

Date: **August 22, 2025 (Revised October 16, 2025)**
Project No.: **20985**
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From: **Mike Giggey**
Subject: **Orleans Nitrogen Management in Mill Pond Sub-Watershed
Urine Diversion**

Ten options have been identified for reduction in nitrogen load in the Mill Pond sub-watershed. One of those options is the use of individual urine diversion systems to reduce septic load. This option is described and evaluated in this memo.

Description

This option involves the installation of urine diversion (UD) systems on some or all of the developed parcels in the sub-watershed. The UD system would include new plumbing fixtures that allow users to divert urine into a storage tank, thus separating it from the other human wastes received by toilets. The urine storage tank would be pumped occasionally and the urine taken to the Orleans WWTF for treatment and disposal. The existing septic tank would continue to receive shower and kitchen wastes, as well as fecal matter from upgraded toilets. The groundwater recharge from the leaching field would have a lower nitrogen concentration in homes with UD systems, perhaps 50% to 60% less than the recharge from typical systems.

Ownership

We should expect that UD systems in the Mill Pond sub-watershed would be privately owned and maintained. The Town would establish ground rules for technical aspects of the UD systems and could perhaps organize an equipment procurement to establish a reduced price to be paid by homeowners. The Town would also need to track collected urine volumes to document nitrogen removal credits under a future watershed permit. Individual property owners would be responsible for individual system cost and system maintenance and eventual replacement.

Performance and Extent

Although it has been studied for decades, urine diversion is still a relatively new waste management technique in the United States and there are few if any operating projects designed to comply with nitrogen-based TMDLs. Investigations to date have shown that urine accounts for about 80% of typical residential septic nitrogen load. There is very little data available of how much of a home's urine is actually diverted once new plumbing is in place.

Average water use in the Mill Pond sub-watershed has been about 167 gallons per day. Using traditional nitrogen accounting (as per the Massachusetts Estuaries Project—MEP-- with a groundwater impact at 26.25 mg/l from a Title 5 system), the average septic load is about 5.4 kg/yr per home. If 80% of the per-home septic load is associated with urine, then the urine load would be 4.3 kg/yr per home, assuming

100% capture by modified plumbing. Nitrogen load removal would be as follows for a range of UD system capture percentages:

- 80% urine capture 64% overall nitrogen removal 3.4 kg/yr removal per home
- 70% urine capture 56% overall nitrogen removal 3.0 kg/yr removal per home
- 60% urine capture 48% overall nitrogen removal 2.6 kg/yr removal per home
- 50% urine capture 40% overall nitrogen removal 2.1 kg/yr removal per home

With a target septic load removal of 750 kg/yr, UD systems would be needed on anywhere from 220 to 280 homes (80% to 100% of all homes in the sub-watershed). Note that UD systems could achieve only 730 kg/yr septic removal at 60% urine capture and 590 kg/yr at 50% urine capture, even if installed at all 280 homes. If 750 kg/yr is the target, across-the-board UD systems are only sufficient if they achieve 62% urine capture or better, on average.

In the upcoming comparison of alternatives, this option should be characterized as needing 250 UD systems, capturing 70% of the urine. For comparison, a traditional municipal sewer extension would remove 100% of the septic load from each sewered home (5.4 kg/yr), requiring that 140 homes be sewered to achieve the 750 kg/yr target removal.

Costs

Costs are difficult to estimate given the evolving technology and regulatory requirements. Compared with municipal sewerage, on a per-home basis, UD systems should have a lower first cost (perhaps \$10,000 to \$20,000 per home), and a much lower costs for operation and maintenance. The most uncertain costs are those associated with house-specific plumbing changes, the specifics of sizing and locating the urine storage tank, and the costs for trucking and disposal of the collected urine.

Speed in Water Quality Improvement

The use of UD systems would reduce septic loads at their source. For a home at the far reaches of this sub-watershed, prior septic system nitrogen discharges would continue traveling with the groundwater for many years before the reduced load would reach Mill Pond. A more rapid impact would occur for homes close to the pond. In general, the benefits of widespread UD systems would not be achieved for 10 or more years after installation of the systems.

Predictability of Performance

Despite claims by UD system vendors, it is very hard to predict the performance of individual systems due to many factors, especially the diligence of the owners, guests and renters to properly utilize the diversion systems. The volume of collected urine, and the nitrogen content of the urine, can be determined only after long-term operation of these systems, in this setting. A plan based on say 200 homes, might be found to be inadequate and an additional 20 homes might need to install these systems to reach a target aggregate nitrogen removal. If the plan requires all of the homes to have urine diversion, the flexibility to add more in the future would not exist.

Reliability

In their fundamental form, UD systems should be very reliable mechanically. UD systems involve no mechanical equipment, unless home layout necessitates small pumps to transport urine to the storage tank. The collection/transport vehicle would be able to empty the urine storage tank by vacuum. While these systems should be very reliable mechanically, their nitrogen reduction reliability is solely determined by the diligence of the users.

Need for Large Town Capital Expenditure

Orleans has committed to remove large amounts of nitrogen in the Pleasant Bay watershed under the 2018 Watershed Permit. The very high costs of that commitment mean that the Town has limited ability to undertake costly nitrogen removal projects in other watersheds, like the Nauset Harbor system. Therefore, a plan based on UD systems has the advantage that the costs would be largely borne by residents of this sub-watershed, with only a small Town expense to organize and oversee the system.

Regulatory Acceptability

Mass DEP has been increasingly supportive of non-traditional nitrogen control approaches, especially those tested at the Massachusetts Alternative Septic System Technology Center (MASSTC). Nonetheless, approval of these systems for addressing nitrogen-based TMDLs is a significant unknown factor in their viability. Gaining nitrogen removal credits under a watershed permit would be somewhat more cumbersome than with a sewer project, and the possibility for regulatory hurdles is unknown.

The Town of Falmouth is undertaking a pilot project, in conjunction with MASSTC, to explore the feasibility and performance of UD systems. A Fall 2025 Town Meeting appropriation is being sought to enable that pilot project to proceed. Attached is a summary of the Falmouth demonstration project.

Public Acceptability

The costs and impacts of this option would affect only those property owners who install UD systems, and impacts on the remainder of Orleans residents would be minimal. Acceptability will hinge on the outlook of the homeowners that would be required to (or would voluntarily agree to) install UD systems and any cost sharing policies that the Town might put in place. A Town-funded incentive program is one way to encourage private investment in these systems; however, the success of such incentive programs on Cape Cod has been limited.

Flexibility in Face of Unknown TMDL and Applicability to a Phased Approach

This option is very amenable to a phased approach. There would be no need to install all of the needed UD systems all at once. Properties with high occupancy that are located close to the pond could be fitted with UD systems in an initial phase. Other parcels could install UD systems in later phase, and/or other options could be implemented to supplement the first-phase UD systems. Such a phased approach is an appropriate way to deal with the fact that the nitrogen removal goal is quite speculative, absent an updated MEP report and the setting of TMDLs.

Environmental Impacts

Unlike most public works projects, the impacts during construction/installation of these systems would be within the home or just outside the home (a buried urine storage tank in homes without basements). In terms of long-term operational impacts, there may be the potential for odors from the urine storage tanks which must be vented to the atmosphere. (One drawback of this approach is the escape to the atmosphere of ammonia gas, which is deposited on the land or in nearby water bodies during rain events.)

Urine contains about 80% of the typical home's nitrogen production, but it also has about one-half of the phosphorus load and a high percentage of the Contaminants of Emerging Concern (contaminants found in personal care products, pharmaceuticals, etc.). With widespread use of UD systems, there could be a centralized processing facility that could convert the nutrients in urine into a salable fertilizer product. While possible, such a central facility is not likely to be cost-effective on Cape Cod in the near future.

Impact on the Orleans WWTF

The existing Orleans wastewater treatment facility (WWTF) has a finite capacity to treat and dispose of municipal wastewater. It will need to be expanded to handle all of the wastewater that would be collected in the current 16-phase sewer master plan. The use of UD systems would reduce the nitrogen load somewhat, but would appreciably reduce the volume of wastewater from this service area, compared with a traditional sewer system, thus helping to defer the expected large capital expense of WWTF expansion.

Ease of Implementation

The use of UD systems should be relatively straightforward, after a system of town oversight has been established and selected homeowners have agreed to participate. However, there is limited experience with these two early steps, and they will require time and expense to complete.

Summary of Advantages and Disadvantages

The use of urine diversion systems has these principal benefits:

- This could be a largely private solution that can be implemented with only a small impact on Town finances.
- It avoids the wastewater flow to the Orleans WWTF that would occur with sewerage.
- It is easily implemented in phases and/or combined with other alternatives.
- It is a relatively low-cost system to implement and operate.

The principal drawbacks include:

- The success of the system depends on the diligence of the homeowners, guests and tenants.
- The performance of the UD systems varies from home to home and is hard to predict.
- Some degree of Town oversight would be needed.

The August 22, 2025 draft of this memo was reviewed by the WMAC at its August 28, 2025 meeting. This updated memo reflects comments made by the WMAC and Town staff at that meeting.

Town of Falmouth – Urine Diversion Toilet Wastewater Demonstration Project

Summary of the ongoing demonstration effort as of August 28, 2025.

- **Purpose & Approach:** UD toilets separate urine, collect it in a holding tank, and recycle it as fertilizer – reducing nitrogen/phosphorus before reaching estuaries. MassDEP may award nitrogen-reduction credit if the pilot proves effective.
- **Project Partners:** Town of Falmouth with Barnstable County's Massachusetts Alternative Septic System Test Center (MASSTC).
- **Scale & Design:** Target of ~50 UD systems in volunteer homes with quarterly monitoring for three years.
- **Timeline:** Tentative start Spring 2026; installation, permitting, and monitoring to follow.
- **Participants & Logistics:** Over 150 residents expressed interest. Tanks ~200–500 gallons; expected pumping about twice per year.
- **Regulatory Pathway:** Pursuing MassDEP I/A approval; Plumbing Board variances needed; MDAR oversees fertilizer product approvals.
- **Funding Status:** In July 2025, MASSTC received >\$416,000 in state funds. Estimated install costs ~ \$4,000 per toilet (plus tanks/fixtures).
- **Program Rules & Waivers:** Limited waivers for ~25 volunteers under discussion; program may interact with sewer betterments.
- **Prior Local Experience:** 2012–2014 eco-toilet project provided early lessons but had low participation.
- **Bottom Line:** A 50-home, three-year pilot is advancing, with Spring 2026 launch planned. Success could establish UD as a credit-earning tool in Falmouth's watershed management.