August 12, 2024

Ms. Liz Burdick
Director of Land Use & Planning
Town of Ledyard
741 Colonel Ledyard Highway
Ledyard, CT 06339

RE: Avery Brook Homes
Job # 01213

Dear Ms. Burdick:

At your request, we are providing you with a peer review of a report prepared by Angus McDonald Gary Sharpe & Associates, Inc. (AMGS), dated June 20, 2024 specifically addressing a *Septic System Effluent Renovation Analysis* of the potential impacts to Billings Avery Reservoir.

First, by way of introduction to DYMAR and myself, I am the principal of DYMAR and have been consulting for over 40 years, serving both private and public clients in the land use industry. Personally, I have been providing Wastewater Management Services during this tenure with broad experience in large and small scale treatment plants of various processes, On-site Sewage Disposal Systems for design capacities in excess of 75,000 gpd, conveyance and pump stations and facility planning. I have significant experience in the permitting, design and construction of both CT Department of Public Health (CTDPH) and the Department of Energy and Environmental Protection (CTDEEP) on-site sewage disposal systems, and quite familiar with the technical standards for both agencies. I presented to a CTDEEP organized public conference in October 2019 on the specific topic of "*Justifying Site capacity – A Guidance Approach to Satisfying CTDEEP Criteria*", which addressed how aquifers respond to on-site sewage disposal systems and the modelling approaches to analyzing impacts.

In regards to Avery Brook Homes, this is a re-subdivision proposal for 18 single family home lots situated on 6.38 acres located at 96-100 Stoddard's Wharf Road. The proposal also includes a groundwater easement restriction on 94 Stoddard's Warf Road, a 2.8+/- acre parcel adjoining the subject parcels to the east. Typically, a subdivision application for single family lots comes under the jurisdiction of the public health code and in this case is The Ledge Light Health District as the local authority. The inference here is that CTDPH has adopted a set of standards that addresses ***public health*** for systems design flows of 7,500 gallons per day (gpd) or less. The design flow for each proposed lot is 450 gpd at 3 bedrooms each, significantly below the threshold. The idea that regulatory agencies can require a higher standard has to be met, which circumvents the authority of another agency having jurisdiction over health related issues, is treading to make CTDPH and the local health departments obsolete in its authority to regulate smaller on-site sewage disposal systems. This practice would be inconsistent with state statutes on the jurisdictional authority granted to the CTDPH and CTDEEP for regulating sewage systems. It would be harmful to property owners in trying to meet such a standard.

In applying a different set of standards to this project, based on CTDEEP criteria, has a profound negative impact to setting a precedence that most residential properties could not satisfy and would be significantly costly for anyone to do so. This is especially true for coastal Towns that have high water tables and more permeable soils. Nitrate nitrogen and bacteria travel time are the most difficult thresholds to satisfy when applying the CTDEEP criteria. Hydraulics, effective leaching area and separation distance to groundwater are also a challenge for single family lots, especially when the depth to groundwater is shallow and tighter soils of a lower infiltration capacity are encountered. If this burden was again applied to the general public for any residential lot, and this would hold true for anyone that sits on a commission, many of these home sites could not have been built utilizing CTDEEP criteria. The CTDEEP evaluates impacts within the zone of influence to wetlands or watercourses, but also considers a property line.

The prior and most recent subdivision application submitted to the Town of Ledyard has been challenged by Groton Utilities as an intervener, and thru its consultant Wright-Pierce, are making claims that the on-site sewage disposal systems will have unacceptable impacts to Avery Billings Reservoir. Specifically, they cite impacts due to nitrates (NO3) and viruses. It must be noted that there are no on-site wetlands or regulated activities concerning Inland Wetlands & Watercourses in accordance with the Town's regulations. The project site does lie within the public water supply watershed of the City of Groton.

The evaluation of these impacts by AMGS was based on CTDEEP's "Guidance for Design of Large-Scale On-Site Wastewater Renovation Systems", dated February 2006. The impacts of wastewater absorption systems on the waters of the state requires the understanding of the regional and local hydrogeological setting, and determining the physical characteristics of the aquifer in which the on-site disposal system discharge to. The primary characteristics we need to understand is 1) the groundwater gradient and direction of flow, 2) the depth of the saturated and unsaturated soil boundaries that water flows through, 3) the permeability of the soils, which is the capacity of the soils to transmit the flow of water and 4) the background water characteristics both in the groundwater and surface water, as they may apply. Lastly, what is the point of concern from the Subsurface Wastewater Absorption System (SWAS).

What has been presented to DYMAR for review is AMGS's renovation analysis on an evaluation of impacts associated with nitrate and phosphorous nutrients and bacteria/viruses on Billings Avery Reservoir. DYMAR's response on each parameter examined is as follows:

1. **Nitrogen/Nitrates:** AMGS concluded a concentration of 8.24 mg/l based on a contributing area of 9.21 acres (19 lots) for recharge/infiltration, 48 inches of rainfall per year and a 51% infiltration rate. This equates to 0.06707 feet/day that is the sum of various infiltration assumptions for contributing sources i.e, roof rechargers, two infiltration subsurface devices, grass areas and other impervious areas. The CTDEEP sets a limit of 10 mg/l to the point of concern, which typically would be the property line where there is no wetlands or watercourse on the property. The sewage flow is always based on the average daily flow (ADF) on an annual basis. The nitrogen dilution area is the zone of influence, which rainfall precipitation can reasonably co-mingle with the

groundwater to reduce the nitrate nitrogen concentration from a disposal system to the point of concern.

AMGS used an ADF per bedroom of 48 gallons per day (gpd) and a raw sewage Nitrogen concentration of 90 milligrams/liter (mg/l). Both values are not unreasonable, as a typical household of 4 can generate anywhere from 20 to 50 pounds of total nitrogen (TN) per year. Using AMGS values, a three bedroom house is estimated to generate 0.1081 pounds/day or 39.4 pounds/year of TN. This is completely acceptable.

AMGS created a groundwater contour map from groundwater readings taken on January 5, 2023 as well as April 8, 2024. Both readings occurred during seasonal high groundwater periods. The groundwater flow direction is primarily from east to west and northwesterly. There is a substantial wetland located between Avery Brook Home property limits and Billings Avery Reservoir. This environmental setting is an important attribute that will provide additional nutrient uptake, and should be considered when reviewing impacts.

AMGS did consider the entire property for dilution as it relates to all 19 systems, which includes 94 Stoddard Wharf Road. It is our opinion the dilution water volume purported at 57,735 liters per day is overstated when considering CTDEEP criteria. The positioning of the proposed septic systems on each lot, relative to the mapped groundwater contours to the point of concern, suggests the nitrogen dilution area and infiltrated precipitation is different for each disposal system on how the dilution volume co-mingles with the groundwater. Both of the stormwater infiltration basins that collect the road system provide minimal nitrogen dilution capabilities and at least 8 of the roof recharge systems are located outside of the zone of influence for nitrogen dilution. The horizontal transverse/lateral extent of a SWAS discharge to define the plum limits, and thus the zone of influence, is provided for in the CTDEEP manual under Section X.

DYMAR did review the Groundwater Report prepared by GEI Consultants and refer to Figure 9 in the report and the slide titled “Computed Groundwater Contours (Present Condition)”. The groundwater contours suggest that there is flow contributing across the subject property from lands of the City of Groton that will provide additional precipitation and dilution that is not accounted for in any analysis. Assuming a background level of nitrogen in the groundwater of 1 mg/l, the estimated dilution area needed for a 3 bedroom house is approximately 21,000 square feet or about 0.5 acres. The land mass of Groton Utilities to the east and west of the property is substantial and likely will not be developed. As previously noted, what separates the property from the reservoir is a substantial shoreline wetland system. In a wetland, nitrates are absorbed by plants or converted (through an anaerobic process called denitrification) to nitrogen gas and lost to the atmosphere. Nitrate-N (NO3) is efficiently and more readily removed from wetland surface waters by aquatic plants, which is a primary benefit to nutrient removal, nitrogen included.

The topic of potential nitrogen impacts on the reservoir however needs to be expanded to place it in perspective and reality. The CTDEEP criteria is extremely conservative in suggesting dilution can only consider the rainfall that falls within a zone of influence to the point of concern and sources of rainfall that can co-mingle with the groundwater on the property. The intervener has raised concerns on the potential water quality impacts

the septic systems will have on the reservoir, and thus the analysis should go beyond the property boundaries to assess the impact. The reality is that aquifers extend beyond the limits of property boundaries and can carry a significant amount of water across and within a property. Published information on Avery Billings Reservoir suggests the reservoir is about 11 acres, has a watershed of approximately 2 square miles and storage of about 54 acre-feet or 17.6 million gallons.

The CTDEEP nitrogen limit of 10 mg/l threshold is a unit of concentration not reflective of the nutrient load imposed by the proposed septic systems on the reservoir. Nutrient loads are measured in pounds per day (lbs./day). The potential estimated pounds per day of nitrogen being discharged to the reservoir from the proposed 19 septic systems (after pre-treatment) is 1.23 lbs./day based on an average daily flow 2,736 gpd. The impact on the potential change in the reservoir chemistry relates to the existing reservoir volume and the background TN nutrient level. Assuming the current TN background level of 1 mg/l in the reservoir, which is not unreasonable to assume, this equates to a potential load of 146.8 lbs./day. The added TN load from the septic systems is @ 0.83% +/- and will result in an insignificant impact on the reservoir chemistry or create any health or ecological issues.

In addition, the nitrogen cycle is complex, with the chemistry of nitrogen in ponds and water bodies changing seasonally, as it is affected by pH, temperature, rainfall, aquatic plants, lawn fertilization, fish and various invertebrates' contributions. We also understand that the concentration of nitrogen will change with the depth of the water column and higher values potentially occurring in the pond sediment and along the shoreline. Nitrogen levels will also often increase in a reservoir during the spring and fall with greater activity of fish and invertebrates excreting waste, as well as the biodegradation of organic debris occurring. The drainage basin for the Avery Billings Reservoir is approximately 2 square miles, with several stream networks contributing nutrients from other developed property and road networks in the watershed. The wetlands at the headwaters of the reservoir are substantial and play an important role in removing nutrients contributed by the watershed, including those in proximity to the subject property.

In summary, the applicant has provided a Nitrogen Dilution Analysis that purports to satisfy the CTDEEP guidance document for concentration at point of concern, which is the westerly/north westerly property line. Our opinion is that the CTDEEP criteria was not satisfied and the analysis incorrectly overstated the dilution volume. However, as to the question of water quality impacts on the reservoir, which is the question raised by the intervener, it is also our professional opinion the impacts of nitrate nitrogen on the reservoir will be insignificant, as the load of nitrogen nutrients will result in insignificant changes in the reservoir chemistry.

As a recommendation, we would suggest the applicant improve the stormwater infiltration design for nitrogen dilution to capture the true zone of influence for the septic systems. We do not believe the applicant should be held to the standards of the CTDEEP, as the jurisdiction of the septic systems is under the public health code and should be regulated by the local health office.

2. **Virus/Bacteria Travel Time:** AMGS provided documentation of travel time for lots 16, 17 and 18 as the proposed SWAS's serving these lots were the closest to the wetland boundaries along the reservoir north of the property. The measured distances to the point of concern along the reservoir was 270, 343 and 352, feet for lots 16, 17 and 18, respectively. Travel time is calculated based on the velocity of a particle of water and the time to travel a distance within the groundwater saturated zone to the point of concern. The velocity is calculated based on the groundwater gradient, values typical of the seasonal high groundwater table, the rate of flow the soils can transmit water in a given period of time described as the soil permeability, and the effective porosity of the soil, which is the ratio of the volume of interconnected pores to the total volume that allow groundwater to move in and out of the soil. AMGS used the CTDEEP book value for sands of 0.25 for effective porosity.

   AMGS provided velocity values for both maximum and minimum groundwater gradients. CTDEEP typically uses the maximum gradient and highest geometric mean value for soil permeability, estimated by AMGS at 180 feet per day. The travel times estimated by AMGS based on the maximum gradient of 1.3% for lots 16, 17 and 18 was 29, 36 and 37 days, respectively. The CTDEEP minimum requirement is 21 days.

   DYMAR's opinion is that the travel times are understated, as the geometric mean of permeability values were primarily based unsaturated soil characteristics. The washed sieves analyses also suggest permeability ranges based on an empirical relationship and formula established by Hazen used for sandy soils. There are numerous methods for measuring the permeability of soils but the least reliable is by grain size distribution, as it can be off by a factor of 2 or 3 times of the insitu field value. The method ignores the effect of compaction (soil density), soil structure and shape of the soil particles. The uniformity coefficient provided in the test results offers some insight that the ranges presented are questionable, noting they would be described as well sorted sands and gravel having coefficients exceeding 20 in most cases. The higher the uniformity coefficient the more likely the permeability values will be lower, as there will be more interlocking of soil particles to reduce the pore channels and the passage of water. The Hazen formula is not suitable for extreme particle shape and size distribution. It is better used for what is consider a poorly sorted sand or gravel where the uniformity coefficient is below 5.

   AMGS only provided 3 permeability values that were in close proximity to the saturated zone (soil within the groundwater). The values were for test pits 102, 103 and 111 located on lots 15 and 16, bag samples taken from 114 to 15.8 feet below grade. The geometric mean of the permeability values was 143 feet/day. Travel times should be computed based on permeability values compiled from data collected within the saturated zone. It is our experience that because of the depth to the water table being deep within a stratified drift aquifer, a minimum of 3 deep test wells should have been installed to conduct slug tests within the saturated zone, a more reliable test to determine the flow of water in the soil in estimating travel times. If the permeability value used was at 143 feet/day in lieu of the180 feet/day, the travel time would equate to 36 days for lot #16, the closest SWAS to the reservoir point of concern.

   In summary, it is our opinion the bacteria/virus travel time estimates suggested by AMGS are reasonable, are likely understated, and will not create a pollution issue on the

reservoir. DYMAR would have likely approached the project differently by installing a few test wells to conduct slug tests in the saturated zone, but our experience also with these tests typically yield lower average permeability values than a recompacted lab test or estimates based on empirical formulas of grain distribution. Lower values of permeability yield longer travel times. In addition, there is a vertical component of travel time that is typically omitted, but within deeper soils to groundwater can add an additional day or so.

3. **Phosphorous Sorption Capacity**:

AMSG followed the CTDEEP guidelines for calculating retention time of soils to absorb phosphorous (typically in the form of Phosphates PO4) in the unsaturated zone below the septic leaching field.

The mechanism for the control of chemical mobility of phosphorous and removal from the leach bed seepage occurs in the unsaturated soils by a chemical mineral reaction at the soil surface. These reactions typically occur with soils having positively charged cations of iron, aluminum and/or calcium oxides present, which the reaction then binds the negatively charged phosphorous anions to the soils as an absorbent, making the phosphate ion immobile, with the reaction tending to be irreversible. The most important factor is the reaction time to allow iron phosphates to form, as there is a slow reaction of phosphates to be absorbed by the aluminum and iron oxides. The CTCEEP standard is a 6 month period for regenerative soil sorption capacity.

A soils ability to absorb phosphorous varies with the soil type and structure. Sandy and gravel type soils have less sorption capacity than silty or clay soils. Published data CTDEEP has accepted suggests the values can range from 8 milligrams/100 grams (mg/100g) of soil to as high as 30 milligrams/100 grams of soil. The lower value of 8 mg/100 g would be perfectly acceptable, however AMGS used a more conservative value of 6 mg/100 g in their calculations.

AMGS prepared Phosphorous Sorption Capacity estimates for each lot with a suggested minimum leaching field foot print (effective horizontal area) for each system. The analysis considers the depth of unsaturated soil depth from the bottom of the leaching system to the high ground water table and the dry unit weight of soil at 110 pounds/cubic foot. The concentration of phosphorous from the leaching field was assumed at 12 mg/l, which suggests a raw value for domestic waste of 17 mg/l. Published typical values of phosphorous in domestic wastewater range from 4-15 mg/l with the statistical average in three U.S. regions around 10.4 mg/l. We note the contribution of phosphorous in the waste stream has been trending downward since the 80's. The value used by AMGS is conservative, as a more realistic and acceptable value after pre-treatment would be 10 mg/l.

Appendix F in the AMGS report provides an analysis for each lot, providing an estimate of excess capacity above the 6 month threshold at 50% of the soil mass. The excess retention time varies from 13 days to as high as 111 days (3.7 months).

In summary, it is our opinion there will be no phosphorous nutrient impact on the reservoir from the individual proposed on-site sewage disposal systems.

4. **Leachfield Construction and Groundwater Mounding**:

   AMGS provide a simple calculation using Darcy's Law to estimate how much the groundwater would increase in height (the mound) above the seasonal high ground water table. CTDEEP typically uses the lower values of permeability and the higher hydraulic gradient base on the design flow as the most conservative approach in estimating the mound height below a leaching field. The available unsaturated soil depth from the bottom of the leaching systems varies from 6 feet to 18 feet. The minimum required depth was estimated by AMSG at 4.8 feet to satisfy CTDEEP criteria, based on the same permeability value and groundwater gradient for all lots.

   Assuming all values are equal accept the soil permeability, what is lowest value of soil permeability required to satisfy the CTDEEP separating distance threshold of 3 feet to the bottom of the trench to the mounded water table for any given lot. The worst case is Lot #2 with an unsaturated soil depth of 6 feet. The minimum value required is estimated at 61 feet/day. Lot #10 is the next worse case at 8 feet unsaturated soil depth, which equates to a minimum required permeability value of 38 feet per day to satisfy CTDEEP criteria.

   However, it is noted that there are no representative soil permeability values in the unsaturated zone reported for or in close proximity of Lot #1, 2, 3, 4, 9, 10, 11 or 13. AMGS assumed the same permeability value of 130 feet per day for all lots as well as the same hydraulic gradient of 1.3% in its calculations. The gradient does vary across all lots based on the groundwater contour maps supplied and is further noted of different values in their discussion of hydraulic gradients on page 7 of the report. As noted above, the mound calculation is based on the lowest hydraulic gradient and permeability values, which yields the highest mound height.

   In summary, AMGS drew a conclusion the separation distance from the mounded groundwater table to the bottom of the leaching beds is adequate for all lots. How they drew that conclusion cannot be justified, as not all lots have the same soil and hydraulic gradient characteristics. Additional data on soil permeability in the unsaturated zone would be necessary, as many of the lots are lacking sufficient data, and they should apply the correct hydraulic gradients for each lot based on information they do possess. Making a universal assumption that all lots are homogeneous in values is inaccurate and AMGS should revisit their calculations to correct the record.

In closing, on the subject matter of impacts on the Billings Avery Reservoir, it is our professional opinion there will be no adverse impacts resulting from the on-site septic systems due to nitrate nitrogen, bacteria travel time or phosphorus. The applicant's consultant AMGS should provide additional information to justify its conclusion on the separating distance to the mounded water table for each lot and fill in the data gaps to justify its conclusion. We further note of our prior recommendation that the applicant improve the stormwater infiltration design for nitrogen dilution to capture the true zone of influence for the septic systems. The site is comprised of deep, well drained soils and it should not be difficult to improve the rainfall infiltration volume into the soils that directly affect the on-site sewage system discharges.

Thank you and I look forward to addressing any questions you and the Town Land Use agencies may have in deliberating on the project application.

Very truly yours

Mr. Mark E. Lancor, P.E.
Principal

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