17.55 acre site (Nobis). (The Commission recognizes the approximate nature of these estimations and the uncertainties of some input parameters.)

• These annual mass nitrate loadings exceed both the "critical loading" thresholds for freshwater wetlands of about 35 kgN/ha/yr (Bobbink et al., 2003) as researched by the Commission and noted by others, and the annual "uptake capacity" of 200-800 kgN/ha/yr (or 20-80 g/m2/yr) noted by the Applicant in his submittal to the Sherborn BOH of 12/11/2015 (though there are significant questions about this range that are discussed in Attachment A).

• The nitrate "uptake capacity" of wetlands is generally significantly higher than critical loading levels. This is due largely to uptake capacity being a calculated physical limitation assuming a properly functioning ecology. However, the literature says that at loading levels below uptake capacity but above critical loading levels, the ecosystem tends to cease to function in the very ways needed to sustain calculated uptake capacities over time. Therefore, as also noted in the literature, uptake capacities may not be sustainable over time - an important issue in this case given the large loading and that this loading will very likely exceed the uptake capacity.

The following are limitations the Commission finds with the use of uptake capacity as the best way to measure protection of the interests of the WPA:

1. Uptake capacity does not address the impact of likely wetland ecosystem changes to other interests of the Act such as wildlife habitat protection.
2. Given the range of potential long-term ecological changes, use of the uptake capacity calculation neglects the long term effects of continual loading and uptake on ecology, which reduces uptake capacity over time.
3. Reduced uptake capacity over time will lead to much more, and clearly adverse, impacts to the wetlands over time.
4. Uptake capacity does not address the uncertain impact of other septic related contaminants, which have been less studied but have been labeled as "contaminants of emerging concern" (such as in Schaider et al. (2013)) - an issue also for critical loading but less so given the lower levels.

• Despite the uncertainties and approximations, the magnitude of the proposed septic system effluent together with the site conditions is expected to lead to an exceedance of the critical loading level of the adjacent wetlands. Based on the scientific literature and experts detailed below—**and of principal concern to the Commission—exceeding critical loading levels will lead to vegetative, water quality and biological activity changes that will, in the short term and over time, significantly and adversely impact the wetland resource's ability to contribute to all of the following interests of the Act: protection of water supplies (public and private water supply as well as ground water supply), prevention of pollution, protection of wildlife habitat and flood control.** Furthermore, the Commission contends that uptake capacity is not the appropriate measure to use for sufficiently protecting the wetlands.

• Wetland impacts on this site are of particular concern because the property's wetlands are part of an important wetland system:

- with regard to ground and surface water and water quality:
    - the local residential reliance on private wells for drinking water and the quality and quantity of this water in the town, the neighborhood and intensively on the site,

    - the property and some of its wetlands are in the protective area (Zone II Potable Water Supply Aquifer Area) of a municipal water supply for Holliston,
    - the wetlands, including an intermittent stream, are part of the impaired Charles River watershed for which various protections and improvements are required (such as phosphorus reduction)
- with regard to wildlife habitat:
    - the property contains a certified vernal pool and its critical terrestrial vernal pool habitat;
    - the property is within Priority and Estimated Habitat for a species of Special Concern (Blue-spotted Salamander) as noted by NHESP, whose conditions might not be sufficient given the above magnitude of septic effluent,
    - the property is part of a BioMap2 Core Habitat, which pertains "to exemplary natural communities and intact ecosystems" and "critical habitat" for Blue-spotted Salamanders.

Credible Evidence from Competent Sources

Given the Commission's initial analysis of and concerns the Town of Sherborn contracted an independent hydrologist, James Vernon from Nobis Engineering ("Nobis") as a "competent source" to provide "credible evidence" regarding nitrate concentrations and loading levels for wetlands adjacent to the project. The Nobis report is included as Attachment B (along with only some of its attachments due to its size with the other attachments sent separately), though it should be noted that the report also contains information relevant to work he was contracted to do for the Sherborn Board of Health regarding the same project. The work done for Conservation Commission is primarily contained in Section 3, and otherwise mentioned in the Conclusions. In addition, the Commission consulted with Aquatic Scientist, Elisabeth Cianciola from the Charles River Watershed Association regarding the effects of high nitrogen concentrations and loadings on various aspects of wetland ecology and nutrient processing (her memo is Attachment C) in order to better understand whether the interests of the WPA would be protected. Other credible sources that have informed this memo are Scott Horsley, a water resources consultant hired by a group of citizens to analyze various effects of the proposed projects (see Attachment D for one of his analyses), and the Commission's own scientific literature review regarding various aspects of the effects of nitrogen loading on wetlands of the type adjacent to the site.

Results of Hydrological Analyses

The results of the Nobis analysis and some of the Applicant's work show a high degree of interaction between septic effluent in groundwater from the proposed project and two areas of wetlands adjacent to the project site. The smaller wetland, referred to by the Applicant in his 12/11/2015 submittal as the "impacted wetland," (see Attachment E for figure) in particular stands in harm's way.

Below is Table 3 from the Nobis report that shows the various concentrations and loadings for wetlands adjacent to the site:

Table 3
Nitrate Loading Analyses
247A Washington Street
Sherborn, MA
Proposed 40b Project

SUMMARY

Calculation	Predicted Nitrate Concentration (mg/L)	Predicted Annual Nitrate Load (kg/hectare/yr)	Water Level Measureme nt Date	Data Table
Calculations Based on CLAWE AOIs				
Calculation A: Predicted Nitrate Concentration, N edge of "Impacted Wetland", CLAWE AOI, December 2015	31		Low water & High Water	October EIR
Calculation G: Predicted Nitrate Concentration, N edge of Dirty Meadow Swamp, CLAWE High Water AOI, January 2016	26		4/15/2015	Jan-16
Calculation H: Predicted Nitrate Concentration, N edge of Dirty Meadow Swamp, CLAWE Low Water AOI, January 2016	26		8/14/2015	Jan-16
Calculations Based on Nobis AOIs				
Calculation B: Predicted Nitrate Concentration, N edge of "Impacted Wetland", Nobis AOI	31		3/30/2015	October EIR
Calculation I: Predicted Nitrate Concentration, N edge of Dirty Meadow Swamp, Nobis Low Water AOI, with Mounding, with Corrected Data, February 24 2016 (Well F included in AOI)	24		8/14/2015	CLAWE Table 2/23/16
Calculation J: Predicted Nitrate Concentration, N edge of Dirty Meadow Swamp, Nobis Low Water AOI, with Mounding, Corrected, Selected Data, February 25, 2016 (Well F and maybe Well G included in AOI)	23		8/14/2015	CLAWE Table 2/23/16
Calculation Based on Entire Site				
Calculation C: Predicted Nitrate Concentration, N edge of Dirty Meadow Swamp, Entire Site	10		3/30/2015	October EIR
Nitrate Loading Calculations				
Calculation D: Predicted Nitrate Load per Hectare, "Impacted Wetland", CLAWE AOI, December 2015		1612	Low water & High Water	October EIR
Calculation E: Predicted Nitrate Load per Hectare, "Impacted Wetland", Nobis AOI		1601	3/30/2015	October EIR
Calculation F: Predicted Nitrate Load per Hectare, "Impacted Wetland" & DMS, combined, entire Site		77	3/30/2015	October EIR

Nobis based these calculations on a septic system effluent of 8,360 gpd with a nitrate concentration of 35 mg/L (and small fertilizer applications as per Applicant figures), and some of these calculation are based on the "Guidelines for Title 5 Aggregation of Flows and Nitrogen Loading, 310 CMR 15.216", revised 2/3/16. As can be seen in the table, nitrate concentrations around the edge of the wetland closest to the septic leaching fields, referred to as the "impacted wetland" by the Applicant in his 12/11/2015 submittal to the Sherborn Board of Health, is calculated as 31 mg/L and 23-24 mg/L at the edge of the larger Dirty Meadow Swamp to the south. The Applicant has claimed that most or much of the time all nitrogen from the septic effluent will load into the 27,825 square foot "impacted wetland." If that occurs, Nobis calculates that nitrate load to be about 1,600 kg/hectare/year. If some of that effluent travels beyond the "impacted wetland' via surface water connection or via groundwater, then some will reach Dirty Meadow Swamp. If the effluent proportionally reaches the Dirty Meadow Swamp, averaged over the entire swamp area estimated to be about 7 hectares, the loading would be about 77 kg/hectare/year.

As it was noted in the Commission's 1/12/2016 memo to DEP, here again we note that in the Applicant's appeal ("Appeal") of the Commission's 11/17/2015 NOI denial, the Applicant states that the 195-foot distance between the leaching fields and the adjacent "impacted wetland" is sufficient to address some concerns of pollutant loading. But, with highly permeable on-site soils and lack of vegetative uptake or other denitrifying attenuation mechanisms (due to building cover and lack of deep-rooted vegetation in the path of the septic plume), the distance is not sufficient for the volume of discharge and concentration of pollutants/contaminants therein (even after recharge dilution), particularly those pollutants dependent on biological attenuation mechanisms such as nitrate. (These calculations do not include attenuation which is highly variable and often not include in these types of calculations.) While the Commission recognizes that some attenuation will occur, it does not appear to be sufficiently significant to reduce adverse impacts to the adjacent wetlands.

Critical Loading vs. Uptake Capacity as Proxy for WPA Interest Protection

As referenced in the Commission's memo dated 1/12/2016, the critical loading threshold of nitrogen in freshwater wetlands is ~35 kg/hectare/year (Bobbink et al., 2003). Nobis results show loading of nitrate at more than 1,600 kg/hectare/year to the "impacted wetland." Thus, the current project appears to propose loading more than 40 times the estimated critical loading threshold for freshwater wetlands. Scott Horsley, in a letter to the Sherborn Zoning Board of Appeals ("ZBA") dated January 26, 2016, cites similar loading thresholds, stating, "Scientific literature on critical nitrogen loading rates to wetlands suggest that impacts to wetlands occur at rates of 35 kg/hectare or 31 pounds/acre or greater (Bobbink, Ashmore, Braun, Fluckiger, and Van den Wyngaert, 2003)."

It is useful to note that the approximation of 1,600 kg/hectare/year that Nobis calculated derives from the numbers produced by the Applicant's engineer for volume of septic effluent (8,360 gpd), nitrate concentration when leaving the leachfields (35 mg/L) along with the Applicant's small amount of nitrogen fertilizer use, and surface area of the "impacted wetland" (27,825 square feet). Both the Applicant's engineer and Nobis arrived at 890 pounds/year nitrate in their separate analyses, and Nobis applied this amount to the 27,825 square foot wetland to produce the loading of approximately 1,600 kg/hectare/year.

Where the Applicant's and Commission's analyses differ, however, is in the inference each draws about the potential impacts to wetland resources—and the interests of the WPA as a result. The Commission holds that by greatly exceeding *critical loading* values for freshwater wetlands, some interests of the Act will go unprotected. The Applicant, on the other hand and based on his comments from 12/11/2015 that the **"**wetland has enough capacity for denitrification of the plume through uptake and biochemical process in the wetland," appears to be arguing that the wetlands' *uptake capacity* is a better indicator of whether the interests of the Act will be protected. (Then there is the issue that the Applicant did not provide support for its estimated wetland's uptake capacity, and this support should include whether this uptake capacity is sustainable over time.)

The Commission notes that critical loading thresholds take into account ecological effects, and are set based on what happens to a wetland resource when loading thresholds are exceeded. Verhoeven et al. (2006) describe the change when a critical loading threshold is exceeded thusly: "when nutrient loading rates surpass this critical level, species composition and ecosystem functioning change dramatically over short periods of time and the systems often move to a different stable state" (p. 100). In the January 26, 2016 letter from Scott Horsley to the ZBA referenced above describes the issue similarly, "Excessive nutrient inputs to wetland systems cause alterations to species composition and abundance and to downgradient waters and ecosystems." Essentially, critical loading thresholds indicate when ecological functioning of wetlands is adversely affected. Since an interest like <u>wildlife habitat protection</u> is dependent entirely on plant community structure and composition, going over critical loading thresholds is an indicator that the interest is being harmed.

Contrast this with the Applicant's focus on nitrogen "uptake capacity" as a proxy for protecting the interests of the WPA. As Verhoeven et al. put it, the "ecological consequences of nutrient loading on the species composition and structure of wetlands…has been ignored in most catchment water-quality enhancement initiatives, where wetlands are considered simply as systems with a high potential for nutrient retention" (p. 99). From this view, <u>wildlife habitat protection</u> is unaddressed.

Scott Horsley also notes this flaw in the Applicant's position in a letter submitted to the Sherborn Zoning Board of Appeals dated January 26, 2016 (Attachment D), saying, "the Applicant's analysis does not consider ecological impacts (or alterations) but rather focuses solely on potential assimilation rates regardless of stresses and alterations to the ecosystem." He goes on to note that the Applicant's "analysis does not consider ecological impact on the wetland but rather focuses on the maximum physical uptake rates regardless of those impacts" and that "the analysis should take into account the ecological impacts of lower loading rates that may constitute an 'alteration' as defined by the Massachusetts Wetlands Protection Regulations (310 CMR 10.00)."

One could argue that <u>wildlife habitat</u> is indirectly protected if one assumes that when a wetland retains a certain amount of nitrate through vegetative uptake and microbial denitrification processes, that the species composition and structure of the wetlands will not be significantly altered—that this is what they are capable of doing. But, this assumption is contradicted by the literature when there are no upper bounds placed on that capacity for uptake. Verhoeven et al. address this when stating that "critical nutrient loads are easily surpassed in many natural wetlands and …, depending on their original trophic status, shifts in species composition and/or increases in nutrient concentrations in the outflow will occur, in spite of rates of nutrient retention remaining high. (p. 101). Stating it another way, the authors say that "prolonged nutrient loading can have profound effects on the nutrient dynamics of the wetland, leading to shifts from one stable state to the next, often involving structural changes in the vegetation and losses of plant species diversity" (p. 96). It is clear, then, that such structural changes and loss of diversity mean that wetland species are adversely affected, and interests like wildlife habitat are not protected.

Nitrogen uptake capacity can be protective of *some* of the interests of the WPA in the *short term*, such as prevention of pollution, public and private drinking water supply and groundwater supply. Putting aside other interests like wildlife habitat that discussed above for the moment, there are two issues with the Applicant relying on uptake capacity to protect even these three interests.

First, as noted in the Commission's memo to DEP dated 1/12/2016, there were mistakes in the Applicant's calculation of uptake capacity for the ~890 pounds of nitrate being directed annually to the "impacted wetland." The corrected calculation showed that the "impacted wetland" only had an uptake capacity for ~285 pounds annually using 50 g/m^2/year, the higher of the two uptake capacity values used by the Applicant in their calculations), far short of what it would need in order to have what the Applicant states as "enough capacity for denitrification of the plume through uptake and biochemical process."

Second, even if, for the sake of argument, the calculation did show that there was enough uptake capacity, Verhoeven et al. point out that this capacity is usually only for the short-term. They say that one way to tell if a critical loading threshold for a wetland has been surpassed is when there is a "distinct increase in the nutrient concentrations of water that is exported from the ecosystem (e.g. in wetland outflow)" (p. 101). In other words, the nitrogen is not being denitrified or taken up by vegetation as effectively as it was initially. Elsewhere Verhoeven et al. say that, regardless of trophic classification, "All [wetland] systems…show a characteristic breakdown of the nutrient retention function after prolonged high nutrient loading" (p. 100). The Commission suggests that the 890 lbs. of nitrate being delivered every year qualifies as "prolonged high nutrient loading." Given that the adjacent wetlands are red maple swamps, it is on point when Ehrenfeld (2012), discussing those kinds of swamps, says, "Despite the ability of red maple swamps on poorly and very poorly drained soils to remove significant amounts of nitrate in both surface and subsurface soils, large inputs of N from adjacent developed land can result in nitrogen enrichment of both soils and vegetation, and produce symptoms of nitrogen saturation" (p. 155-156).

Thus, both in actual uptake capacity and in the long-term demands of uptake in general on wetland function and values, the three WPA interests of prevention of pollution, public and private drinking water supply and groundwater supply are not likely to be protected.

Returning to critical loading values, then, the Commission strongly asserts that critical loading thresholds are far more reliable indicators of whether the interests of the WPA are protected from the effects of nitrate (and other pollutant) loading on the wetlands adjacent to the site. Not only do critical loading thresholds account for interests like wildlife habitat, but because wetland species composition and structure are protected when loadings are below these thresholds, the very species that *provide uptake services* needed to protect the interests of groundwater supply, public and private water supply, and prevent pollution remain enabled to do so.

Significant Adverse Effects on Wetland Resources

Given this project's high loading of nitrogen and other contaminants to the adjacent wetlands far in exceedance of critical loading thresholds for wetlands of this type, the Commission will discuss what it sees as the significant adverse impacts that result, and their relationship to the interests of the Act. In general, we'll discuss ecology, nutrient uptake/retention and greenhouse gas production.

1 Ecology

Verhoeven et al. (2006) specify several ecological changes that occur in wetlands in general when critical loading thresholds for nitrogen are surpassed. They are:

- Structural changes in vegetation
- Loss of plant species diversity
- Increased primary productivity
- Shifts in dominance
- Shifts in composition
- Shifts in species

The authors characterize this process as wetlands "losing their ecology integrity" (p. 96). They say that this is due to the fact that "[w]etlands that are characterized by low productivity and high plant diversity dominated by slow growing, nutrient-conserving species shift to systems dominated by large, fast-growing helophytes following a strong increase in nutrient-loading rates" (p. 100).

1.1 Microbial Processes

Two main areas affect the processing of nitrogen by wetlands. The first is vegetative uptake, the second is denitrification by microbes in the soils. Denitrification by microbes promotes pollution prevention and provides protection for groundwater supply and public and private drinking water supply. We quote Morris (1991) at length regarding the effect of nitrogen loading on the microbial processes providing denitrification:

> Changes in deposition rate and the chemical form of nitrogen in deposition can influence microbial processes and details of the internal nitrogen cycle of wetlands. For instance, decomposition rate is sensitive to the nitrogen concentration of decomposing tissues and of the surrounding environment. Tissues with elevated nitrogen concentrations normally are observed to decompose at a faster rate than tissues containing low nitrogen concentrations…The temporal dynamics of nitrogen within decomposing litter is also sensitive to the nitrogen status of the original tissue. That is, litter of low original nitrogen content often acts as a net nitrogen sink during the first months of decomposition, whereas nitrogen-rich litter is likely to be a nutrient exporter rather than an accumulator during decomposition. (p. 267)

Thus, when primary productivity increases due to nitrogen deposition, the increased levels of nitrogen in resultant leaf litter act as *source* of nitrogen. Thus, microbial activity is simply freeing sequestered nitrogen and feeding it back into the system. If, as Verhoeven et al. (2006) suggest regarding vegetative uptake, the nitrogen is only truly removed from the system "if the vegetation is harvested as part of the management of that system" (p. 98), then the nitrogen will remain as part of the internal nitrogen budget of the wetland. Since there is no plan to remove vegetation from the wetlands adjacent to the site, it becomes clear that the nitrogen being added will stay within the system and, combined with new inputs of 890 pounds annually, will eventually result in saturation. When that occurs, excess nitrogen will either leach into soils or flow out of the wetland through any surface outlets, or be cycled into groundwater as it passes through and under the wetland.

Morris (1991) also observes that "[m]icrobial nitrogen transformations are also affected by the nitrogen status of the environment. It is well known that NH4 + inhibits the activity of nitrogen fixing bacteria (diazotrophs) (25). There is a repression of nitrogen fixation in salt marsh sediments enriched with either NH4 + or N03 - (43). It is thought that NH4 + represses synthesis of the nitrogenase enzyme." (p.268). Though the wetlands adjacent to the site are not salt marshes, in regard to microbial activity there is no difference, and forested swamps are more akin to salt marshes in terms of nutrient availability and denitrification than less nutrient rich bogs or fens. Morris also says, "Acidification, which may be caused by deposition of NOx or NH4 +, can affect the nitrogen cycle. Decomposition rates are decreased by acidification" (p. 268). Thus, the very processes by which nitrogen is rendered into harmless N2 gas by microbial activity are inhibited by loading of excess nitrogen, as is the case on this site.

Inhibition of microbial activity that provides denitrification and decomposition services adversely impacts wetland functioning, and through that the interests of groundwater supply and public and private drinking water supply and pollution prevention.

1.2 Primary Productivity

Given that intact function and values of wetlands protect the flood control, wildlife habitat and water quality interests of the act, adverse effects on elements of that ecology such as primary productivity, are important to note.

As Greaver, Liu, and Bobbink (2011) suggest, different wetlands respond to nitrogen loading differently. They characterize the work of Morris (1991) on the topic as saying that forested swamps such as those on site fall within a range of most to least sensitive. They are less sensitive than bogs, fens, and marshes, and more sensitive than intertidal wetlands. Verhoeven suggests that, for less sensitive systems, one key change is in showing an increase in primary productivity. Morris notes that if nitrogen is loaded continually in the long-term, as would happen in the wetlands adjacent to this site, the increase in leaf growth would increase the "demand for mineral elements and water from the soil" (p. 265). He goes on to say that, increased productivity would also increase rates of evapotranspiration, which can elevate "soil salinities…and influence the direction of wetland succession by altering the water balance of the soil. One modeling study indicated that nitrogen inputs greater than a threshold of 0.7 $gN/m^2/yr$ can change the direction of succession…" (p. 266). The nitrogen loading levels proposed for the "impacted wetland" in this project are converted to 160 $gN/m^2/yr$, far above the levels that influenced successional direction in the study Morris cites.

1.3 Sphagnum Moss

One particularly essential element of red maple swamp ecosystems is Sphagnum moss. They readily take up nitrogen, as they are sensitive to its presence, tolerating low levels of nitrogen until it becomes available. Thus protecting them protects the interests of pollution prevention, groundwater supply and public and private drinking water supply. Also, their ability to take up and hold large quantities of water means they help protect the interest of flood control. Sphagnum moss is documented by the Applicant as "dominant" in the herbaceous layer of the wetlands adjacent to the project site (see Applicant's "Report for Rare Species Habitat Evaluation" dated May 23, 2014). Greaver, Liu and Bobbink (2011) say of this genus of moss that

> documented responses to N deposition by Sphagnum mosses in the United States and Canada are limited to changes in N tissue concentration, bulk density, and NPP. There is additional information from European ecosystems that prolonged N deposition may ultimately lead to N saturation, leaching of excess N, and ultimately a shift in community composition…In more southerly bogs in Europe, excess N permitted an invasion of vascular plants normally held at bay due to low N concentration because of the N-filtering capacity of mosses" (p. 195).

Elsewhere, these authors observed that with nitrogen deposition in Europe, there was "the replacement of *Sphagnum*-forming species with nitrophilous moss species" (p. 203).

Bobbink et al. (2003) note several effects of the addition of nitrogen when they say,

> Responses to nitrogen addition as low as 10 kg N ha-1 yr-1 have been observed in a number of bog species (in terms of survivorship, flowering, and density). Bryophyte species, in particular *Sphagnum* spp., appear to be susceptible to the rise in anthropogenic nitrogen pollution, showing a decline in favour of grass and other competitive species, changes in competition between *Sphagnum* species, and changes in physiological and biochemical characteristics. (p. 78)

Morris (1991) says that "Excess nitrogen has a direct toxic effect on some species. Decreased growth of *Sphagnum cuspidatum* accompanied an increase in tissue-N concentration…" (pp. 269-270). He points out that "Peat-forming *Sphagnum* spp. are largely absent from bogs in Western Europe where bulk deposition rates are about 4 g N m-2 yr- 1. This equates to 40 kg/hectare/year, which is just above the 35 kg/hectare/year that Bobbink et al. (2002) use as an upper threshold for various freshwater wetlands.

Given Sphagnum species' sensitivity to nitrogen, a loss of this species due to high nitrogen loading to the adjacent wetlands will fail to protect the interests of the WPA.

1.4 Wildlife Habitat

The New Hampshire Department of Environmental Services (2005) states the following:

> "Human activities in upland areas immediately adjacent to red maple swamps may…adversely affect the functions and values of those wetlands. These operations may include…installation of private septic systems. For a red maple swamp to maintain a high level of wildlife diversity, it must sustain several layers of vegetation. To support diverse wildlife, there must be an ample and clean water supply to sustain the diverse plant community. Therefore, projects being undertaken in or adjacent to red maple swamps…need to take the necessary measures to ensure that water regimes and water quality are not negatively impacted." (p. 3)

In the text that follows, the Commission focuses its analysis ono the Blue-spotted salamander as a proxy for discussing adverse effects of nitrogen loading on wildlife habitat on the site.

1.4.1 Blue-spotted Salamander

The Fields at Sherborn project site is wholly within NHESP Priority and Estimated Habitat for Blanding's Turtles (state rare species designation: Threatened) and Blue-spotted Salamanders (state rare species designation: Special Concern). While NHESP determined that the limit of work of the project would result in "no take" of the Blue-spotted Salamander (it was determined jointly by the Applicant and NHESP that there was no evidence of the presence of Blanding's Turtles), that determination was conditioned upon whether the project activity remained within the limit of work that was defined. Further, the shape of the limit of work, and its location on the 17.55-acre property are partly due to NHESP requiring that the project activity stay outside of three 800-foot vernal pool buffer zones they determined for the Blue-spotted Salamander on, and adjacent to, the property. The Commission notes here that the "impacted wetland" and Dirty Meadow Swamp both sit outside that limit of work and *inside* (the "impacted wetland" completely, and Dirty Meadow Swamp largely) the vernal pool buffer zones. Therefore, any significant adverse impact to the adjacent wetlands as it relates to habitat for this species may be considered a "take" by NHESP.

It must first be noted that in addition to vernal pools, Blue spotted salamanders and other amphibians routinely use red maple swamps themselves as breeding habitat, especially when vernal pools are not reachable or are dry. Swain & Kearsley (2001) address this in saying, "Parts of red maple swamps that have two or three months of ponding and lack fish can function as vernal pools; these sections provide important amphibian breeding habitat" ("Red Maple Swamp" pages). NHESP (2015) says, "Eggs and egg masses of [Blue-spotted salamanders] are typically attached to the twigs of submerged shrubs or to leaves, twigs, and other detritus on the bottom of the wetland. Eggs may also be attached to submerged grass blades or simply scattered on the bottom substrate." (p. 4). It's clear that not just vernal pools, but also the red maple swamps adjacent to the project site are very likely to provide important breeding habitat for this species of Special Concern.

Given that the adjacent wetlands are likely used by Blue-spotted salamanders, research showing the adverse impacts of nitrate on wetland waters used as breeding habitat is particularly relevant. Though there has been little to no study of nitrate effects on waters used by Blue-spotted salamanders (*Ambystoma literale*) in New England, study of a close relative, the Northwestern salamander (*Ambystoma gracile*), should provide particularly relevant information. Marco, Quilchano and Blaustein (1999) studied the sensitivity of pond-breeding amphibians (including *Ambystoma gracile*) of the Pacific Northwest to nitrate and nitrite. They found "a strong sensitivity of…*A. gracile* larvae to relatively low levels of both nitrate and nitrite…[with a strong] acute effect" (p. 2838). They go on to state that

> [m]any public water supplies in the United States contain levels of nitrate that routinely exceed concentrations of 10 mg N/L [8]. In the Willamette Valley, average nitrate concentration of 17.8 and 21.9 mg N/L were recorded in water samples from some crop soils receiving recommended rates of nitrogen fertilization [35]. These average values are highly toxic for...*A. gracile*. (p 2838)

Given that the Applicant himself has admitted that septic effluent will reach the "impacted wetland," and that the Nobis has calculated the concentration at that wetland edge at 31 mg/L, then there is a high likelihood of adverse impacts to <u>wildlife habitat</u> for this wetland species.

Veysey and Babbitt (2005) discuss other adverse impacts on Jefferson and Blue-spotted salamander habitat from nitrogen loading. Though they are discussing fertilizers, nitrogen is still the key element. They say that "Fertilizers can leach into soil and ground and surface water and eventually arrive in wetlands where it may cause algal and bacterial blooms" (p. A-194) and go on to note:

> Algal and bacterial blooms (as well as the fertilizers themselves) may be toxic to salamanders or cause anoxia, which affects salamanders or prey resources. Larvae often exhibit decreased feeding and swimming activity, and increased disequilibrium, paralysis, incidence of abnormalities and edemas, and mortality (Marco et al. 1999, Baker and Waights 1994). (p. A-194)

The information provided to the Commission by the Applicant and other sources indicates that high nitrate loadings will occur in the wetlands adjacent to the site, and that these loadings will have significant adverse impacts on <u>wildlife habitat</u> that supports the Blue-spotted Salamander lifecycle. Thus, it appears that this interest of the Act will not be protected in the proposed project and that the NHESP could be notified of these potential impacts.

One last note is that, in addition to the NHESP Priority and Estimated Habitat, the wetlands adjacent to the site are within Biomap2 Core Habitat 1449. Biomap2 Core Habitats are designated jointly by NHESP and the Nature Conservancy to "identif[y] specific areas necessary to promote the long-term persistence of rare species, other Species of Conservation Concern, **exemplary natural communities**, and **intact ecosystems**" [bold added]. Core Habitat 1449 is designated habitat for the Species of Conservation Concern, the Blue-spotted Salamander. BioMap2 designates Species of Conservation Concern in the following way: "Using the observation records in the NHESP database, Natural Heritage biologists with expertise regarding these species delineated the extent of the critical habitat associated with each record, following species-specific mapping guidelines." As one can see, with adverse impacts to such critical habitat, again, this project is not protective of the interests of the WPA.

1.4.2 Impacts of Nitrates on Wildlife [entirely from Cianciola memo – Attachment C]

"The greatest numbers and biomass of insects in freshwater wetlands has been observed in areas that are sparsely vegetated, as opposed to areas that are densely vegetated or open water (McLaughlin and Harris, 1990). Sparsely vegetated areas provide microhabitat diversity and reliable food sources, but also experience good through-flow, which helps to flush biochemical waste products and maintain high dissolved oxygen levels. Because they feed on submerged aquatic vegetation, crayfish are considered to be an indicator of high water quality in freshwater wetlands. Insects, mollusks, and other invertebrates are an important food source for birds such as swallows and swifts as well as amphibians. Amphibians, in turn, provide a food source for wading birds, mink, raccoons, and occasionally fish (Mitsch and Gosselink 2007, 2007).

Most waterfowl that inhabit freshwater wetlands are herbivorous or omnivorous (Mitsch and Gosselink 2007, 2007), meaning that they modify their feeding behaviors in response to changes in wetland vegetation. Familiar birds that would be expected to use the wetlands at The Fields at Sherborn site include Mallard ducks, Great Blue Herons, and red-winged blackbirds, but would also likely include wrens, plovers, terns, bitterns, and rails. Other herbivores one would expect to find in the wetlands at the Fields of Sherborn project site include muskrats, shrews and voles. Foxes and weasels will also visit freshwater wetlands to feed and would thus be affected by nitrate toxicity impacts among wetland herbivores."

1.5 Ecological Risks of Nitrate Toxicity [quoted entirely from Cianciola memo – Attachment C]

"High concentrations of nitrate can have toxic effects on vertebrates and invertebrates alike, by inhibiting growth and impairing the immune system. A 2005 study (Camargo *et al*., 2005) found that long-term exposure to nitrate concentrations exceeding U.S. EPA's maximum contaminant level for drinking water of 10 mg/L could negatively impact freshwater invertebrates and amphibians, including amphipods, caddisflies, chorus frogs, leopard frogs, and toads (*E. toletanus*, *Cheumatopsyche pettit*i, *Hydropsyche occidentalis*, *P. triseriata, R. pipiens, R. temporaria, B. bufo*). The study recommends a maximum nitrate concentration of 2 mg/L in freshwater ecosystems to protect the most sensitive wildlife. In their 2012 study, Soucek and Dickinson observed median lethal effect doses of 357-937 mg/L nitrate among stoneflies, amphipods, and freshwater mollusks (*A. vivipara, A. delosa, H. azteca, L. siliquoidea, M. nervosa, S. simile,* and *L. stagnalis*). Adding a 100-fold safety factor to avoid adverse impacts and account for uncertainties in environmental conditions versus laboratory conditions as well as the sensitivity of organisms that have not been studied, this concentration is similar to U.S. EPA's recommended Ambient Water Quality Criteria for Ecoregion XVI (0.31 mg/L vs. 0.36 mg/L). All of the organisms mentioned here could inhabit the wetlands at The Fields at Sherborn site. In addition, Adelman et al. (2009) found that U.S. EPA's recommended maximum nitrate criteria for warm-water fish, 90 mg/L, may not be protective, given that they determined a maximum acceptable toxicant concentration of 84 mg/L nitrate for fathead minnows (*P. promelas*).

In comparison to their relatively high tolerance of nitrate, freshwater invertebrates are much more sensitive to nitrite. Although planarians (*P. felina*) can survive at nitrite concentrations up to 60 mg/L, more than 50% of amphipods (*E. echinosetosus and E. toletanus*) experience lethal effects at nitrite concentrations between 2 and 2.6 mg/L (Alonso and Camargo, 2006)."

2 Drinking Water Quality: Nutrient Retention/Uptake, Holliston's Zone II Wellhead, and the Charles River

In addition to Microbial Processes discussed in 1.1 above, Verhoeven et al. (2006) state in general that:

> Naturally nutrient-poor (i.e. oligotrophic and mesotrophic) systems react more drastically than do naturally nutrient-rich (eutrophic) systems. Nutrient-poor systems show a complete shift in plant species composition as well as a drastic change in nutrient dynamics, whereas nutrient-rich systems might show only further increased productivity. All systems, however, show a characteristic breakdown of the nutrient retention function after prolonged high nutrient loading. (p. 101)

Verhoeven et al. also state that one way to detect whether a critical loading threshold has been exceeded in a particular wetland is through detection of a "distinct increase in the nutrient concentrations of water that is exported from the ecosystem (e.g. in wetland outflow)" (p. 101).

Increase in outflow of nitrogen and other contaminants from the "impacted wetland" over time will affect the interests of pollution prevention, groundwater supply and public and private drinking water supply.

Given the Applicant's assertion in a February 2016 Board of Health meeting that nitrate loaded to the "impacted wetland" will flow out of it via an intermittent stream connecting to the larger Dirty Meadow Swamp beyond it to the west and south. While the Applicant saw this as a dilution of nitrate loading, the Commission finds it concerning for three reasons. First, because even if one averages the 1,600 kg/hectare/year loading to the "impacted wetland" over the entire Dirty Meadow Swamp, the loading would be about 70 kg/hectare/year, twice the critical loading threshold. There would also be an estimated nitrate concentration of about 10 mg/L, which would be significant even with some nitrogen attenuation.

Second, one would expect that since it is emerging from a point of connection with the "impacted wetland" that the deleterious effects of the nitrate loading would be more pronounced closer to the "impacted wetland." Lastly, and perhaps most importantly, the place where the intermittent stream emerges from the "impacted wetland" is the boundary line of a Zone II Wellhead Protection Area for the neighboring town of Holliston. Thus, all three elements of nutrient retention failure due to nitrogen overloading fail to protect the interests of public and private drinking water, pollution prevention, and groundwater supply.

2.1 Nitrogen Loading in the Charles River Watershed: Existing Conditions [quoted entirely from Cianciola memo – Attachment C]

"Total nitrogen and nitrate/nitrite loads across the Charles River watershed have consistently exceeded the U.S. Environmental Protection Agency's recommended nutrient criteria for this ecoregion, with 79% of the nearly 800 water samples the Charles River Watershed Association (CRWA) has collected in the past 20 years exceeding the criteria, as illustrated in the figures below (excerpted from CRWA's 2014 Annual Water Quality Report). The movement of human wastewater through the watershed is one of the largest sources of nitrogen pollution in the watershed. Despite a separation of nearly 4 miles of relatively unurbanized area, including ponds and wetlands, concentrations of nitrogenous compounds are consistently significantly higher at CRWA's sampling location downstream of the Milford Wastewater Treatment Plant. To provide context, The Fields at Sherborn project site is located between monitoring sites 290S and 387S. Without the enhanced nitrogen removal technology that Trask [Applicant] originally proposed as part of The Fields at Sherborn project, increased nitrogen pollution in local groundwater reserves proportionate to the number of people served by the septic system is to be expected. Although ammonia is the most toxic of the three nitrogenous compounds of primary concern in aquatic ecosystems, most nitrogen in wetlands is present as nitrate, because bacteria readily oxidate ammonia and nitrite to produce nitrate."

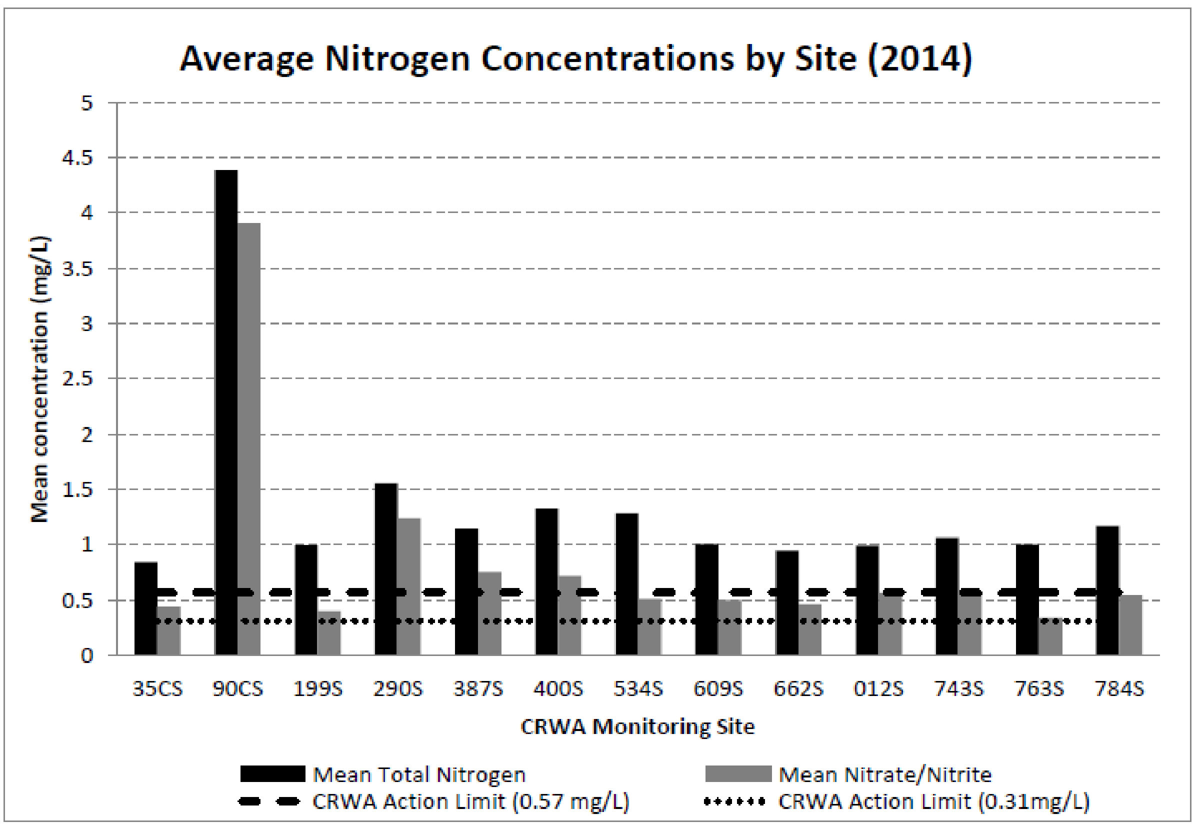

Figure 21. Average total nitrogen and average nitrate/nitrite concentrations in 2014 (mg/L).

Source: Cianciola – Attachment C

3 Enhanced greenhouse gas production

Though not specifically related to the interests of the WPA, greenhouse gas production is of concern in wetlands providing denitrification services whose interests are in the WPA. Therefore, the Commission finds it worthy of comment.

To quote Verhoeven et al. (2006):

> The major process responsible for nitrate removal in wetlands is denitrification. However, in situations where the reduction of the nitrate to N_2 is incomplete, the denitrification process can also be a major source of the greenhouse gas N_2O, which has a global warming potential 310 times that of CO_2 [53]. N_2O accounts for ~6% of the total greenhouse effect and also has an important role in the destruction of the stratospheric ozone… N_2O emission in wetlands is generally promoted under conditions that are suboptimal for denitrification, such as low pH or soil moisture. However, N_2O production is also promoted by high nitrate availability, because it is energetically favorable for denitrifyers to reduce nitrate instead of N_2O.

Morris (1991) echoes this by saying that "$N0_3$– [nitrate] and NH_4+ have been shown to influence the relative and absolute production of end-products of dissimilatory nitrate reduction (12, 73, 100). High $N0_3$ - concentrations are thought to favor N_20 production and inhibit N_2 production" (p. 268).

Conclusion

Based on the above work, the Commission thinks that it has provided "credible evidence" from "competent sources" to overcome the presumption that, regardless of Title 5 permitting, the current conditions of the proposed project's septic system will have multiple, significant adverse impacts to wetlands adjacent to the site. This will fail to protect all of the interests of the Act and should strengthen the grounds to uphold the Commission's denial of the project NOI dated November 17, 2015.

Attachments

A. Sherborn Conservation Commission (January 12, 2016), "The Fields at Sherborn (DEP File No. 283-0366) Appeal of Denial (dated November 17, 2015): Overcoming the Presumption That Title 5 Compliance Protects Interests of the Wetlands Protection Act", memorandum to DEP Northeast Region Project Reviewer

B. Nobis Engineering Inc. (March 4, 2016), Phase 1 and Phase 2 Report – Independent Hydrogeologic Study, The Fields at Sherborn" by James Vernon.

C. Elisabeth Cianciola memo, 2/23/2016 email.

D. Scott W. Horsley (1-26-2016), "RE: Fields of Sherborn 40B – Hydrology Issues", letter to Daniel C. Hill.

E. Site Figure

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