Town of Charlestown Office of Onsite Wastewater Management and Laboratory of Applied Watershed Management

2023 Interim Summary: Nutrient Loading, Coastal Water Resource Risk Assessment and Funding Strategies for Mitigation
May 2023

TOWN OF CHARLESTOWN

Town of Charlestown, R.I. On-Site Wastewater Management Program

Water Resource and Environmental Protection

Charlestown Laboratory of Applied Watershed Management

Background

Charlestown's coastal zone contains the highest density of septic systems in the Town. Our delineated coastal watershed encompasses one-third of Charlestown's land area but contains nearly 60% of the Towns developed parcels. Charlestown's economy is primarily based on our coastal zone where tourism, recreation, and coastal businesses thrive. In fact, one of the most productive oyster farms in the eastern United States resides in Ninigret Pond. Recent Town data indicate that nearly 70% of municipal revenue is generated from within the coastal watershed of Charlestown (Charlestown, 2023).

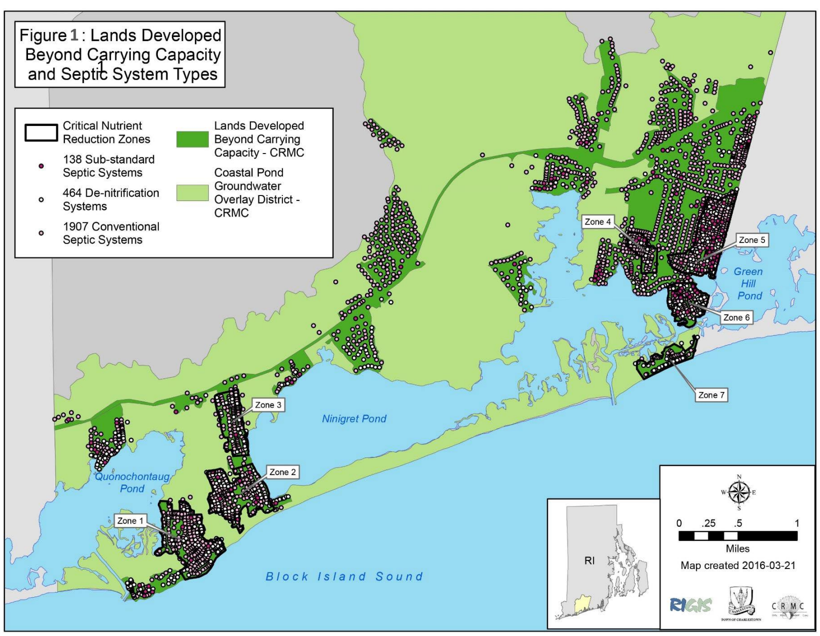

Figure 1 – Density of septic systems in the Charlestown Coastal Watershed

Every household and business in Charlestown relies only on septic systems to manage wastewater onsite and only on groundwater for our sole potable water source. Onsite Wastewater Treatment Systems (OWTS) (i.e., septic systems) can be an effective method of managing wastewater on an individual property in the absence of a sewer system by treating and recycling wastewater. However, even in the best circumstances, not all pollutants are removed during wastewater treatment (Lusk et al., 2017). Conventional septic systems are typically effective at removing bacteria and pathogens, however, the pollutant nitrogen remails at elevated concentrations in septic effluent from older conventional septic systems and is problematic for both human health and surface water resources (Nolan and Hitt, 2006).

Wastewater from septic system is discharged to the subsurface and intersects groundwater after percolating through the soil beneath the systems leachfield. This wastewater then travels within the groundwater in distinct tubular shaped plumes (Valiela et al., 1997) and may extend in length beyond 130m (430-feet) (Robertson et al., 1991). When these plumes comingle, concentrations of pollutants compound and remain elevated where private wells intersect the groundwater. Nutrient laden groundwater in the coastal watershed ultimately discharges to our three Salt Ponds by outwelling where nutrient enrichment results in algae blooms and decreased water quality (Masterson et al., 2007; Nixon and Buckley, 2007).

Sewering would translate the pollutant load elsewhere, but this option is fiscally and technically infeasible (Woodard & Curran, 2011). The Town's only option to manage the primary source of groundwater quality impact is to help facilitate the removal of older substandard septic systems with nitrogen reducing OWTS technologies through its Onsite Wastewater Management (OWM) Program. Each new modernized OWTS that replaces an older conventional system can typically reduce the nitrogen load discharged to the ground by two thirds from the conventional systems loading (Amador et al, 2018). The Town and our partners at the University of Rhode Island Laboratory of Soil Ecology and Microbiology and the Onsite Wastewater Resource Center have been sampling wastewater effluent quality from existing nitrogen reducing systems for the last eight years and have determined that when properly managed, these systems are highly effective at pollutant reduction (Ross et al., 2020; Lancellotti et al, 2017; Dowling et al, 2021).

Analysis of Groundwater Nitrogen Concentrations and Mass Loading and Impact on Water Quality

Charlestown's OWM Office has correlated a statistically significant linear relationship of groundwater nitrogen concentrations to the density of septic systems in our coastal watershed. Measured groundwater data indicate that the lowest expected concentration of groundwater nitrogen in our coastal watershed is 2 mg/L (Dowling et al., 2023). Natural background concentrations of nitrogen in groundwater are 0.5 mg/L. Concentrations higher than that indicate anthropogenic inputs (Shaider et al., 2016; RIDOH, 2010).

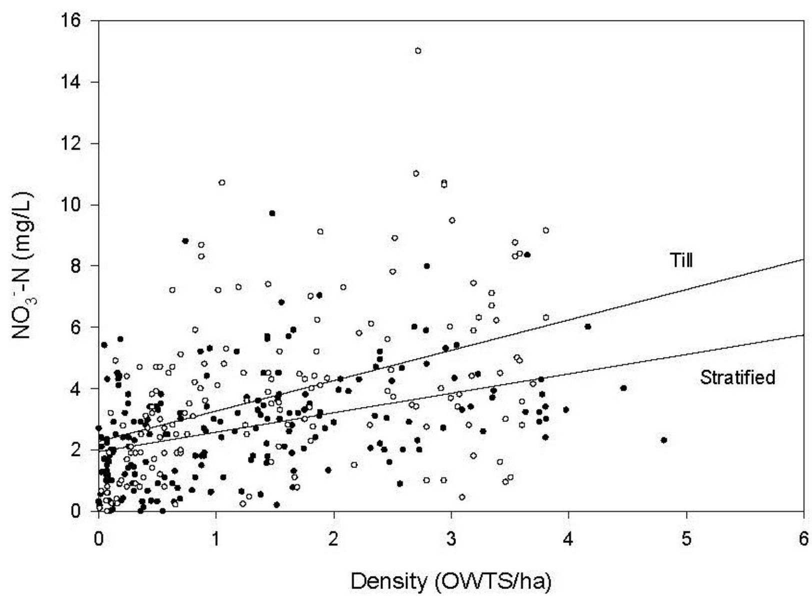

Figure 2 - Linear regression analysis of groundwater nitrate concentrations from 367 private drinking water wells in Charlestown compared to density of septic systems at the sample site by hectare (1 ha = 2.5 acres). Results are graphed for the two aquifer types in Charlestown, glacial till and stratified sand/gravel.

Impacts to drinking water quality are exacerbated in the coastal zone since potable wells need to be installed in the shallow aquifer, typically at depths of less than 40-feet in the proximity of the coast to avoid intercepting deeper and denser salt water. Treated and recycled wastewater from OWTS discharges nutrients into the shallow aquifer which comingles with this shallow groundwater utilized for potable water.

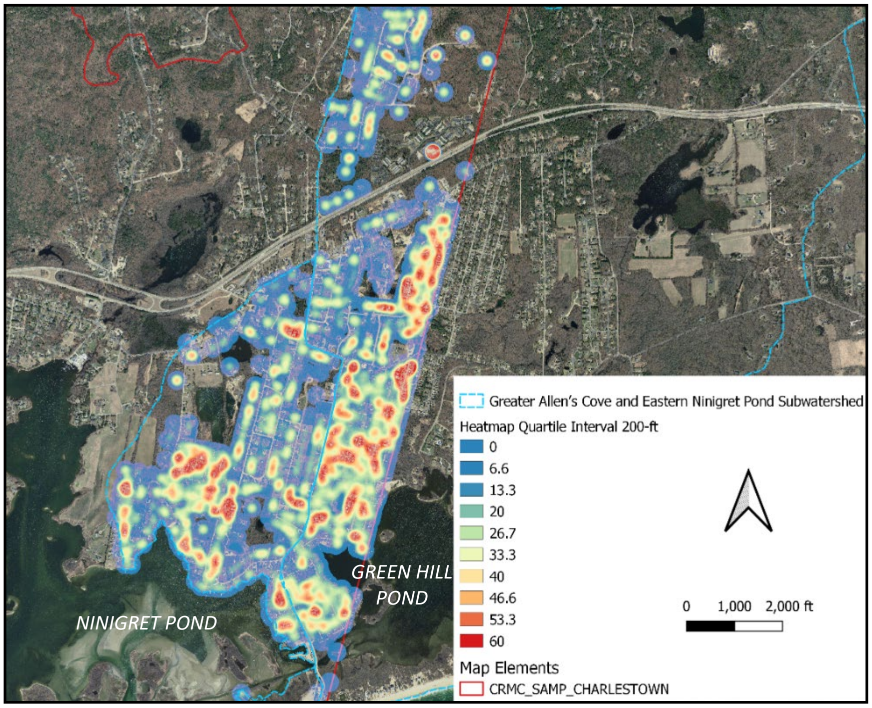

Figure 3 - Greater Allen's Cove and Eastern Ninigret Pond sub-watershed SNEP pilot watershed. The heatmap reflects annual loading rates of Kg-N/yr based on loading calculations which include - # of bedrooms, residency, and system type.

In the densest developed areas of Charlestown's coastal zone, where the density of OWTS exceeds 10 per acre, groundwater nitrogen concentrations are above the EPA Action Levels of 5 mg/L and some exceed the Maximum Contaminant Level (MCL) drinking water standard of 10 mg/L. In fact, the mean measured groundwater nitrogen concentration in our coastal zone is approximately 3.2 mg/L, which is indicative of "high-risk" for groundwater pollution (Dowling et al., 2023; RIDOH, 2010). URI Cooperative Extension has determined that 80% of this groundwater nitrogen originates from OWTS in the densest developed areas of the coastal watershed (URI NEMO, 2014). It is not anticipated that impacts to this extent are prevalent outside of the coastal zone based on land use, where intermittent elevated development densities are surrounded by larger undeveloped and lightly developed parcels where groundwater recharge can dilute septic plumes and associated nutrient concentrations.

Nutrient "concentrations" versus nutrient "loading" should be considered. Concentrations of nutrients in groundwater are an acute measure, from which regulatory thresholds are established. For example, the Maximum Contaminant Level standard for nitrogen in drinking water is 10 milligrams per liter (mg/L), and the nitrogen reducing OWTS nitrogen discharge standard is 19 mg/L. This is a measure of the amount of pollutant in a solution at a given time. The loading of pollutants, that is the total "mass" of pollutants discharged to an aquifer over time is equally important for affecting chronic water quality impairments.

<u>Example:</u> A one-bedroom conventional OWTS typically discharges nitrogen to the subsurface at a concentration of 65 mg/L with a daily flow of 435 liters per day results in a total load of 10.3 kilograms (22.7 pounds) per year. A five-bedroom conventional OWTS has a daily flow of 2,175 liters per day and results in a total load of 51.6 kilograms (113.8 pounds) per year. So, flow matters, higher flow leads to higher loading and more mass of pollutant discharge to chronically impact water quality. Comparatively, a three-bedroom nitrogen reducing OWTS typically discharges nitrogen to the ground at a concentration of 19 mg/L with a daily flow of 1,305 liters per day. This results in a total discharge of 9.1 kilograms (20.1 pounds) of nitrogen per year.

To better understand both the acute and chronic nitrogen impacts to our coastal watersheds from OWTS, the Charlestown OWM Office has determined annual loading of nitrogen in mass per year within the Town's coastal watershed and is summarized here:

Total Septic Systems Townwide = 5,070

- N Reducing 879 (17.2%)
- Conventional/Other 4,197 (82.8%)

Total Septic Systems in the Coastal Watershed = 2,962, (58% of Charlestown Systems located in Coastal Watershed)

- N Reducing 798 (26.9%), 91.4% of N reducing systems located in Coastal Watershed
- Conventional/Other 2,164 (73.1%), 51.6% of Conventional located in Coastal Watershed

We have calculated nitrogen loading for every septic system in the Coastal Zone by applying daily flow, occupancy, system type and drainfield type. In the Coastal Zone a total of **50,158 kg** (**110,580 pounds**) of nitrogen per year are discharged to the groundwater from septic systems. Of this total;

- **45,496.4 kg/year** originates from the 2,164 conventional systems, an average of 21.0 kg/yr/system, and

- **4,661.4 kg/year** originates from the 798-nitrogen reducing systems, an average of 5.8 kg/yr/system.

- If all conventional OWTS in the coastal watershed were upgraded to nitrogen reducing technology, the annual nitrogen pollution load would be **reduced by 30,027 kg/year**, to a total load of 19,475 kg/year, a **38% reduction** (Dowling & Amador, 2023).

Summaries of all septic system types Townwide and in the Coastal Watershed are attached as **Table 1** and **Table 2**, respectively.

The implementation of nitrogen reducing systems comes at a high cost, currently nearly always over $30,000 per system. No incentive or any financial option exists outside of loans for OWTS owners to mitigate their own pollutant load by pre-emptively upgrading their outdated septic system to modern OWTS technology.

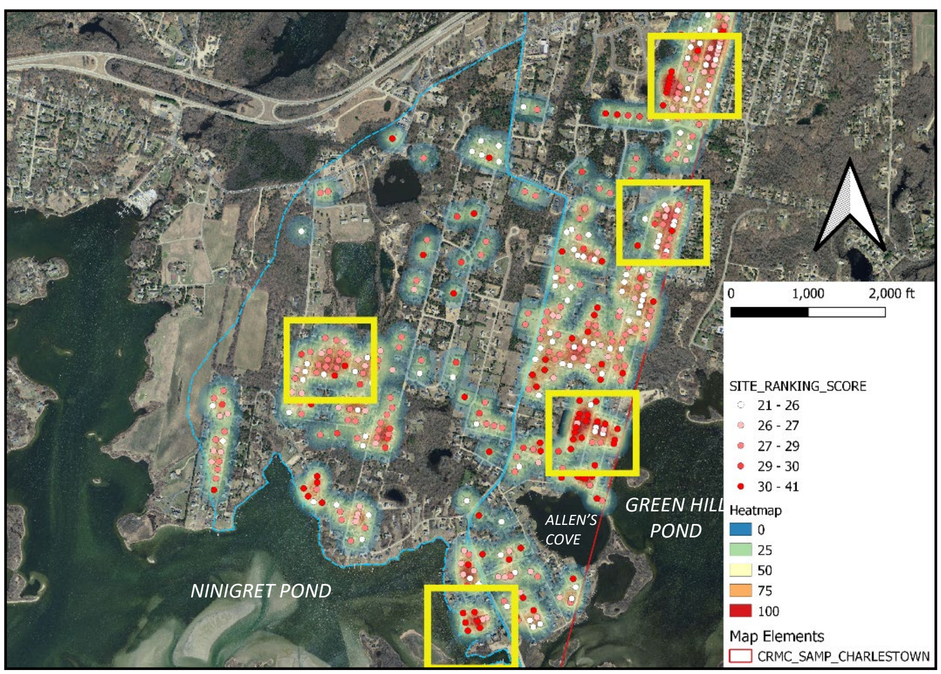

Figure 4 – Charlestown Coastal Watershed critical resource area nutrient loading hotspot analysis and delineation of targeted mitigation areas under an EPA funded Charlestown septic system upgrade program

Table 1 - Townwide - Onsite Wastewater Treatment Systems Breakdown 4-21-23

		Soil Treatment Area Option Installed		
System Type	**Systems Installed**	**BSF**	**Pressure Dosing**	**Gravity**
FAST	109	31	2	76
HydroKinetic	12	5	6	1
Norweco Singulair	104	31	10	63
Cesspool	3	0	0	3
Composting	10	0	0	10
Conventional	4070	0	0	4070
Drip Irrigation	1	0	1	0
Fuji Clean	5	0	5	0
Holding Tank	14	0	0	0
LSTA	4	0	4	0
Metal Tank Substandard	15	0	0	15
Peat Filter	1	0	1	0
RUCK	22	0	0	22
Recirculating Sand Filter	9	0	4	5
Single Pass Sand Filter	1	0	1	0
Septitech	6	4	1	1
Substandard	107	0	0	107
Advantex	577	364	103	110
Totals	**5070**	**435**	**138**	**4483**

		% Total
Total N Reducing	873	17.2%
Total Conventional/Substandard	4197	82.8%

Soil Treatment Area Option	**Systems Installed**	**BSF**	**Pressure Dosing**	**Gravity**
% of N Reducing	873	49.8%	15.8%	32.99%

Notes - Data obtained from Town of Charlestown Onsite Wastewater Management database queried on April 21, 2023. Data represent number of installations at that time and will change.
Gravity soil treatment area options use no pressure dosing.
Bold system types represent nitrogen reducing technologies or methods of wastewater management
BSF - Bottomless Sand Filter
100% of conventional systems use gravity soil treatment area

Table 2 - Charlestown Coastal Watershed - Onsite Wastewater Treatment Systems Breakdown 4-24-23

		Soil Treatment Area Option Installed			Assumed Occupancy	
System Type	**Systems Installed**	**BSF**	**Pressure Dosing**	**Gravity**	**Seasonal**	**Full Time**
FAST	91	26	2	63	47	44
HydroKinetic	12	5	6	1	7	5
Norweco Singulair	100	31	9	60	56	44
Cesspool	1	0	0	1	0	1
Composting	10	0	0	10	10	0
Conventional	2068	0	0	2068	926	1142
Drip Irrigation	1	0	1	0	0	1
Fuji Clean	5	0	5	0	0	5
Holding Tank	14	0	0	0	12	2
LSTA	4	0	4	0	0	4
Metal Tank Substandard	11	0	0	11	9	2
Peat Filter	1	0	1	0	0	1
RUCK	22	0	0	22	15	7
Recirculating Sand Filter	8	0	4	4	7	1
Single Pass Sand Filter	1	0	1	0	1	0
Septitech	5	3	1	1	3	2
Substandard	82	0	0	82	60	22
Advantex	526	327	97	102	308	218
						0
Totals	**2962**	**392**	**131**	**2425**	**1461**	**1501**

Salt Ponds Region (2961)	Installed	% Total	**Town Wide (5070)**	% Installed in Salt Ponds Region
Total N Reducing	798	26.9%	873	91.4%
Total Conventional/Substandard	2164	73.1%	4197	51.6%

Soil Treatment Area Option	**Systems Installed**	**BSF**	**Pressure Dosing**	**Gravity**	**Seasonal**	**Full Time**
% of N Reducing	798	49.1%	16.4%	32.96%	56.77%	40.23%

Loading Calculation	**kg/year**
Nitrogen Reducing OWTS	**4,661.4**
Conventional/Substandard	**45,496.4**

Notes - Data obtained from Town of Charlestown Onsite Wastewater Management database queried on April 24, 2023. Data represent number of installations at that time and will change.
Gravity soil treatment area options use no pressure dosing.
Bold system types represent nitrogen reducing technologies or methods of wastewater management
BSF - Bottomless Sand Filter
100% of conventional systems use gravity soil treatment area
Loading calculations based on, occupancy (seasonal/full time), OWTS design flow (# bedrooms), System type and drainfield type. Final effluent concentrations used are 65mg/L from Conventional and substandard, 19 mg/L for N reducing with BSF or gravity drainfield, and 13 mg/L for N reducing with pressure dosing drainfield

External Funding

A goal of the OWM Office over the last eight years has been to seek funding to facilitate the upgrade of the most high-risk septic systems within our most critically impacted watersheds. As part of a $1M US EPA Southeast New England Program (SNEP) grant received by the Town in 2016, the OWM office developed a risk assessment-based procedure to identify OWTS at most risk for impacting groundwater and surface water quality in our most sensitive areas relative to public health and resource protection. Through this risk assessment and subsequent outside funded implementation programming, the OWM office has thus far facilitated the grant funded, cost sharing replacement of 21 substandard, older, polluting septic systems in the most critical of areas of our Town with modern nitrogen reducing technologies. These upgrades alone constitute an estimated nitrogen annual pollutant load reduction of ±227 kg/year (500 lb/year) (Dowling et al., 2021). Charlestown's OWM Office site selection risk assessments and cost sharing design for OWTS upgrade funding has been utilized by EPA New England Region 1 as a template for other communities in the northeast region with similar challenges and seeking to manage coastal resources.

Through Town funding and EPA grant match, the Charlestown OWM and our partners at URI have developed a design standard and are currently assessing four installations of the Charlestown Experimental Nitrogen Reducing Layered Soil Treatment Area (LSTA) OWTS. This non-proprietary and cost-effective field-built nitrogen reducing septic system cost approximately one third less than a proprietary system and monthly analytical data collected from July 2022 indicate greater reductions of nitrogen than the state required 50%. The OWM office and our partners at URI will continue to work with Charlestown property owners and OWTS designers to install the necessary total of 10 pilot systems and continue the subsequent monitoring requirements to seek full approval from RIDEM for this important technology. The OWM Office has prepared a LSTA design and installation video resource on here (Charlestown, 2022)

The Charlestown OWM program is currently seeking additional funding in the amount of $200,000 from the RI Infrastructure Bank as part of resiliency funding, and $3M in legislative grants from Senator Whitehouse and Representative Magaziner's Office's to facilitate large scale modernization of OWTS in our most critical areas of our Town. Further, the OWM program manager has initiated conversations with our legislators including the Speakers Office to bring to light the major funding gap for septic system repairs and modernization across the State of Rhode Island. Well designed, large impact funding models for septic system upgrades currently exist in Suffolk County, NY and Eastern Massachusetts that could serve the basis for a Rhode Island specific funding design.

With multiple large-scale funding resources available and through the Town's wide-ranging analytical understanding of its watershed dynamics and building on our previous funding successes, the Charlestown OWM Program is well positioned to rank high with funding agencies to access further fiscal allocations. These programs benefit the town through incremental but real and compounding reductions of pollutants to our collective water resources in Charlestown.

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