Avoiding Septic Shock

How Climate Change Can Cause Septic System Failure and Whether New England States are Prepared

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"As sea-level rise causes a rise in groundwater levels, it will saturate onsite septic systems, increase failure rates and exacerbate groundwater pollution problems. Residents are investing significant dollars to elevate and flood proof homes with the expectation that these areas will be livable; however, if groundwater levels become too high the use of onsite septic systems may become impossible. The future impacts of sea-level rise in these areas needs to be more thoroughly investigated."[1]

1 Report of Findings from a Study of the Effects of Sea-level Rise and Climate Change on Old Saybrook, Connecticut, 16 (December 2015), https://perma.cc/2BLQ-EJJQ.

Introduction

Climate change poses a number of difficult challenges to New England's infrastructure. The most commonly discussed impacts include flooding of roads, bridges, and culverts, or water damage to buildings and electric utilities. A less discussed, but equally alarming challenge to infrastructure is how climate change is impacting onsite wastewater treatment systems, more commonly known as septic systems. Almost half of homes in New England depend on septic systems to dispose of wastewater. When functioning properly, these systems filter out harmful bacteria and pathogens to ensure nearby groundwater and surface waters are safe for human health and the environment. But rising sea levels, increased precipitation, and warmer temperatures due to climate change are all adversely impacting these systems.

This white paper addresses whether states in New England are adequately addressing the issues presented by climate change in septic system regulation. Part One describes how climate change impacts can adversely affect septic systems. Part Two discusses the human health and environmental harms associated with septic system failure. Part Three summarizes the results of a state-by-state comparison analyzing if and how each New England state is addressing the issue of climate change impacts on residential septic systems (the complete results of the analysis are contained in the Appendix). Part Four identifies common problem areas in septic system regulation, and suggests recommendations and best practices for how states and municipalities can work to change laws, amend rules, or adopt new policies or incentives to better construct, manage, and regulate septic systems to be resilient to climate change. Part Five concludes with a call to action, imploring state and local municipal leaders to review their regulatory frameworks for septic systems and ensure that they adequately account for the rising groundwater, warmer temperatures, and heavier rainstorms we anticipate in the near future.

PART ONE
How Climate Change Can Cause Septic System Failure

Conventional septic systems collect sewage from residential or smaller-scale commercial properties and store it in a septic tank. There, bacteria begins to break down the solids, while septic tank effluent flows through a pipe into a soil treatment area (also referred to as a "leachfield"). Treatment takes place as wastewater percolates through the unsaturated portion of the soil profile beneath the leachfield, where moisture and oxygen levels are conducive to the removal of pathogenic organisms, and where chemical and microbial processes can help reduce the concentration of other contaminants.[2]

New England households rely much more on septic systems than homes in the rest of the country. New Hampshire, Maine, and Vermont reported that approximately half of all homes in their states are served by septic systems.[3] By comparison, about one in five households across the U.S. depend on septic systems.[4] But no matter the location, reliance on these onsite wastewater treatment systems is continuing to grow throughout the country. About one-third of all new development in the U.S. is served by a septic or other decentralized treatment system.[5]

Climate change poses several challenges to septic systems. First, rising sea-levels associated with climate change cause near-shore groundwater tables to rise and reduce separation distances to the leachfield base, compromising the systems' ability to treat bacteria and pathogens in wastewater. Leachfields rely on unsaturated soil for proper physical and biochemical treatment of wastewater. When sea-level rises, saltwater from the ocean intrudes into groundwater reservoirs. The saltwater then displaces the less dense, lighter freshwater, causing the groundwater to rise into the soil profile above, limiting the amount of unsaturated soil beneath the leachfield.[6] Research out of Cape Cod, Massachusetts showed that the ground water table rises at a rate of about 35 percent of sea-level rise.[7] In other words, if sea-level rises 10 feet, the groundwater table would rise by about 3.5 feet (35 percent of 10 feet).

Second, increased heavy precipitation events associated with climate change add to the problem of a rising groundwater table. Increased water percolating into the soil from above refills, or "recharges" the groundwater table, resulting in an even higher groundwater table.[8] When increased recharge of groundwater tables (caused by increased precipitation) is combined with rising sea-levels, the groundwater levels could rise as much as an additional foot higher than the projected median sea-level rise at some coastal locations during these precipitation periods.[9]

Third, the saturation from increased precipitation depletes oxygen in soils, compromising aerobic microbial activity and resulting treatment of wastewater.[10] And rising temperatures from climate

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2 Jennifer A. Cooper, et al., *Hell or High Water: Diminished Septic System Performance in Coastal Regions Due to Climate Change*, PLOS ONE, 2 (Sept. 1, 2016), https://perma.cc/K6KF-73C5.
3 *Id*.
4 Learn about Septic systems: Septic System Overview, EPA, http://perma.cc/VQX9-WGXE (last updated September 23, 2016).
5 *Id*.
6 Cooper, *supra* note 2, at 2.
7 Donald A. Walter, et al., *Potential effects of sea-level rise on the depth to saturated sediments of the Sagamore and Monomoy flow lenses on Cape Cod, Massachusetts*, USGS, 41 (October 2016), https://perma.cc/F6DN-ZVPZ.
8 Cooper, *supra* note 2, at 2.
9 David M. Bjerkile et al., *Preliminary Investigation of the Effects of Sea-Level Rise on Groundwater Levels in New Haven, Connecticut*, USGS (May 1, 2012), https://perma.cc/6NFM-YQ32.
10 Cooper, *supra* note 2, at 2; *see also* D.M. Linn and J.W. Doran, *Aerobic and Anaerobic Microbial Populations in No-till and Plowed Soils*, 48 SOIL SCI. SOC. AM. J. 4, 794-799, 797-98 (1984).

change further compromise healthy aerobic microbial function due to greater oxygen demand that effects biochemical treatment processes in the soil.[11]

Climate scientists predict that sea-level rise and increased extreme precipitation events will be the two dominant climate change impacts to New England.[12] Sea-level in the Northeastern U.S. is projected to rise anywhere from three to six feet by 2100 (depending on the location and emissions scenario).[13] In addition, precipitation events are expected to increase in occurrence and severity over the same time period.[14] Accordingly, it is incredibly important to consider how to best prepare our septic systems to handle warmer and wetter, or saturated, soil conditions.

PART TWO
Human Health and Environmental Implications of Septic System Failure

Septic system failures result in unpleasant and potentially unsafe conditions for residents surrounding the system, as well as those who depend on groundwater or enjoy recreating on surface waters that come into contact with a failed system. This is because residential wastewater contains bacterial and viral pathogens, as well as nitrates, which pose public health risks if left untreated.[15] In fact, the U.S. Environmental Protection Agency identified contaminated residential wastewater from failed septic systems as the third largest contributor to groundwater pollution in the country.[16]

In addition, residential wastewater can be a significant source of nitrogen to coastal ecosystems.[17] Nitrogen limits primary production in coastal ecosystems, and excessive nitrogen inputs to marine environments can lead to harmful ecological and human health impacts.[18]

Several communities in New England have already begun seeing the impacts of water contamination from septic system failures. For example, the town of Rye—a small coastal town in New

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11 Cooper, *supra* note 2, at 2-3.
12 *Climate Impacts in the Northeast*, EPA, https://perma.cc/S8ES-T5QQ (last update September 29, 2016).
13 Huber et al., *Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends,* N.H. Coastal Risks and Hazards Commission Science and Technical Advisory Report (2014) https://perma.cc/EFN6-KVZY; *see also* Donald A. Walter *supra* note 7, at 6.
14 Huber, *supra* note 13.
15 United States Environmental Protection Agency. *Onsite Wastewater Treatment Systems Manual* (2002). Available at: http:/nepis.epa.gov/Adobe/PDF/30004GXI.pdf.
16 *Id.*
17 Valiela et al., *Couplings of watersheds and coastal waters: sources and consequences of nutrient enrichment in Waquoit Bay, Massachusetts*. ESTUARIES, 15(4), 443-457.
18 *See, e.g.,* Bergondo et al., *Time-series observations during the low sub-surface oxygen events in Narragansett Bay during summer 2001*. MARINE CHEMISTRY, 97 (1), 90-103 (2005).

Hampshire— is experiencing first-hand the problems of failed septic systems. Namely, high levels of bacteria are being carried into the ocean at Wallis Sands Beach—a favorite summer spot for locals and tourists alike—by a local waterway known as Parsons Creek.[19] The beach may soon be unsafe to visit if pollution issues go unchecked. The New Hampshire Department of Environmental Services categorized Parsons Creek as an impaired water body in 2008 due to test results showing high fecal bacteria counts, causing area residents to nickname Parsons as "Stinky Creek."[20] In 2011, after extensive studying, the town of Rye discovered the major source of the bacterial contamination was coming from malfunctioning residential septic systems.[21] The town is now struggling to gain residents' cooperation in identifying which septic systems are leaking the bacteria into the creek. While rising sea-level and other climate-related impacts to septic systems have not been identified as the sole cause of the system failures, people within the community acknowledge the threat of climate change impacts to these often old and fragile systems.

Rhode Island's Narragansett Bay has repeatedly experienced the negative effects of nitrogen pollution from residential wastewater, including hypoxia and anoxia, alterations to food web dynamics, loss of biodiversity and habitat, and increased frequency of algal blooms.[22]

With such high reliance on septic systems in New England, it is imperative that state and local governments take preemptive measures now before more systems fail and cause problems similar to those experienced in the town of Rye. Many local and state governments are engaged in robust adaptation efforts to ensure communities are resilient in the face of climate change impacts. A few local municipalities across New England are taking action to specifically address this particular issue of septic failures, including the town of Rye, whose adaptation measures are discussed below. But for the most part, state and local leaders are not focusing on how regulatory reform of septic system management to account for climate change could better protect communities from health and environmental risks.

PART THREE
State-by-State Comparison of Septic System Laws and Regulations

The Appendix of this white paper contains a detailed analysis of each state's regulatory framework for septic systems. However, the chart below summarizes and compares the major design and inspection parameters in each state's regulations that are relevant to a systems' preparedness for climate change.

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19 Nicole Anderson, *Rye Urges Residents to Help Fix 'Stinky Creek'*, SEACOASTONLINE, (Jan. 10, 2016), https://perma.cc/84KL-FZJ2.
20 *Id.*
21 *Id.*
22 Bergondo et al., *supra* note 18.

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State	Septic System Regulation	Date of updated regulation	Minimum Separation Distance	Post-construction Inspections Required?	Inspections recommended?
CT	Regs. Conn. State Agencies §19-13-B100a.	2015 (Technical Design Standards)	1.5 ft (non-coastal areas) to 2 ft (if soil percolation is faster than 1 min per inch).	No.	Local directors of public health perform inspections "when deemed necessary."
MA	310 CMR 15.000 ("Title V")	2016	4ft (if soil percolation is slower than 2 min per inch) to 5 ft (if soil percolation is faster than 2 min per inch).	Yes. Septic systems must be inspected when property is sold, increased flow, or expanded. If alt/ innovative system, then required quarterly inspections.	N/A
ME	10-144 CMR Ch. 241	2015	1-2 ft., depending on soil profiles & conditions	No.	Inspection required at time of property transfer within coastal zones.
NH	Env-Wq 1000	2016	2ft-4ft, depending on slope of site and components of system.	No.	State recommends local health officers conduct inspections once every three years.
RI	R.I. Code R. 25-16-17:32, 39	2016	2ft in all watersheds, except 4ft in "critical resource area" watersheds. Mandatory advanced N-removal technologies in CRA watersheds. Requires new system (conventional or alternative/innovative) if the current system is a cesspool near a public drinking water supply, a public well, or a bordering tidal water area.	No.	State *may* at its discretion inspect any aspect of the installation, but not statutorily required (system designer is responsible for this). Existing systems inspected under town wastewater management programs.
VT	Vt. Admin. Code §16-3-300	2007	Prescriptive = 2 ft Enhanced Prescriptive = 1.5 ft Performance Based = 6 inches plus calculated induced groundwater mounding	No.	After installation, inspections are done at the discretion of the State.

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PART FOUR

Recommendations for Climate-Ready Septic System Regulations

State regulations governing septic systems across New England are not adequately addressing the issue of groundwater rise associated with climate change. Nor are these regulatory programs contemplating other equally damaging impacts of climate change to septic systems, such as the impact of increased precipitation or higher temperatures on the microbial activity upon which septic systems rely. Primarily, this regulatory failure is because states and municipalities are relying on historic (as opposed to predicted) values for groundwater table height, and focusing regulatory programs only on permitting and installation, neglecting operation and maintenance of the systems.

There are, however, some examples of state and local governments taking positive steps towards more climate resilient septic system regulation. The recommendations below highlight some best practices that states and local municipalities should consider adopting to ensure septic systems are built and operated in a manner that is resilient to climate change.

1. **Incorporate future seasonal high water table projections when siting septic systems.**

One of the most egregious problem areas for all of New England states' septic system regulations is the inadequate accounting of future groundwater table rise due to sea-level rise. All states require a varying degree of separation distance between the bottom of the leachfield and the seasonal high water table (between six inches to four feet, see chart above). However, this begs the question of how system installers are measuring the seasonal high water table. All the states in New England currently base the seasonal high water table measurements on present or past data from Federal Government soil and flood maps (such as those produced by the Natural Resource Conservation Service, the United States Geologic Survey, or the Federal Emergency Management Agency). This is problematic because these maps are often several decades old and do not contemplate the impact that sea-level rise will have on the water table. Accordingly, none of the regulations take future groundwater rise into account when approving a new septic systems.

To remedy this problem, states should revise their regulations to account for dynamic (rather than static) seasonal high water table in coastal areas. At a minimum, state regulations should contain vertical distance requirements between the leachfield and the groundwater table deep enough to provide a margin of safety for if/when the groundwater table rises. But in addition, states should also require the use of future high water table projections when determining the seasonal high water table. At the federal level, agencies like NRCS and USGS should update their analyses to account for rising sea-level and groundwater levels, and provide states with needed resources to assist in making future seasonal high water table projections.

2. **Implement state-level mandatory inspections, at least at the point of sale of any home.**

On occasion, septic system installers will supplement Federal Government-issued soil maps with on-site water table monitoring to determine the seasonal high water table. But problems still arise with regard to this kind of snapshot-in-time data collection because it presumes that once the seasonal high water table is measured (or soil moisture levels) are measured, that those conditions will not ever change over the lifespan of the septic system. As discussed in Part One above, research shows this is not the case. Sea-level rise and more heavy rain events are predicted in New England, and those effects will invariably alter the seasonal high water table and soil saturation levels. Frequent inspections are needed in order to make sure that existing septic systems are retrofitted where necessary if soils or water table heights no longer support a safe system set-up.

At a minimum, states should require septic system inspections when a property is sold (currently, Massachusetts is the only state to have this requirement, in addition to requiring inspections when design flow is increased or the home is expanded).

Several municipalities in New England have wastewater management plans and ordinances that require inspection and pump-outs of all septic systems on an as-needed basis, based upon inspection findings. In Rye, New Hampshire, the town recently adopted a pump-out ordinance effective June 1, 2016 that requires septic systems in the Parsons Creek watershed to be pumped out once every three years.[23] But *state* level inspection requirements would ease administrative burdens on municipalities who are enforcing stricter inspection or maintenance ordinances on their own.

3. **Heighten State-level Regulations to ease burden on municipal enforcement.**

In all New England states, local municipalities may set more stringent septic system design standards or inspection requirements than the state. However, when it comes to enforcement, the state will only step in to assist with regard to violations of *state* standards. This lack of enforcement support makes imposing stricter standards more burdensome and less desirable for municipalities. Accordingly, states should consider heightening select standards in state-level septic system regulations to ease the burden on municipal-level enforcement.

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23 Town of Rye, Health Reg., Onsite Wastewater Treatment System Pump-out and Inspection Parsons Creek Watershed, https://perma.cc/W5KK-755D (June 6, 2016).

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4. **Monitor system treatment performance, as opposed to just system operability.**

Septic system operability does not necessarily equate to adequate treatment. A system's components could appear in good condition, but for some reason, the system is not treating wastewater as intended. For example, septic system performance data collected from advanced nitrogen-removal systems installed in Massachusetts showed that these systems do not always perform as assumed.[24] Another study in Rhode Island showed that 25 to 30 percent of tested systems failed to comply with nitrogen removal standards that the systems were designed to achieve.[25]

The most effective monitoring approach from a water quality standpoint would check not only the functionality of system components, but also that the system is properly *treating* the wastewater (i.e., treatment performance). On Cape Cod, for example, Barnstable County requires that septic system treatment performance for nitrogen be monitored on a quarterly basis. A recent study of the Cape Cod monitoring system found that more frequent operation and maintenance visits including actual analysis of system final effluent allowed for service providers to make adjustments necessary to facilitate effective system performance.[26] The study authors concluded that analysis of wastewater properties likely translates into more proactive system maintenance because service providers can learn more about how the system is performing internally, rather than rely solely on visual observations to make assessments.

5. **Create, or further implement a risk-based tiered approach, where areas susceptible to groundwater rise or other contact with surface waters are more protected from wastewater contamination.**

Various factors contribute to the risk profile of a certain property's septic system, including historic land use of the site, proximity to the coast, or other environmental factors. A state's regulations governing the minimum vertical separation distance between the bottom of the leachfield and the groundwater table should account for these parameters. For example, several New England states require that septic systems located in coastal areas subject to future groundwater rise or flooding have a greater vertical distance between the bottom of the leachfield and the seasonal high water table. This risk-based tiered approach should be incorporated into all states' regulatory framework.

24 Barnstable County Health Dep't of the Env't, *Study of factors controlling nitrite build-up in biological processes for water nitrification* (2012). WATER, SCIENCE, AND TECHNOLOGY, 26 (5-6), 1017-1025.
25 Lancellotti et al., *Performance evaluation of advanced nitrogen-removal onsite wastewater treatment systems*, manuscript submitted to WATER, AIR & SOIL POLLUTION in late 2016 (manuscript on file with author).
26 *Id*.

6. **Require advanced/innovative septic treatment systems in high-risk areas.**

States should require use of advanced/innovative septic treatment systems (such as those with advanced treatment and shallow narrow leachfields) in certain high-risk areas where groundwater tables are expected to rise in the future. New septic systems that contain shallow narrow leachfields receive effluent that has undergone a secondary treatment in an advanced treatment component, which allows the infiltrative surface to be placed higher in the soil profile than a conventional leachfield.[27] In addition, the shallow narrow leachfield designs incorporate frequent time-dosing of small volumes of wastewater, preventing prolonged periods of soil saturation.[28]

While these advanced treatment systems cost more than conventional septic systems (roughly two to three times more) they also have some cost advantages. Specifically, they may open up the use of a site for development that was otherwise constrained by a high water table, and they can prevent harmful water quality problems and associated adverse impacts to human health and the environment. Rhode Island is the first state in New England to require such advanced nitrogen removal systems in high risk zones state-wide (Barnstable County in Massachusetts does so on a regional level). Rhode Island is also the first state in New England to use shallow narrow leachfields and bottomless sand filters to mitigate potential impacts of sea-level rise.

7. **Create incentive programs to encourage residents to address failing septic systems, and/or switch over to advanced/innovative septic treatment systems.**

Incentives could include nitrogen credits for new developments, which is done in Massachusetts; tax rebates for purchasing the systems; free inspections of the systems for a length of time; or, for residents living near sensitive watersheds, offering a certain dollar amount to put towards the new system.

For example, officials in Rye, New Hampshire have offered to inspect twenty-five conventional systems free of charge, and offered up to $5,000 to five owners of failing systems who commit to repair or upgrade their system. The Rhode Island Clean Water Finance Agency has a financial incentive program to help homeowners who have failed septic systems. Residents can get a low interest loan from this program that allows up to $25,000 for the installation of an appropriate septic system for that location. The Rhode Island Department of Environmental Management requires a continuous operation and maintenance contract for all advanced treatment technologies in the state. This requirement is entered into the land evidence records, so at the time of property transfer the new owners are aware that they own an advanced technology and it needs operation and maintenance. Rhode Island also provides a line of credit to communities with state-approved wastewater management plans.

27 Cooper, *supra* note 2, at 3.
28 *Id.*

In Vermont, the town of Colchester identified a gap in funding for repair and replacement of decentralized wastewater treatment systems, especially when compared to the funding available for centralized systems.[29] In order to fill this funding gap, Colchester established a local, low-interest loan program specifically for decentralized wastewater system repairs and replacements.[30]

8. **Create a public outreach program to inform residents on septic maintenance, inspection, and pumping.**

For many homeowners, this is an out-of-sight or smell, out-of-mind issue. So long as there is no obvious failure, residents do not realize their systems could be leaching pollutants into the groundwater. In Rye, New Hampshire, town officials have been trying a number of public outreach tactics in order to remediate water quality issues in Parsons Creek, a watershed dealing with contamination due to failing septic systems. Town officials first went door-to-door with surveys designed to locate malfunctioning systems. But the surveys received a very low rate of participation. Rye's next step is to hold a public forum highlighting the difficulty of reversing the effects of septic system failure through public outreach to promote system maintenance, including the location of faulty systems. The Rhode Island communities of Charlestown, Jamestown, North Kingstown, and Portsmouth have active wastewater management programs, where educating residents is a high priority and a key component of their programs. They have found that residents embrace wastewater management when they understand the importance of sound wastewater treatment and its connection to public health, and protecting ground and surface waters.

9. **Support local research to identify areas at risk of septic system failure due to anticipated groundwater rise, and test the treatment effectiveness of various alternative technologies.**

For example, researchers at the University of New Hampshire are using a groundwater rise model to identify hazardous waste sites, such as unlined landfills, that require attention due to sea-level rise. The same modeling should be done to determine which septic systems should be evaluated for current functionality/retrofitting. Conventional systems that were installed 20 to 40 years ago may have complied with the bare minimum vertical separation standard at the time they were installed. Now, however, many years later and with no required sampling for treatment performance in the intervening years, it is unknown what systems are failing or at the brink of failure. Researchers in this field predict that we are likely already seeing the implications of sea-level rise through septic system failure. Research in URI's Laboratory of Soil Ecology and Microbiology—sponsored by the

29 *Discussion of Wastewater Management Options*, STONE ENVIRONMENTAL INC. (January 2011), 27-28, https://perma.cc/LB7Q-TNMJ.
30 *Id.* at 27 ("The Town of Colchester administers a long-term, low-interest (20-year term, 3% interest) loan fund with Clean Water SRF funding originating from the Vermont [Department of Environmental Conservation].").

Rhode Island Agricultural Experiment Station—currently focuses on measuring changes in separation distance beneath the leachfield of septic systems in coastal communities, and the possible use of vegetation above the leachfield to lower nutrient and water inputs to the leachfield. A joint study between the Barnstable County Dept. of Health and Environment and URI's Laboratory of Soil Ecology and Microbiology—sponsored by the USEPA—is testing non-proprietary leachfield designs that remove nitrogen from wastewater and increase the separation distance below the leachfield, which can help address the impact of sea-level rise.

Conclusion

Currently, New England states are not adequately addressing rising groundwater and other climate change impacts when regulating the location, operation, or inspection of septic systems. When the waters begin to rise, conventional septic systems will start to fail because there will not be enough unsaturated soil to treat effluent. The untreated effluent will migrate into and through groundwater and surface waters, putting the health of people and the environment at risk. Residents may not see the effluent, but they will smell it. Rye's "Stinky Creek" will no longer be a rare occurrence. Everyone will start to smell the result of failing septic systems, or worse, fall ill due to contaminated drinking water.

If regulators start taking action now, there is a chance to avoid mass septic systems failure. Regulators need to start considering using future calculations of the seasonal high water table, begin requiring innovative and alternative systems in sensitive areas, and offer incentives to help people transition over to these new systems more quickly.

Some states have taken steps to protect sensitive water sources. Using a tiered system for vertical separation will be helpful for coastal communities. However, it is not enough. Regulators need to acknowledge that it is not only going to be a select number of septic systems that will fail due to climate change. Septic systems located inland, in high elevations, or in areas where it is usually dry will all be affected to varying degrees by climate change. This is an area where an ounce of prevention is worth a pound of cure. Regulators need to start taking steps now to address this issue head on to prevent potential catastrophic system failures.

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Appendix: State-by-State Analysis of New England Septic System Regulations

This Appendix contains the full analysis of the current regulatory framework of each New England state to see if and how the states are addressing the issue of climate change impacts on residential septic systems. The major topics analyzed include: when the regulations were last revised; the vertical separation requirements between the leachfield and the seasonal high water table; if there is a stricter vertical separation requirement for septic systems located on the coast or near water bodies; whether the requirements address groundwater rise; and when/if the systems are required to be inspected.

Connecticut

The Connecticut Department of Health ("DOH") is responsible for governing and establishing minimum requirements for septic systems within that state.[31] The DOH's complete regulations governing individual sewage disposal systems are codified in the Connecticut Public Health Code and titled: "Technical Standards for Subsurface Sewage Disposal Systems" ("Technical Standards").[32] The Technical Standards were last amended in January 2015.

The Technical Standards begin by generally requiring that leaching systems not be constructed in areas where the seasonal high water table will interfere with its operation. The Technical Standards follow a tiered approach, requiring a distance of separation of at least eighteen inches above the seasonal high water table in *non-coastal areas*, and a minimum distance of separation of twenty-four inches in *coastal areas*.[33] The Technical Standards define coastal areas as those areas which have a groundwater table that is tidally impacted.[34]

Similar to coastal areas, areas of "special concern" are subjected to more stringent standards. These areas of special concern include sites where the maximum groundwater table height is less than three feet below the ground surface.[35] In these areas of special concern, the local director of health may require investigation for maximum groundwater level at any time where it is determined to be

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31 Regs. Conn. State Agencies, §19-13-B103a.
32 Connecticut Public Health Code, *Technical Standards for Subsurface Sewage Disposal Systems*, http://www.ct.gov/dph/lib/dph/environmental_health/environmental_engineering/pdf/011916_final_technical_standards.pdf (2015).
33 *Id*. at 36.
34 *Id*.
35 Regs. Conn. State Agencies. §19-13-B103d(e)(1)(A)-(H) (some other examples include areas located within the drawdown area of an existing public water supply, and areas designated as wetlands).

at or near its maximum level.[36] Additionally, plans for these systems of special concern must: (1) be prepared by a professional engineer; (2) demonstrate an ability to solve the particular difficulty or defect associated with the area of special concern; and (3) may be required to have a professional engineer supervise the construction.[37]

The Technical Standards do not expressly incorporate future groundwater table heights that may increase due to rising sea-level as affected by climate change.[38] With that said, there are several significant resilience efforts taking place in Connecticut. For example, the coastal town of Guilford, Connecticut, issued a detailed resiliency plan in July 2013 addressing "the current and future social, economic and ecological resilience of the town's shoreline to the impacts of sea-level rise and anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion."[39] The plan specifically highlighted the concern of septic system failure in coastal areas due to sea-level rise, and put forward some potential solutions in that regard:

> First and foremost, septic systems can be elevated to maintain an appropriate vertical separation between effluent leach fields and the surface of the groundwater table. . . . Engineering erosion control techniques may be needed to assist with reduction of the erosion. If elevating a system is not possible, a suitable site for a new system may be found elsewhere on a property. . . . In cases where the full area needed for renovation of wastewater is no longer available, property owners could attempt to install and maintain advanced sewage treatment facilities. . . . Incinerating toilets, composting toilets or heat-assisted composting toilet can be utilized for replacing failing subsurface sewage disposal systems. . . . In cases where septic systems cannot be improved, it may be possible to install effluent holding tanks. The tanks would then be pumped out and sanitary wastewater would be delivered to a sewage treatment plant elsewhere.[40]

Furthermore, the United States Geological Survey ("USGS") performed investigations in New Haven, Connecticut and found a direct correlation between sea-level rise and seasonal high water table rise:[41]

> The results of this preliminary investigation indicate that under two scenarios for rise in sea-level, increases in groundwater levels in coastal areas such as New Haven can be expected. .

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36 *Id*. at §19-13-B103d(e)(2)-(3).
37 *Id*.
38 *But see* Conn. Public Health Code *supra* note 23, at 36 ("Maximum groundwater determinations in tidally affected coastal areas shall take into account water level rise associated with high tides); *Id*. at 51 (on application Form #2, the applicant is to consider the "probable high groundwater").
39 *Community Coastal Resilience Plan,* Town of Guilford (2013), ES-1, 16,https://perma.cc/JHE4-8BZM.
40 *Id*. at 16 (emphasis added); *see also* Climate Adaptation Committee Town of Saybrook, *Report of Findings from a Study of the Effects of Sea-level Rise and Climate Change on Old Saybrook, Connecticut* (December 2015), https://perma.cc/2BLQ-EJJQ ("As SLR causes a rise in groundwater levels it will saturate onsite septic systems, increase failure rates and exacerbate groundwater pollution problems. . . . if groundwater levels become too high the use of onsite septic systems may become impossible.").
41 Bjerkile, *supra* note 9.

. . Under the scenarios for rise in sea-level simulated in this study, basements of buildings and conduits for some underground utilities may be flooded. Some of the aging storm drains and sanitary sewers may intercept the water table and act as a conduit for groundwater flow.[42]

When it comes to inspecting septic systems, Connecticut requires only that individuals seeking to construct a subsurface sewage disposal system submit applications for a permit and be subject to compliance inspections by the local director of health.[43] Inspections of subsurface sewage disposal systems are performed by the local director of health to ensure compliance with the standards at two different times: (1) after construction and prior to covering, and; (2) "at such other times as deemed necessary."[44]

Connecticut laws and regulations do not expressly acknowledge the affects that sea-level rise and other factors associated with climate change have on groundwater rise and septic systems. With that said, there are some communities in Connecticut taking steps to change this approach, and to start considering plans to prevent and mitigate the effects of climate change.

Maine

Maine state laws and regulations governing septic systems are the responsibility of the Maine Department of Health and Human Services ("DHHS").[45] The "Subsurface Wastewater Disposal Rules" ("Rules") issued by the DHHS regulate the design and siting requirements, construction and inspection procedures, and administrative policies of subsurface wastewater disposal systems.[46] The Rules were last amended in January 2011.

The Rules follow a tiered approach when calculating the vertical separation between the disposal field, Maine's term for a leachfield, and the seasonal high water table. The Rules require that disposal fields be located between 12 to 24 inches above the seasonal high water table, depending on the underlying soil profile and conditions.[47]

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42 *Id*. at 25.
43 Conn. Agencies Regs. §19-13-B103e; *see also* Department of Public Health, The Connecticut Department of Public Health Office of Local Health Administration and Local Health Infrastructure Overview, https://perma.cc/VYX2-BNWS ("Connecticut's local public health system is decentralized. Local health agencies [and the local director of health] are autonomous and under the jurisdiction of the towns/municipality or health district served.").
44 Conn. Agencies Regs. §19-13-B103e(g).
45 22 M.R.S. §42(3) ("The department shall adopt minimum rules relating to subsurface sewage disposal systems. . . but this does not preempt the authority of municipalities . . . to adopt more restrictive ordinances.").
46 10-144 CMR Ch. 241.
47 10-144 CMR Ch. 24, §4, Table F4; *see also* 10-144 CMR Ch. 241, §7(C) (discussing the criteria used for approval of a variance: (1) applicant must fill out a form; (2) applicant must demonstrate that there are no practical alternatives for wastewater disposal; (3) must be no conflict with the Shoreland Zoning; (4) Department evaluates the potential for malfunction, contamination, and other potential impacts; (5) shoreland areas are subjected to higher scrutiny and expectations on the application form.).

The DHHS' Division of Health Engineering released a Technical Guidance Manual relating to these Rules which adopts a policy recommending that disposal fields be constructed "as shallowly as practical to . . . stay as far as possible above the [seasonal high water table]."[48]

In order to determine the seasonal high water table, the rules require that groundwater level and temperature monitoring be performed on or before April 1st; subsequent monitoring and readings are required at least every seven days until June 15th.[49] The monitoring data must be compared and modified with information from the USGS to determine whether it is at or is near its normal level.[50] Similar to United States Department of Agriculture (USDA) and Natural Resource Conservation Service (NRCS) maps, the USGS does not incorporate *future* groundwater table heights that may increase due to rising sea-level, but are rather based on historical levels. The USGS does acknowledge the threat that climate change and sea-level rise poses on our subsurface disposal systems.[51] As for inspection requirements, septic system owners must obtain an initial inspection for compliance at the time of construction. Maine does not require routine inspections of the system, except for during the transfer of property located in coastal shoreland areas.[52]

At the local level, some towns in Maine have adopted ordinances that increase the standards contained in DHHS rules.[53] Other towns have even acknowledged the threat of sea-level rise,[54] and conducted reports on the effects it will have on their disposal systems.[55] Additionally, the island town of Georgetown, Maine, has conducted a resiliency report with the National Oceanic and Atmospheric Administration, which briefly discussed the implications of climate change on septic systems.[56] Nevertheless, the State of Maine's requirement of a 12 to 24-inch protective barrier between the seasonal high water table and the disposal field is one of the lowest separation distance

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48 *Technical Guidance Manual for the Maine Subsurface Wastewater Disposal Rules*, Maine Dept. of Health and Human Services (2012), https://perma.cc/TVY4-WGFL.
49 10-144 CMR Ch. 241, §4(L)(7).
50 10-144 CMR Ch. 241, §(4)(L)(12)-(13).
51 *Sea-level Rise Hazards and Decision Support – Coastal Groundwater Systems*, USGS (last modified Nov. 24, 2014), https://perma.cc/R6EL-JA6U. ("Changes in climate and sea-level will drive changes to the coastal groundwater system that will impact both human populations and coastal ecosystems. Increases in sea-level will raise the fresh water table in many coastal regions. . . . Impacts to humans may include an increase in the potential for basement or septic system failure.").
52 30 M.R.S. § 4216(2), Transfer of Shoreland Property; see also *Septic System Inspection: A Guide for Lending Institutions, Realtors and Prospective Home Buyers*, MAINE DEP, https://perma.cc/EX23-4Q2J (last visited December 14, 2016).
53 *See*, e.g., *Supplemental Plumbing Ordinance*, York, ME (November 6, 2012), https://perma.cc/3M8E-9GTA (increasing the design flow for residential systems by 33 percent, and prohibiting any reduction in design flows for water conservation devices).
54 *Natural and Marine Resources*, Ogunquit, ME (October 7, 2004), 27-29, https://perma.cc/QGW6-%LED.
55 Woodard & Curran, *Ogunquit Sewage Treatment Plant Preliminary Engineering Report* (2012),https://perma.cc/EF5A-3AY8 (considering the risks of sea-level rise and Ogunquit's current sewage treatment plan, and estimating that mitigation measures will need to take place in the next 20-30 years).
56 *Climate Change Adaptation Report: Georgetown, Maine*, GEORGETOWN CONSERVATION COMMISSION (2015), 11, https://perma.cc/PUB4-F4FG ("The main way that climate change affects . . . wastewater treatment is sea-level rise, especially for residences near the shoreline. Higher seawater elevations increase seawater . . . flooding of septic systems, causing their failure. In addition, extreme precipitation events can lead to . . . high groundwater tables. . . .").

requirements in New England.[57] This is cause for concern, especially considering that Maine has one of the largest coastlines in the U.S., and over half of Maine's population lives in coastal counties.[58] Maine's underlying geologic composition varies greatly from north to south (northern Maine has generally impervious bedrock material, whereas southern Maine is located on top of more porous bedrock substrate). This discrepancy in bedrock material could provide an explanation for Maine's lower overall separation distances, because rising sea level will not cause groundwater to rise up into septic system leachfields located on top of impervious bedrock material. However, this issue deserves further attention, perhaps with a focus on communities in southern Maine that are located on more porous geologic surfaces.

Massachusetts

Massachusetts' septic systems rules are known as "Title V" and are issued and enforced by the Massachusetts Department of Environmental Protection ("DEP").[59] The newest regulation amendments took effect in September 2016.

DEP's septic systems regulations determine minimum separation distance based on soil percolation rates. Accordingly, in soils with a recorded percolation rate of slower than two minutes per inch, Title V requires a minimum vertical separation distance of four feet between the bottom of the stone underlying the soil absorption system and the high groundwater elevation mark.[60] If the recorded percolation rate of the soil is faster than two minutes, then the requirement increases to a five foot vertical separation between the bottom of the stone underlying the soil absorption system and the high ground water elevation mark.[61]

In addition, certain areas that are given a special designation require additional strict standards. For example, when a potential septic system placement is in the Special Flood Hazard Area[62] and is subject to high velocity wave action or seismic sources, it is considered to be in a "velocity zone."[63] No new septic tanks or humus/composting toilets are allowed to be constructed in a velocity zone on a coastal beach, barrier beach, or dune, or in a regulatory floodway.[64] The only exception is if there needs to be a replacement to an already existing tank and the placement of the tank outside

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57 *Compare* Maine's fifteen-inch coastal protective barrier, *with* New Hampshire's four-foot protective barrier, *and* Connecticut's twenty-four-inch coastal protective barrier.
58 Steven G. Wilson & Thomas R. Fischetti, *Coastline Population Trends in the United States: 1960-2008*, U.S. CENSUS BUREAU (2010), https://perma.cc/AA9T-LVK5 (*see* Table 2 on page 4).
59 310 CMR § 15.
60 *Id*. at § 15.212 (1).
61 *Id.*
62 *Special Flood Hazard Area,* FEDERAL EMERGENCY MANAGEMENT AGENCY, https://www.fema.gov/special-flood-hazard-area (the land area covered by the floodwaters of the base flood is the Special Flood Hazard Area (SFHA) on NFIP maps. The SFHA is the area where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies).
63 310 CMR § 15.213 (1).
64 *Id.*

the velocity zone is not feasible.[65] Additionally, for new constructions in "Nitrogen Sensitive Areas,"[66] the septic system's design cannot have a design flow of more than 440 gallons per day per acre.[67] Systems with advanced nitrogen removal, however, are not subject to the nitrogen loading limitation of 440 gallons per day per acre.[68] As a result, more homeowners pursue alternative systems with advanced nitrogen removal because it will allow them to receive nitrogen credits, which in turn increases the amount of allowable bedrooms per square foot of land.[69]

According to DEP, there are a number of acceptable methods of estimating the high ground water elevation, including the following: the disposal system's plans; observation on site; determination from local conditions; consulting the local board of health, the local water department, or the local sewer department; consulting the USDA; consulting the Federal Emergency Management Agency ("FEMA") floodplain maps; or subscribing to the USGS groundwater records.[70] None of the aforementioned methods consider how the groundwater table may rise in the future; rather, they are all retrospective assessments based on past observations.

Before a system receives a certificate of compliance, DEP must conduct a final inspection of the system.[71] The system must also be inspected within two years of a title transfer, if there is any increase in the design flow, or prior to any expansions (such as adding an additional bathroom or bedroom).[72] In addition, any residence that has a recirculation sand filter system or alternative technology system with a design flow of less than 2,000 gallons per day must have both the influent and effluent quality monitored quarterly.[73] The system owner shall then submit all monitoring results to the local approving authority[74] and the MA DEP by January 31st of each year.[75]

The most progressive and forward-thinking regulation of septic systems on the local level in Massachusetts can be found in Barnstable County. With rapid development in the last 30 years and approximately 85 percent of sewage from residents on Cape Cod being disposed of in conventional on-site septic systems, county officials were struggling to keep up with the new changes.[76] As a solution, so-called "innovative/alternative" septic systems have been installed across Barnstable County as a means to reduce nitrogen output on a case-by-case basis. Innovative/alternative

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65 *Id.*
66 Nitrogen Sensitive Areas are designated in 310 CRM 15.215.
67 310 CMR § 15.214(1).
68 *Id.* at § 15.217(1).
69 Alex Elvin, Wastewater: Plumbing All the Alternatives, Vineyard Gazette (Sept. 17, 2015), https://perma.cc/74NC-BL2Q.
70 Guidance for the Inspection of On-site Sewage Disposal Systems, MassDEP, https://perma.cc/85CN-KU6R (last visited on December 14, 2016).
71 310 CMR § 15.021(2).
72 *Id.* at § 15.301(1),(5).
73 *Id.* at§ 15.2002(4)(c).
74 *Id.* at § 15.002 (the board of health or its authorized agent or an agent of a health district constituted pursuant to M.G.L. c. 111, § 27 acting on behalf of the applicable board of health).
75 *Id.* at § 15.202(4)(c).
76 *Id.*

systems are those that are not designed or constructed in a way conventional with Massachusetts' Title V rules governing septic systems. Some examples of innovative/alternative systems are products developed using proven wastewater methods such as recirculating sand filters, aerobic treatment units, humus/compositing toilets, and intermittent sand filters. Innovative/alternative systems are often better than conventional septic systems at removing solids and other pollutants from wastewater before discharging into a leaching area along with reducing nitrogen content.

Because innovative/alternative systems are more complex than standard on-site wastewater treatment systems, the mechanical components must be maintained on a regular schedule. Individual towns are tasked with ensuring that this upkeep is completed as required. However, to assist with monitoring, the Barnstable County Department of Health and Environment created an online-accessible database management program.[77] The database includes when a system is inspected, if the system passes inspection, and what steps are needed to bring a failed system into compliance. According to preliminary (and yet to be published) research, this quarterly monitoring and database accounting system is proving to be a more effective method to maintaining system performance and resulting water quality than relying solely on visual observations.[78]

Massachusetts's government agencies and councils have discussed changing Title V in order to address groundwater rise, but so far DEP has not indicated that these changes will be made. In a 2011 climate adaptation report, the Executive Office of Energy and Environmental Affairs briefly considered whether Title V should be changed for additional protective separation distances for septic systems.[79] However, there seems to be no follow up to this report to determine whether any actual action is taking place. More recently in 2015, the Metropolitan Area Planning Council (MAPC) released another adaptation report. This report states MAPC will work with its partners to "persuade" DEP to consider the redesign of septic system standards in floodplain areas to offset climate change impacts such as saltwater intrusion, elevated groundwater table, and flooding.[80] Again, no follow-up action from this report could be found.

New Hampshire

The Subsurface Systems Bureau of the New Hampshire Department of Environmental Services ("DES") is responsible for regulating septic systems. The new amendments of the rules, codified under Env-Wq 1000, recently came into effect on October 1, 2016. The Bureau conducts on-site inspections, licenses septic system installers and designers, and manages complaints. Cities and municipalities also have the right to regulate septic systems, as they affect local health issues

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77 Innovative/Alternative Septic System Tracking, BCDHE, https://perma.cc/992W-35LS.
78 Lancellotti et al., *supra* note 25.
79 Massachusetts Climate Change Adaptation Report, EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS, 118 (Sept. 2011), https://perma.cc/8BWC-P3WP.
80 Metropolitan Area Planning Council, *Metro Boston Regional Climate Change Adaptation Strategy Report*, 3-35 (March 2015), https://perma.cc/S67U-KV2A.

(especially groundwater contamination).[81] However, most local health officers seem to only engage in septic system oversight at the approval level, rather than through post-construction inspections.

New Hampshire state laws and regulations governing septic systems[82] generally require the leachfield (referred to in New Hampshire as the "effluent discharge area") to be four feet above the seasonal high water table.[83] There are some exceptions to this rule, such as when replacing an existing system or on sloping sites, where only two feet of distance is required.[84,] According to the regulations, the seasonal high water table is defined as "the depth from the mineral soil surface to the level at which the uppermost soil horizon that contains 2% or more distinct or prominent redoximorphic features that increase in percentage with increasing depth."[85] Estimated seasonal high water table is determined from USDA/NRCS maps or actual data, if available.[86] Because USDA/NRCS maps indicate present or historical seasonal high water table data (as opposed to any anticipated future data),[87] septic system designs do not incorporate *future* groundwater table heights that may increase due to rising sea-level.

Any individual who installs or otherwise acquires a septic system must operate and maintain the system to prevent a nuisance or potential health hazard due to failure of the system.[88] Accordingly, in the event that the water table did rise to the point where it was causing a septic system to fail, the owner has a duty to remediate. However, there is little by way of routine inspection required, at least at the state level (select local level inspection policies are described below). DES is authorized to enter any premises to inspect and evaluate maintenance of septic systems and issue compliance orders,[89] but this is complaint-driven (i.e., there is no routine state inspection).

Septic tanks must be inspected for accumulation of sludge and scum at a frequency sufficient to allow the tank to be pumped by a licensed septage hauler when the combined thickness of the sludge and scum layers equal one third or more of the tank depth.[90] A DES-published "Health Officer's Manual" recommends pumping the tank once every three years.[91] But again, this

81 RSA 147:1.
82 *See* RSA 485-A:29-44; Chapter Env-Wq 1000.
83 Env-Wq 1014.08(a).
84 Env-Wq 1014.08 (b-d); Env-Wq 1014.09.
85 Env-Wq 1002.61.
86 Env-Wq 1025.04(g)(6).
87 For USDA/NRCS soil maps, the "high water table (seasonal)" is "the highest level of a saturated zone in the soil in most years"; estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. *See*, e.g., *Soil Survey of Grafton County Area, New Hampshire*, USDA/NRCS, 217-219 (1998), https://perma.cc/539F-LAFT.
88 RSA 485-A:37.
89 RSA 485-A:37.
90 Env-Wq 1023.01.
91 *Health Officer's Manual for Septic systems*, NH DES (September 2011), https://perma.cc/52C5-B57B.

maintenance requirement does not address whether the system as a whole is failing due to a rise in groundwater table. Lastly, if a homeowner is selling developed waterfront property, a site assessment study is required. But, such a site assessment is not considered an "evaluation" of the existing septic system on the property,[92] and this assessment only occurs at the point of sale, not on a routine basis.

On the local level, using New Hampshire RSA 147, and any health regulations adopted at the local level, municipal health officers have direct enforcement authority over septic system failures and may conduct inspections. However, many local health officers merely participate in the application process to install septic systems and do not require annual inspections. The town of Rye is pursuing strategies to remediate water quality problems due to failed septic systems, including implementing a mandatory pump-out and inspection ordinance.

Rhode Island

The rules regulating septic systems in Rhode Island were adopted by the Rhode Island Department of Environmental Management ("RIDEM") in accordance with Chapter 42-35 of the Rhode Island General Laws and the R.I. Cesspool Act of 2007 (R.I. Gen. Laws 23-19.15).[93] The most recent updates of the regulations occurred in June 2016 in order to incorporate revisions made to the R.I. Cesspool Act.

The regulations require a minimum of two feet between the bottom of the leachfield and the seasonal high water table (four feet in the Critical Resource Areas of the state).[94] Rhode Island also has a tiered system, where septic systems located within critical watersheds must utilize advanced nitrogen reducing technology instead of conventional systems.[95] Concerns about nitrogen loading in Rhode Island's watersheds started back in the mid-1980s, and have led to the widespread use of advanced technology systems in the Critical Resource Area watersheds that reduce nitrogen output from effluent.

To determine the depth to the seasonal high water table, a Soil Evaluator primarily uses the depth to, type, location and abundance of hydromorphic features and other characteristics.[96] The groundwater table observations may also be made using a minimum of two groundwater test wells placed to a depth of ten feet.[97] Wet season determinations are intended to measure the

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92 Env-Wq 1025.01(a).
93 R.I. Code R. §42; https://perma.cc/WCS7-L33G.
94 Reg. R.I. Code R. 25-16-17:32, 39. CRAs are defined by rule and include coastal ponds, the Narrow River, and drinking water reservoir watersheds.
95 Reg. R.I. Code R. 25-16-17:39 (specifically identifying the salt pond and narrow river critical resources area).
96 Reg. R.I. Code R. 25-16-17:15.
97 Reg. R.I. Code R. 25-16-17:15.9.3.

groundwater table at its annual highest level.[98] However, when there are fluctuations in the seasonal high water table, RIDEM may adjust factors to compensate for periods of low groundwater recharge that results in the seasonal high water table to be lower than normal.[99] There is nothing in the rules that allows for adjustments for periods of *higher* groundwater elevations, as is anticipated with climate change.

When a septic systems is installed, RIDEM may, at its discretion, inspect any aspect of the installation.[100] By statute however, a license designer must inspect the system installation and make a report to RIDEM.[101]

Although not universally done in every community, inspection of existing septic systems in Rhode Island is done at the town level, and many towns have wastewater management ordinances requiring periodic inspections and results reported electronically to the town. At the time of inspection, system deficiencies and failures would be identified by private sector inspectors and reported to the town wastewater management specialist who would follow up to assure upgrades are done.

Discussion of Rhode Island's regulatory framework around septic systems necessarily requires mention of the state's leading efforts to eradicate cesspools. Cesspools are an antiquated, less reliable type of sewage disposal system used throughout New England. Any system that was installed prior to 1968 (when the state published its first septic rules) was probably a cesspool. Cesspools are dry-fit stone or concrete block structures into which sewage flows. Cesspools store solids and infiltrate wastewater into the surrounding soil. Cesspools tend to concentrate the wastewater in one location, unlike a conventional septic systems which has a distribution box and leaching field.[102]

Rhode Island is the only New England state working to eliminate cesspools. By statute, all hydraulically failed cesspools are required to be replaced immediately. If a house has a cesspool and is undergoing a home improvement project that will add one or more bedrooms, will affect 50 percent or more of the floor space, or the cost of the improvement is 25 percent of the replacement value of the home, then the resident is required to update their septic system.[103] If the cesspool is within 200 feet of the inland edge of all shoreline features bordering tidal water areas, within 200 feet of all public wells, or within 200 feet of a public drinking water supply, then the

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98 Reg. R.I. Code R. 25-16-17:15.5.3
99 *Id.*
100 Reg. R.I. Code R. 25-16-17:43.5
101 *Id.*
102 *Frequently Asked Questions: Cesspools and the Rhode Island Cesspool Act*, RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT OFFICE OF WATER RESOURCES, 3 (Sept. 2015), https://perma.cc/EL98-BKZV.
103 *A Guide for Homeowners Planning Home Improvements: Does Your Septic System Meet State Standards?:* RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT- OFFICE OF WATER RESOURCES, https://perma.cc/9CRM-FY68.

cesspool must be removed or abandoned immediately.[104] The most significant change to the Cesspool Act in the 2015 session was that any cesspool serving a property subject to sale or transfer must be removed from service within one year of the closing date.[105]

Rhode Island has also implemented various programs to incentivize homeowners to address septic system concerns. The Rhode Island Clean Water Finance Agency has a financial incentive program to help homeowners who have failed septic systems. The State provides a line of credit to communities with RIDEM-approved wastewater management plans. Residents can get a low interest loan from this program that allows up to $25,000 for the installation of an appropriate septic system for that location. RIDEM requires a continuous operation and maintenance contract for all advanced treatment technologies in the state. This requirement is entered into the land evidence records, so at the time of property transfer the new owners are aware that they own an advanced technology and it needs operation and maintenance.

Though Rhode Island regulations address nitrogen reduction, there are no new regulations dealing with the issue of groundwater rise due to climate change. Scientists at the Laboratory of Soil Ecology and Microbiology at the University of Rhode Island ("LSEM") have conducted research to better understand the impact of climate change on septic systems and have informed regulators of their findings.[106] The LSEM study looked at different types of septic systems leachfields to see how those systems operate under various climate change conditions, such as the low, medium, and high sea-level rise scenarios, increased temperature, and increased precipitation conditions predicted to occur in New England in the next 100 years. The New England Onsite Wastewater Training Program, the outreach group of the LSEM team, conducts classes and seminars across the region for septic system designers, wastewater practitioners, and decision makers to inform them of climate change impacts to these systems.

Vermont

The Agency of Natural Resources ("ANR") is responsible for the regulation of septic systems in Vermont. The last time ANR amended these regulations was in 2007, when ANR overhauled their preceding regulatory approach.[107]

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104 R.I. Gen. Laws § 23-19.15-6.
105 R.I. Gen. Laws § 23-19.15-12.
106 Welcome to the New England Onsite Wastewater Training Program, (2016) https://perma.cc/PF25-G6CC; See also Cooper, supra note 2.
107 24 V.S.A. §§3631-3635; Amendments to the Wastewater System and Potable Water Supply Rule and a Summary of Significant Changes Made to the Statute That Authorizes the Rule, AGENCY OF NATURAL RESOURCES (November 2007), https://perma.cc/4FDU-33TA.

Under these regulations, an individual seeking to install or replace a sewage system must undergo a permitting process and receive approval from ANR.[108] Minimum standards for separation of septic systems to the seasonal high water table are split up into three sets of requirements, only one of which needs to be met for approval: (1) prescriptive approach; (2) enhanced prescriptive approach, and; (3) performance based approach.[109] A site to be used for wastewater disposal under the prescriptive approach must have at least 24 inches from the surface of the naturally occurring soil down to the seasonal high water table.[110] A site using the enhanced prescriptive approach must have at least 18 inches from the surface of the naturally occurring soil down to the seasonal high water table.[111] A site using the performance-based approach must first determine the amount of rise in the groundwater table that will occur when the effluent from the leachfield is added to the existing water table. This rise is called induced groundwater mounding. The level must be six inches plus the calculated induced groundwater mounding. For example, if the induced groundwater mounding in the water table is eight inches, the separation distance must be 14 inches.[112]

The applicant is to indicate on the Permit Application which approach has been satisfied and will be used if the permit is approved.[113] In determining seasonal high water table, monitoring is performed by ANR from March 1 until May 31, and groundwater level readings must be taken once every seven days during that monitoring period.[114] Once the seasonal high water table is determined, the determination may be used for two purposes: (1) to determine if the site is suitable for wastewater disposal under the regulations; and (2) to help decide what type of system may be used.[115] Vermont's approach to providing a margin of safety in the design of septic systems is quite different from other New England states. Depending on which of the three approaches is employed, there could be anywhere from a six-inch to a twenty-four-inch separation distance.

The permitting process requires inspections of the site before approval, and if a project does not conform to the guidelines, the Secretary may condition approval upon requiring periodic inspections to ensure that the project is functioning as designed.[116] Subsequent monitoring and inspections of a project is not mandatory, but is performed at the discretion of ANR.[117]

Tropical Storm Irene caused catastrophic erosion and inundation throughout Vermont's river valleys in 2011, reminding Vermonters of the risk of placing infrastructure near river beds. Some

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108 24 V.S.A. §3634.
109 Vt. Admin. Code 16-3-300:1-805.
110 Vt. Admin. Code 16-3-300:1-903(b).
111 *Id*.
112 *Id*.
113 *See* Vermont Department of Environmental Conservation Drinking Water & Groundwater Protection Division, Wastewater System & Potable Water Supply Permit Application Instructions, 3, https://perma.cc/585Q-QHF9.
114 Vt. Admin. Code 16-3-300:1-903(e).
115 Vt. Admin. Code 16-3-300:1-903(a).
116 Vt. Admin. Code 16-3-300: Appendix 1-A.
117 Vt. Admin. Code 16-3-300:1-910.

wastewater systems fared well while others sustained significant damage. ANR issued a resiliency report highlighting the community and individual wastewater systems that fared well during Hurricane Irene.[118] The Report also discussed how ensuring the long-term resilience of new or expanded infrastructure will require a careful evaluation of planning and siting to avoid septic systems encroaching on floodplains and river corridors. "When possible," the report noted, "we should consider alternative locations for water and wastewater systems that lie outside of high risk areas."[119]

Municipalities are permitted to adopt more stringent standards relating to sewage systems, as long as they are approved by the Vermont Department of Environmental Conservation. Municipalities also have the ability to request delegation of permitting and enforcement authorities that is initially vested in the state. Additionally, Vermont towns have begun managing the financing of individual (or "decentralized") septic systems. For example, the town of Colchester identified a gap in funding for repair and replacement of decentralized wastewater treatment systems, especially when compared to the funding available for centralized systems.[120] In order to fill this funding gap, Colchester established a local, low-interest loan program specifically for decentralized wastewater system repairs and replacements.[121] These kinds of voluntary local funding programs provide an opportunity for an affordable transition into a more sustainable, efficient, and effective decentralized wastewater infrastructure.

Although Vermont's septic systems may be sheltered from the effects of sea-level rise, the region is still expected to experience an increase in extreme precipitation events, flooding, increased rises in temperatures, and erosion, which could have serious consequences on infrastructure like septic systems. Additionally, over half of Vermont homes use decentralized wastewater systems, which is the highest use rate in the United States.[122]

118 *Resilience: A Report on the Health of Vermont's Environment*, VERMONT AGENCY OF NATURAL RESOURCES (2011), https://perma.cc/4TWB-4XCJ.
119 *Id.* at 22.
120 *Discussion of Wastewater Management Options*, STONE ENVIRONMENTAL INC. (January 2011), 27-28, https://perma.cc/LB7Q-TNMJ.
121 *Id*. at 27 ("The Town of Colchester administers a long-term, low-interest (20-year term, 3% interest) loan fund with Clean Water SRF funding originating from the Vermont [Department of Environmental Conservation].").
122 Vermont Legislative Research Service, *Decentralized Wastewater Management* Systems, UNIVERSITY OF VERMONT (April 2015), https://perma.cc/X8FE-JWP7.