EXHIBIT

WRIGHT-PIERCE
Engineering a Better Environment

Memorandum

Date: **August 15, 2024**

Project No.: **21347**

To: **Peter Gelderman and Steven Studer, Berchem Moses PC**

From: **Michael D. Giggey, PE**

Subject: **Avery Brook Homes Subdivision, Ledyard CT**
Review of Water Quality Impacts from 18-Lot Re-Subdivision

Introduction

Avery Brook Homes, LLC has proposed an 18-home subdivision to be located on three existing lots (6.38 acres in aggregate area) off Stoddards Wharf Road in Ledyard, within the watershed of Groton Utilities. The developer has presented a report to the Ledyard Planning & Zoning Commission to address potential water quality concerns. That report, entitled *Avery Brook Homes: Septic System Effluent Renovation Analysis,* is authored by Angus McDonald Gary Sharpe & Associates and is dated June 20, 2024.

This Wright-Pierce memo presents Wright-Pierce's comments and findings on water quality concerns related to this project, and specifically addresses the June 20, 2024 Angus McDonald report.

Our concerns fall in two related areas:

- impacts on the Billings Avery Reservoir and
- suitability of the site to provide acceptable drinking water quality for the residents.

(It should be noted that a similar project was proposed at this site by the same developer in 2022. That prior project involved 26 lots on four parcels with a total area of 9.21 acres. It was reviewed and denied in March 2023 by the Ledyard Inland Wetland & Waterways Commission. In comparing the prior project with this current proposal, I note that the existing easterly parcel (94 Stoddards Wharf Road) has been removed from the project and 8 fewer homes are now proposed.)

Project Setting

The project is located in the northerly portion of the Groton Utilities watershed, just north of Stoddards Wharf Road. Avery Brook and associated wetlands are located to the immediate east and north of the proposed project. Avery Brook flows into Billings Avery Reservoir at a point about 300 feet northwesterly of the northerly corner of the project site.

The site vicinity is relatively rural. There are approximately 8 to 10 nearby homes along Stoddards Wharf Road, all served by private wells and individual septic systems.

The soils have been shown to be sandy loams with high permeabilities and little attenuative capabilities. Development on these soils requires special attention with respect to movement of contaminants toward wetlands, watercourses and water supplies (both public and private). Bedrock is 10 to 30 feet below the ground surface. Groundwater is generally 10 to 15 feet below the ground surface.

It is my judgement that the groundwater, Avery Brook, Billings Avery Reservoir and the wetlands associated with these watercourses are all inter-related in accordance with fundamental hydrologic principles. The developer has estimated groundwater table elevations under the parcels to be developed, but has not shown the expected and important connections with Avery Brook, Billings Avery Reservoir and their surrounding wetlands. This is a significant omission.

The site is relatively flat at elevations between 145 and 165 feet above sea level. The gentle slope of the ground surface is in easterly and southeasterly directions. The groundwater table is generally between elevations 135 and 144 feet, sloping predominantly northwesterly toward Billings Avery Reservoir, which has a typical water surface elevation of about 132 feet. Without doubt, some groundwater will flow directly toward Avery Brook in some areas of the site, with a more northerly flow direction than depicted by Angus McDonald.

Nearby Similar Projects

Also of interest are a residential subdivision (Aljen Heights) and a mobile home park (Avery Hill Trailer Park) located further north in Ledyard. Those two residential areas are pertinent to this evaluation because they too were developed with on-site septic systems and private water supply wells, and the average lot size is comparable to the Avery Brook Homes proposal. Widespread contamination of the groundwater occurred in those projects, triggering a significant expansion of the public water supply system to alleviate that groundwater contamination, at a large cost to the public (Reference 1). While a public water supply extension has solved the drinking water problem, there continue to be a large number of septic system failures there, and repairs are made difficult by the small lot sizes.

Sensitive Receptors

Given the fragile ecological setting of the Avery Brook Homes project, it is important to identify the sensitive receptors that are likely to be impacted by this project. They are:

- The watercourse named Avery Brook, particularly where it enters the developer's property near its southeast corner and where the brook skirts the northerly boundary of the site.
- The watercourse named Billings Avery Reservoir, an open body of water that is part of the water supply reservoir system owned by Groton Utilities that provides drinking water to a population of over 40,000 in several towns in southeastern Connecticut, including Ledyard.
- The wetlands associated with, and hydrologically connected to, Avery Brook and Billings Avery Reservoir.
- The 18 proposed on-site private wells that would provide drinking water to the proposed 18 homes.
- Existing nearby private wells, particularly those located at homes directly to the west of the project.

The interconnectedness of these systems has not been documented by the developer. Groundwater below this 18-home development will be seriously impacted by numerous contaminants and those contaminants will migrate to these receptors. Most of that groundwater, carrying a host of wastewater contaminants, will reach Billings Avery Reservoir in a few months. On the site's northerly border, contaminated groundwater will reach Avery Brook in a matter of weeks. Under extreme storm conditions, the stormwater facilities will result in immediate flow of contaminants to Avery Brook. It is

critical to recognize that those contaminants that reach Avery Brook will then reach Billings Avery Reservoir in a matter of hours.

Any thorough assessment of potential environmental impacts must consider all of these sensitive receptors and their interconnectedness. The Angus McDonald report does not adequately address all of the environmental impacts.

Water Quality Contaminants of Concern

In residential projects with on-site wastewater disposal, on-site private potable wells and stormwater collection facilities, the important potential contaminants are:

- Nitrogen compounds, particularly in the nitrate form for which there is a drinking water standard of 10 mg/l. Nitrogen sources include wastewater disposal, lawn and garden fertilizer and stormwater runoff.
- Phosphorus compounds which can cause eutrophication of fresh surface waters. Sources include wastewater disposal, lawn and garden fertilization and stormwater runoff.
- Pathogenic organisms, particularly bacteria and viruses. These organisms are found in wastewater effluent and in stormwater that carries pet wastes.
- Suspended solids, such as silt, sand and debris that are conveyed to surface waters by storm runoff.
- Petroleum products, such as oil and gasoline. These are commonly found in stormwater runoff.
- Other organic compounds such as those found in wastewater effluent, lawn care products and stormwater runoff. Personal care products, pharmaceuticals and other persistent organic compounds can be expected to reach the groundwater from septic systems. One class of these pollutants is Volatile Organic Compounds (VOCs). Another is PFAS, the group of so-called "forever chemicals".
- Heavy metals found in stormwater runoff.
- Sodium resulting from the use of de-icing chemicals or water treatment system regenerants.

These contaminants are all associated with residential activities, and their water quality impacts must be dealt with, particularly in this very sensitive setting.

How has Developer Addressed these Contaminants and Their Impacts on Sensitive Receptors?

We have reviewed reports by the developer's consultants and found them to be incomplete in many significant ways. Those deficiencies are summarized in this memorandum. Where those submittals have partially addressed our concerns, our comments are also summarized here.

Nitrogen. The June 20, 2024 report from Angus McDonald estimates the average recharge concentration of nitrogen, a common approach for assessing nitrogen impacts on the groundwater and downgradient receptors. The selected approach is generally presented in the Connecticut DEEP Guidance for Design of Large-Scale On-Site Wastewater Renovation Systems (Reference 2). Angus McDonald has estimated an average groundwater recharge concentration of about 8 mg/l, based only on wastewater nitrogen loads; that is, excluding other sources of nitrogen.

I have applied a more up-to-date and complete nitrogen loading model (Reference 3) to estimate average nitrogen concentrations under several scenarios addressing the most significant input variables used by Angus McDonald.

Lawn and Garden fertilization. The Angus McDonald reports predicts an average recharge nitrogen concentration of 8.2 mg/l, assuming that there will be no nitrogen loading from lawn and garden fertilizers. While restrictions against lawn fertilization are proposed as deed covenants, such fertilizer restrictions are virtually impossible to enforce. My calculations indicate that the average recharge nitrogen concentration will be 8.6 mg/l if half of the homeowners choose to fertilize their lawns and 9.1 mg/l if all of the homeowners fertilize.

Occupancy. The Angus McDonald calculation of 8.2 mg/l is based on an average occupancy of 3.0 persons per home. Even without lawn and garden fertilization, the expected recharge concentrations will be 9.0 mg/l at 3.5 persons per home, and 10.9 mg/l at 4.5 persons per home. With lawn fertilization, the average concentrations will be 9.9 mg/l and 11.8 mg/l, respectively. Occupancy is an important determinant of groundwater nitrogen concentration, and a conservative approach is warranted because occupancy cannot be effectively regulated once the homes are built.

Dilution by uncontaminated recharge from 94 Stoddard Wharf Road. The Angus McDonald computations assume that all of the groudwater recharge from this adjacent lot will flow to the west and northwest and serve to dilute the nitrogen loading from the 18 septic systems in the proposed project. If the Angus McDonald groundwater contours are adjusted to account for groundwater flow into Avery Brook to the east and north of the site, it is apparent that only a portion of the recharge from 94 Stoddards Wharf Road will provide the claimed dilution. If the computation is modified to reflect only one-half of that recharge benefitting this project, the predicted nitrogen concentration would be 11.1 mg/l, with lawn fertilization and at an average occupancy of 3.5 person per home.

The Angus McDonald calculation predicts an average recharge concentration of 8.2 mg/l. The analysis summarized in this Wright-Pierce memo indicates significantly greater concentrations are likely. Another important consideration is that these calculations predict the average concentration across the site. In the areas of the project where septic system and potable wells line up in the same direction of the groundwater flow, the actual nitrogen concentrations will be well above the computed average. Even with the questionable assumptions used by Angus McDonald, there will be potable wells with concentrations higher than the 10 mg/l drinking water standard. How does the developer propose to address the exceedance of drinking water standards on site that his engineer seems to predict?

A more detailed evaluation of nitrogen dilution can be conducted using a technique laid out in the 2006 DEEP guidelines (Reference 2). Use of that approach will result in less groundwater dilution than assumed in the Angus McDonald report and higher predicted concentrations. That approach can be used to estimate the geographic areas of the project where groundwater nitrogen concentration will exceed 10 mg/l. If that approach had been used by Angus McDonald, it would show that an area of unacceptable nitrogen concentration would extend beyond the westerly and northerly boundaries of this project and would include the locations of several proposed private drinking water wells. That DEEP document states

that the developer must obtain an easement to provide the "additional effective area available for dilution". That additional diluting area will extend onto land not owned by the developer. The owner of that land is Groton Utilities, and it is certain that said easement will not be granted.

When nitrogen loading calculations such as these are used to assess future nitrate contamination, it is widely recognized that the threshold concentration should be 5 mg/l, not the 10 mg/l drinking water standard (References 4 and 5). If the average nitrogen concentration is below 5 mg/l then the likelihood of a 10 mg/l concentration at any one well is significantly reduced. All of the scenarios evaluated here predict average concentrations well above that 5 mg/l planning threshold.

I do not know if calculations of this sort were performed to support the Aljen Heights and Avery Hill Trailer Park developments. Given the similarity in lot sizes, it is conceivable that such calculations, if preformed, may have predicted **average** concentrations less than 10 mg/l. It is clear from the documents supporting the grant applications for the public water supply extensions, that actual nitrogen concentrations from individual wells have ranged from 5 to 15 mg/l (Reference 1).

Based on my calculation of a **site-wide average** nitrogen concentration of 11 or more mg/l under realistic conditions, it is clear that this project will not comply with the 10 mg/l standard at the property line. Further, it is evident that many of the 18 proposed on-site drinking water wells will experience nitrogen concentrations above the drinking water standard and will be unusable for potable purposes. The developer has not assessed the nitrate impacts on existing private wells to the west of the site, but they may be affected as well.

Angus McDonald estimates that the project will add about 450 pounds of nitrogen per year to the groundwater from wastewater disposal. I estimate that the nitrogen load will be 510 pounds per year to include loads from wastewater, lawn fertilization and stormwater infiltration, and as much as 700 pounds per year at higher occupancies. Angus McDonald has made no assessment of the impact of that large nitrogen load on Avery Brook or Billings Avery Reservoir. No assurances have been provided that such a high nitrate load will not impact the nitrogen-phosphorus balance in the reservoir, to the detriment of water quality.

Phosphorus. CT DEEP has established a methodology for assessing phosphorus transport, and that methodology has been applied to this project. From my experience on wastewater disposal projects with similar soils, it is my opinion that this proposed project is sufficiently close to Billings Avery Reservoir to allow phosphorus migration there in the future; however, the travel time of the phosphorus load will be many decades.

Pathogens. The Angus McDonald report predicts that the applicable groundwater velocity will be about 9 feet per day, and supporting graphics depict a 21-day travel time to assess the areas needed for pathogen inactivation. Since Angus McDonald has not depicted groundwater contours near the surface waters around the site, that report has not addressed pathogen transport to Avery Brook. When private or public drinking water supplies are nearby, DEEP requires that a 56-day travel time be used to address **virus** inactivation on-site (Reference 2). Angus McDonald has not applied that more appropriate criterion and therefore the associated conclusions about virus inactivation are not valid.

While the burden is on the developer to provide a more accurate assessment of groundwater directions and velocities and to apply the more appropriate travel time, it is my expert opinion that more complete and accurate data will demonstrate that viruses from this project will reach Avery Brook and Billings Avery Reservoir in less than the required minimum 56 days of travel time. Even with the shorter 21-day travel time, it can be concluded from the Angus McDonald report that many of the proposed on-site potable wells will be impacted by pathogens. No assessment has been provided of viral impacts on existing private wells to the west of the site, but such impacts may also occur.

It is a fundamental premise of the 2006 DEEP Guidance that the renovation of wastewater-related contaminants (including nitrogen, phosphorus and viruses) must be accomplished on-site, that is, on land owned or controlled by the proponent. The Angus McDonald analysis ignores that important precept. The developer cannot expect Groton Utilities to allow its public watershed lands and natural resources to be used to attenuate the pollutants from this project.

If widespread failures of on-site septic systems occur, and prompt and effective remediation is not accomplished, surfacing effluent can migrate to stormwater facilities and add to the bacterial and viral impacts of the project.

Suspended solids. The developer proposes stormwater infiltration facilities near the southeast and northeast corners of the site that will provide some removal of suspended solids. We have seen no estimates of the expected removal capabilities of the stormwater facilities, or of the impact of the discharge on Avery Brook, for any of the project's contaminants, all of which are considered pollution.

Petroleum Products. This class of contaminants is not addressed by the developer. Roadways and driveways will inevitably receive spills of oil and gasoline. With the rudimentary stormwater system proposed by the developer, contamination of Avery Brook and its associated wetlands is likely to occur.

Other organic compounds. Both wastewater effluent and stormwater contain organic contaminants other than petroleum products. Studies have documented the presence of these compounds in the groundwater under un-sewered residential developments and their subsequent travel to drinking water supplies (Reference 6). Regulatory threshold loadings and concentrations are still being developed, but the developer has not addressed this subject, even in narrative form. We are aware of a town whose public water supply wells have been shut down due to PFAS contamination from residential septic systems (Reference 7). As residential development has occurred in that town's water supply recharge area, nitrate concentrations have slowly risen at the wellhead. Significant PFAS concentrations were reached at about the time that wellhead nitrogen concentrations reached 5 mg/l. This example illustrates that groundwater nitrate concentration can be used as a surrogate for contamination by other contaminants found in septic system effluents.

Sodium. If a paved roadway is developed on this site, and turned over to the Town of Ledyard, the Town will be responsible for plowing and deicing that roadway. Such activities in close proximity to public water supply are inconsistent with Groton Utilities' responsibility to limit sodium concentrations in the drinking water. If water treatment systems are needed to address private well water problems, common regenerants will add sodium to the groundwater if not properly disposed. While Connecticut prohibits the discharge of spent regenerant into typical septic systems (Reference 8), that prohibition is widely ignored.

The developer of Avery Brook Homes has not provided information on existing groundwater quality (that might show the likelihood that private water treatment systems are needed). In the absence of such data, it should be presumed that there will be a sodium load reaching the reservoir, adding to the burden of Groton Utilities to reduce this contaminant in the water supply.

All contaminant concerns. Unsewered development near public water supplies has been shown, repeatedly, to cause significant impacts from multiple contaminants. An important document is the DEP Report to the State Blue Ribbon Commission on Housing (May 1989) that weighed all of the contaminants, and the expected impacts noted above. It concludes that such projects in this setting should be limited in density to one home per 2 acres of non-wetland area. Applying that standard to this project site would indicate that no more than 3 homes should be located here if these impacts are to be avoided. The developer has proposed a density 5.6 times as high. The state Department of Public Health considers high density unsewered residential development to be a "high risk" with respect to drinking water contamination because of the likelihood of contamination from several important water quality parameters (Reference 9).

Conclusion

Our review of reports by the developer's consultants reveals several key points:

1. A full assessment of potential impacts has not been provided.
2. The assessments we have reviewed are incomplete and/or significantly understate the project's impacts.
3. Unacceptable impacts from nitrates and viruses are certain.
4. While the viability of on-site private wells has not been directly addressed, the developer's assessments to date indicate that on-site wastewater disposal will preclude the use of private wells on this project.

While a 18-lot subdivision can be environmentally acceptable when public water is available and public sewers can remove sewage-related contaminants from the vicinity, such a project is not appropriate when on-site wells and septic systems are proposed in close proximity to a public water supply, and when the proposed private wells will be placed in areas of high nitrate loading from their own and nearby septic systems. A state task force has established a density threshold for projects like this, and the developer is proposing a project that is more than 5 times denser.

The developer may intend to further document the environmental impacts of this proposed project, addressing the many significant comments we have provided. However, it is my expert opinion that the project as currently configured will have unacceptable impacts on public and private drinking water sources and the wetlands and watercourses leading to and protecting those resources. Impacts on the nearby watercourses and associated wetlands will occur. Those impacts will be related to nitrogen, viruses, petroleum compounds, other organic substances and sodium.

References

1. Support Letter for Extension of Water to Aljen Heights, to Connecticut Department of Public Health from Amory Engineers PC, May 29, 2009.

2. *Guidance for Design of Large-Scale On-Site Wastewater Renovation Systems*, Connecticut Department of Environmental Protection, 2006.
3. Title 5 of the Massachusetts State Environmental Code, 310 CMR 15.000 and Guidelines for Title 5 Aggregation of Flows and Nitrogen Loading, February 22, 2016.
4. *Long Island Comprehensive Waste Treatment Management Plan*, 1978.
5. *Technical Bulletin 90-1*, Cape Cod Commission, April 1992.
6. *Yarmouth (Massachusetts) Water System Master Plan*, Kleinfelder, 2019.
7. Yarmouth Massachusetts 2023 Drinking Water Quality Report.
8. *Recommendations to the Connecticut General Assembly for Ensuring the Adequacy and Purity of New Private Drinking Water Wells, Connecticut Department of Public Health*, June 30, 2009.
9. Drinking Water Assessment and Source Protection Program, Connecticut Department of Public Health
10. *Nitrogen Contamination in Private Drinking Water Wells*, Connecticut Department of Public Health, April 2009.
11. *Relationship of Ground Water Quality to Housing Density, Cape Cod Massachusetts*, Persky, USGS, 1986.

Michael D. Giggey, PE

SENIOR VICE PRESIDENT

Project Assignment: Water Quality Technical Advisor

Education
M.S., Environmental Engineering, Stanford University

BS, Civil Engineering, Tufts University

Professional Registration
Massachusetts
Maine
Connecticut
New Hampshire

Experience
50 Years

Joined Firm
1978

Professional Affiliations
New England Water Environment Association
Water Environment Federation
National Groundwater Association
American Water Resources Association

Publications/Presentations
Giggey, M.D., Dudley, B., Ridley, C., "A Watershed Permit to Facilitate Nitrogen Management in Cape Cod's Pleasant Bay," New England Water Environment Association, January 2019

Giggey, M.D., Leonard, E., "A Better Mousetrap? Evaluating Non-Traditional Nitrogen Control Measures for Cape Cod and the Islands," New England Water Environment Association, January 2017

Experience Summary

As Technical Advisor, Mike is responsible for watershed management planning, assessment of water quality problems, coordinating the technical efforts of the diverse project teams, providing QA/QC on technical reports, and interfacing with regulatory agencies on difficult and non-traditional issues. Mike has special expertise in nitrogen management and decentralized wastewater collection, treatment, and disposal. His 50 years of professional experience include a wide range of environmental engineering projects. He has served as project engineer or project manager on the design and construction of roadways, solid waste management facilities, organic waste composting, sewers, and wastewater treatment plants. He often provides assistance to planning commissions, planning boards, and boards of health on water quality issues and has regularly served as an expert witness in regulatory and adjudicatory disputes.

Relevant Project Experience

Climate Adaptation Action Plan, Pleasant Bay, MA

Evaluated climate resiliency options for eight case studies of municipal facilities for water supply, stormwater management, wastewater management and public Bay access. Assisted in the development of sea level rise projections, and a framework for evaluation of grey and green infrastructure. Participated in public outreach activities.

Watershed Permit, Pleasant Bay, MA

Served as lead technical advisor to the Pleasant Bay Alliance in the development of a targeted watershed management plan that became part of the first-in-Commonwealth watershed permit for Chatham, Harwich, Brewster, and Orleans. Assisted in permit negotiations with Massachusetts DEP for both the original 2018 permit and for the updated permit expected in 2024. Prepared annual reports to document permit compliance including documentation of nitrogen removal credits.

Cape Cod Area-Wide Water Quality Management Plan, MA

For the Cape Cod Commission, assessed the cost information contained in the 208 plan update to judge the accuracy and relevance of a large database of cost information for traditional and non-traditional nitrogen management approaches.

Nitrogen Credit Trading Evaluation, Cape Cod, MA

For the Pleasant Bay Alliance, prepared a report to document the applicability of nutrient credit trading approaches to reduce nitrogen control costs in the Pleasant Bay watershed.

Giggey, M.D., "How Can Martha's Vineyard Towns Incorporate Non-Traditional Approaches into Their Nitrogen Management Plans?" MVC Innovation Conf, May 2016

Giggey, M.D., Richardson, M., "Twenty Years of Biosolids Composting," New England Water Environment Association, January 2015

Giggey, M.D., "Survey of New England Drip Dispersal Experience and Costs," New England Water Environment Association, January 2014

Giggey, M.D., Hoyt, J., "Drip Dispersal of Wastewater Effluent Finds Uses in New England," *New England Water Environment Association Journal*, Fall 2014

Giggey, M.D., Ridley, C., "Managing Growth in Nitrogen-Sensitive Watersheds Can Reduce Cape Cod Wastewater Infrastructure Costs," New England Water Environment Association, January 2014

Giggey, M.D., "Vertical Effluent Disposal Systems Offer Cost and Space Savings", New England Water Environment Association, January 2013

Giggey, M.D., "Survey of New England Experience with Drip Dispersal for Effluent Disposal", New England Water Environment Association, January 2012

Giggey, M.D., "Managing Nitrogen Loads in Coastal Embayments: The Benefits and Hurdles of Watershed-Based Solutions," New England Water Environment Association, January 2011

Groundwater Recharge Permitting, Yarmouth, MA
Provided technical assistance to the Town of Yarmouth related to its need for a groundwater discharge permit for its planned new water resource recovery facility. Led a team of town, state, and consultant representatives to determine how best to address concerns over water table rise and its impacts on wetlands near the recharge site.

Water Quality Plan, Martha's Vineyard, MA
For the Martha's Vineyard Commission, prepared an overview of technologies relevant to the control of diverse nitrogen sources to protect the island's coastal embayments.

Stormwater Nitrogen Removal Evaluation, Cape Cod, MA
For the Pleasant Bay Alliance, prepared a report to assess the feasibility for Pleasant Bay watershed towns to achieve nitrogen removal credits from stormwater management activities they have completed or will undertake.

Nitrogen Management Planning, Orleans, MA
Serving as principal-in-charge for the implementation of a nitrogen management plan to address the Town's obligations under the Pleasant Bay Watershed Permit and those obligations expected under upcoming permits for Nauset Harbor and Rock Harbor. Documenting nitrogen removals from traditional sewer systems and from shellfish aquaculture and a permeable reactive barrier.

Water Suppply Protection, Groton, CT
Served as expert witness in hearings related to local approval of a 26-lot subdivision proposed to be located adjacent to a public water supply reservoir in a neighboring town.

Evaluation of Decentralized Wastewater Options, Old Saybrook, CT
Served as technical advisor in a study that compares a 77,000-gpd public satellite wastewater treatment plant with the repair and upgrading of 1,960 existing septic systems. Service area is seasonal waterfront on Long Island Sound. Identified and evaluated diverse sites for effluent disposal to the land, using drip dispersal.

Decentralized Wastewater Treatment and Disposal, Cohasset, MA
Principal-in-charge of the permitting and design of a decentralized wastewater treatment and disposal system for a 200-unit apartment complex. Provided testimony in relation to an appeal to the Housing Appeals Board, and expert advice in conjunction with an appeal of the DEP groundwater permit. Wastewater is treated in a 38,000-gpd MBR and disposed of via rapid infiltration and drip dispersal.

Wastewater Treatment Plant, Pinehills Community, MA
For a private developer, provided planning, design and construction services for a 0.15-mgd SBR treatment plant on a 300-acre parcel in Plymouth. Provided oversight of the testing and design of 5 rapid infiltration basins for disposal, with downgradient water recovery for irrigation.

Leonard, E., Giggey, M.D., "Managing the Cost of Future Growth to Ensure the Sustainability of Small Wastewater Systems," New England Water Environment Association, September 2010

Giggey, M.D., "Countering the Fear of Uncontrolled Growth: Tools for Ensuring that your Wastewater Project is 'Growth Neutral'," New England Water Environment Association, January 2010

Giggey, M.D., "Can Decentralized Systems Save Money? Comparing the Costs for Individual, Cluster, Satellite and Traditional Centralized Wastewater Management," New England Water Environment Association, January 2009

Giggey, M.D., "Cluster Systems: A Decentralized Approach to Enhanced Wastewater Management," Wastewater Workshop Series, August 2008

Giggey, M.D., and B. Murphy, "Role of Local Boards of Health in the Oversight of Private Wastewater Treatment Facilities," New England Water Environment Association, January 2008

Giggey, M.D., "Focused Wastewater Planning: What Makes a Successful CWMP?" Cape Cod Commission Conference Restoring and Protecting Coastal Waters, November 2006

M.D. Giggey, "Porosity of Biofilter Media," *Proceedings, WEF Conference on Biofiltration*, Los Angeles, October 1995

Evaluation of Groundwater Impacts, North Kingstown, RI
On behalf of the Planning Commission, conducted nitrate loading studies for two development proposals involving a golf course residential community and an affordable housing project.

Evaluation of Upgrading Needs at Commercial Wastewater System, Wrentham, MA
Principal-in-charge for evaluation and design of upgrading of a 75,000-gpd treatment system with subsurface disposal. The treatment system includes an MBR with supplemental treatment processes to allow effluent reuse for toilet flushing in a shopping center.

Design and Permitting for Effluent Disposal using Wicks, Tisbury, MA
Principal-in-charge of evaluation of effluent disposal and reuse sites, focusing on protection of nitrogen-sensitive coastal embayment. Designed and permitted a wick-type disposal system that is now in place for 200,000 gpd.

Treatment Plant and Wick Disposal System, West Island, Fairhaven, MA
Served as principal-in-charge of the planning, design, and construction phases of a 100,000-gpd RBC treatment plant. Conceived, designed, and permitted an innovative effluent disposal system consisting of 4 wicks that convey tertiary effluent through a surficial layer of dense glacial till.

Sewer System and SBR Wastewater Treatment Plant, Oak Bluffs, MA
Served as principal-in-charge of Wright-Pierce's work in the planning, design, and construction phases of the sewerage system for this Martha's Vineyard community. The project includes a combination gravity and low-pressure sewer system, a 0.32-mgd SBR plant, and a 7-acre subsurface disposal system in Ocean Park.

Review of Private Development Projects, Yarmouth, MA
For the Board of Health, provided technical review of over ten development proposals utilizing advanced treatment of wastewater, primarily for nitrogen control. Conducted the annual review of operations at six private wastewater treatment facilities.

Evaluation of Vacuum Sewers, Provincetown, MA
Conducted an evaluation of the failure of a vacuum sewer system at a resort community and critiqued proposed design and operational improvements.

Evaluation of Septic System Impacts on Groundwater, Nantucket, MA
Served as expert witness in a dispute over potential groundwater impacts of private septic system on nearby private drinking water wells. Conducted nitrate loading analysis and performed groundwater modeling to predict possible impacts.