Town of Charlestown, RI

Confronting Housing Needs and Nitrate Management: Charlestown Zoning Analysis

A Project Supported by the Rhode Island Housing Municipal Technical Assistance Program

Final Report

February 9, 2025

Weston & Sampson℠

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EXECUTIVE SUMMARY

Rhode Island is facing a housing shortage stemming from decades of insufficient residential construction. One consequence of the shortage has been a sharp rise in housing cost and a dwindling supply of reasonably priced residences, making safe and suitable housing unattainable for a significant number of Rhode Islanders. Charlestown is one of the Rhode Island towns most affected by this housing shortage; however, this housing shortage represents only one side of a major residential-development dilemma in Charlestown as much of the Town's residential land overlays drinking water aquifers and the densest development has been constructed near the salt ponds and barrier beaches.

THE MAKING OF THIS REPORT

This report was prepared under the Town of Charlestown Needs Analysis and Zoning Update project. This project was conducted in three phases with each phase resulting in a phase-report. The Phase 1 report focused on review and analysis of land-use and scientific data. The Phase 2 report identifies management options for improved control of nitrate as well as potential locations for residential development, which minimize risk of nitrate contamination. The Phase 3 report is a culmination of the other two reports with the addition of recommendations for zoning ordinance amendments and other controls. **This is the Phase 3 or final report.**

Groundwater is the only economically viable source of drinking water in Charlestown. In fact, the US Environmental Protection Agency (EPA) considers the groundwater beneath Charlestown to be a sole source aquifer. Due to the porosity of local soils, Charlestown's groundwater is highly susceptible to nitrate contamination. Wastewater and stormwater from residential development represent the primary sources of nitrate to groundwater. Some nitrate levels in local drinking water wells have been measured above the Federal Safe Drinking Water Act regulatory standard of 10 parts per million (ppm). Nitrates at 10 ppm and above in drinking water have been shown to cause significant public health concerns.[1]

In addition to public health concerns, nitrate presents environmental concerns. Many areas of Charlestown overlay aquifers with nitrate levels well above natural background levels. Numerous scientific studies link elevated nitrate with density of residential development and with degradation of the salt ponds. This has led the Rhode Island Coastal Resource Management Council (CRMC) to identify areas in the watershed of the salt ponds that have been developed at densities over one home per half acre as "developed beyond carrying capacity." In these overdeveloped areas, nitrate poses a threat to the ecology of the salt ponds, which are a major draw for tourism as well as an essential underpinning of Charlestown's economy.

This report—Confronting Housing Needs and Nitrate Management—intends to address the issue of housing density in Charlestown considering the strong demand for additional housing units, particularly for persons of low and moderate income while considering environmental impacts of additional

[1] https://deohs.washington.edu/sites/default/files/documents/Nitrates_Blue_Baby_Syndrome_and_Drinking_Water_Community_Factsheet_Mar_2016.pdf

residential construction especially as they relate to nitrate concentrations in drinking water and the salt ponds.[2] The following questions are addressed in the report with responses to them summarized below:

1. **Where is additional density appropriate in terms of land use, land use patterns and landscapes, and in terms of availability of infrastructure and proximity of services?**

   In 1999, the Coastal Resources Management Council identified lands developed beyond carrying capacity in the Salt Pond Region Special Area Management Plan (SAMP). Generally, these lands are areas with residential dwelling units at a density of greater than one unit per half acre. This level of density has been shown to result in levels of nitrate that will make groundwater unsafe for human consumption and will result in impairment of estuarine resources like the salt ponds. This report recommends restricting new development and redevelopment in lands developed beyond carrying capacity by directing development to areas with residential densities of less than one unit per half acre. Generally, these areas are shown in Figure 2-9 of this report. Additionally, this report recommends that any redevelopment in lands developed beyond carrying capacity employs reduction of existing nitrate loading using specific best management practices for land use, stormwater, wastewater, fertilizer application, and pet waste in combination with public education.

2. **What are the implications of permitting secondary dwellings by right within the salt pond watershed both for the salt ponds and drinking water, particularly in terms of consistency with the policies and goals of the Salt Pond SAMP?**

   As noted above in response to question 1, existing development in many parts of Charlestown is at a density that exceeds the carrying capacity of land and has resulted in impairment of both surface water and groundwater. Additional development—such as secondary dwelling units allowed by right—without nitrate mitigation will clearly exacerbate the situation. This report recommends that any development in lands developed beyond carrying capacity be subject to the application of techniques to reduce nitrate loading from the development site. Land-use management techniques, including a nitrogen management overlay district, are recommended to better manage nitrates while allowing for new development and redevelopment.

3. **How effectively does the existing zoning align with, or fulfill, the requirements of the needs analysis?**

   Charlestown has made substantial efforts to manage nitrate through existing programs and approaches such as its onsite wastewater management program, landscaper process, and use of conservation development. These programs and approaches, especially the onsite waste management program, have made major improvements in the reduction of nitrate from developed land; however, they need to be bolstered to improve drinking water quality and reduce degradation of the salt ponds. While current zoning practice aligns with good land-use management practice, it is not enough to respond to housing demand while managing environmental and public health concerns related to nitrate. Land-use management techniques, including a nitrogen management

[2] Nitrate is one of many environmental concerns in Charlestown that relate to density of development. Notwithstanding, this study focuses on nitrate as it is a principal concern related to potable groundwater and the estuarine ecology.

overlay district, are recommended to better manage nitrates while allowing for new development and redevelopment.

Summary of Proposed Management Approach

Effective management of nutrient pollution will require a combination of techniques, including wastewater and stormwater technologies, land-use regulations, fertilizer and pet-waste management, and public education including social marketing. At the same time, the Town needs to provide for housing opportunities, especially for middle-income households. Section 4 of this report lays out an approach to move the Town forward. Key elements of this approach include:

- Continuation of Charlestown's onsite wastewater management program as a cornerstone of nitrate management. The Town should explore strengthening this program through cooperation with the state to require systems that reduce nitrates to 10 mg/L, i.e., parts per million or below followed by discharge to shallow-narrow drainfields.
- Enactment of a nitrogen management overlay district, which is proposed as a specialized zoning tool for enhanced management of nitrates from onsite wastewater treatment systems, stormwater, fertilizer, and pet waste.
- Consideration of other zoning ordinance amendments to allow additional housing density in less environmentally constrained areas of Town.
- Social marketing and other forms of public education should be used to support the implementation of the proposed land-use regulation techniques to ensure that the community understands the critical need to support growth in a sustainable manner.
- Adaptive management should be incorporated in the Town's nitrate management programs. The proposed management techniques will help address housing needs and nitrate management issues, but they are no guarantee of success and will likely need adjustment over time. The Town should establish an implementation committee that meets regularly (e.g., twice per year) to discuss progress and course corrections as needed.

1 BACKGROUND AND PLANNING PROCESS

1.1 Background

Rhode Island is facing a housing shortage stemming from decades of insufficient construction in both rental and homeownership sectors.[3] The consequence is a sharp rise in housing expenses and a dwindling supply of affordable residences, making safe and suitable housing unattainable for a significant portion of Rhode Islanders. However, because of its desirable location along the southern Rhode Island shore and its many amenities, Charlestown has experienced considerable development pressure, especially in the neighborhoods already densely developed south of Route 1. The Town's population has grown 11 times faster than the state within a 50-year period (1970-2020). As shown in Table 1-1, while Rhode Island's population grew from 946,725 to 1,097,379 (15.9% increase) between 1970-2020, Charlestown experienced a population growth from 2,863 to 7,997; a substantial increase of 179%. As shown in Table 1-2, the number of housing units in Charlestown grew at a similar pace from 2,863 to 7,997 or 173%.

Table 1-1. Population growth in Charlestown versus the State

Year	Population	Change in Population	% Change
1970	2,863		
1980	4,800	1,937	67.7%
1990	6,478	1,678	35.0%
2000	7,859	1,381	21.0%
2010	7,827	-32	- 0.4%
2020	7,997	170	2.2%
Total		5,134	179%

Source: U.S. Census Bureau, 2020; Charlestown Comprehensive Plan, 2021

[3] *2023 RIHousing Fair Housing Policy Report. (2024). https://www.rihousing.com/wp-content/uploads/2023-Fair-Housing-Report-FINAL.pdf*

Table 1-2. Housing Units in Charlestown versus the State

Year	Housing Units	Change in Housing Units	% Change
1970	1,971		
1980	3,064	1,093	55.5%
1990	4,240	1,176	38.4%
2000	4,797	557	13.1%
2010	5,142	345	7.2%
2020	5,381	239	4.6%
Total		3,410	173%

Source: U.S. Census Bureau, 2024; RI Division of Statewide Planning, 2024

Charlestown has no public water or sewer and relies exclusively on groundwater for its water supply and individual on-site septic systems for its waste disposal. One-third of the Town's land area falls within the watershed of the salt ponds, which also contains approximately 63% of Charlestown dwellings. The high density and unplanned developments in the salt pond area pose unique challenges to the Town's sole source drinking water supply aquifer due to:

- The presence of residential land overlaying the aquifer.
- The aquifer's proximity to salt ponds.

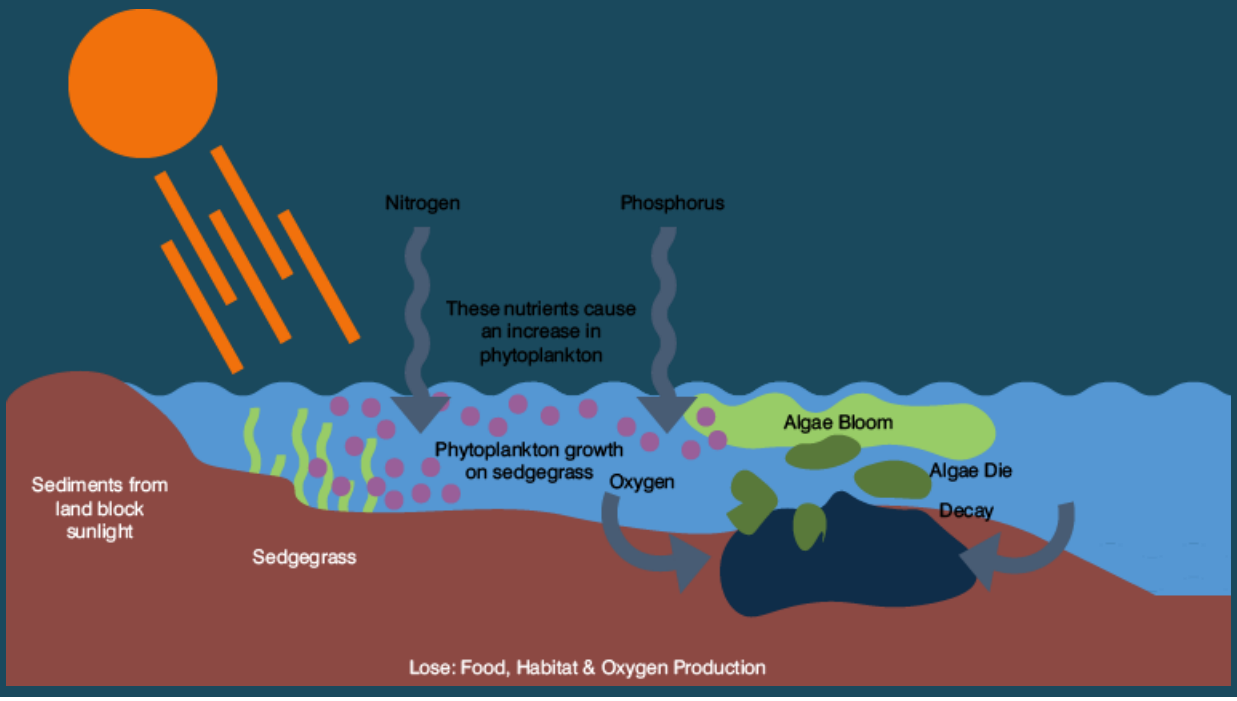
The salt pond watershed is regulated under the RI Coastal Resources Management Council's (CRMC) Special Area Management Plan (SAMP). The dense housing near the salt ponds that are developed at one residential or commercial unit per half acre, have been designated as "lands developed beyond carrying capacity" by CRMC.[4] This area faces significant threats from density and nitrate loading, posing real concerns for groundwater quality. In addition to contaminating drinking-water wells, this nitrate-enriched groundwater eventually flows into Charlestown's three salt ponds, where it promotes eutrophication and increases the risk of hypoxia.

[4] Salt Pond Region Special Area Management Plan. (n.d.). Retrieved September 11, 2024, from http://www.crmc.ri.gov/regulations/SAMP_SaltPond.pdf

EUTROPHICATION

Over-enrichment of water by nutrients such as nitrogen and phosphorus, leading to hypoxia (oxygen depletion).

Source: World Resources Institute, 2024



Project Objectives

The main project objectives include comprehensively addressing the issue of housing density through zoning. The Town would like to proactively address housing needs, particularly in light of recent statewide mandates and anticipated future legislation. These initiatives include by-right allowance of accessory dwelling units (ADUs). The Town is committed to doing its part in providing needed housing but in a strategic and targeted way.

PROJECT OBJECTIVES

- Conduct thorough review and analysis of Charlestown's zoning regulations to identify additional housing opportunities.
- Provide potential solutions for nitrate reducing methods, including water/wastewater management.
- Offer public education and recommendations for zoning ordinance amendments.
- Develop comprehensive insights to the Planning Commission to inform future planning decisions.

Project Funding

Charlestown received funding under the Rhode Island Housing (RIHousing) Municipal Technical Assistance Program (MTAP) to receive professional consultant services from Weston & Sampson for an assessment of where additional housing is appropriate without increasing risk to public health or the environment. This work includes reviewing current residential zoning regulations and identifying amendments to the zoning ordinance for consideration by the Town Council.

RI Housing Municipal Technical Assistance Program

Rhode Island is facing a critical shortage of housing due to decades of underproduction of rental housing as well as homeownership opportunities. This has resulted in rapidly increasing housing costs and a low inventory of available homes and apartments, putting safe and affordable housing out of reach for too many Rhode Islanders.

To help address this problem the General Assembly created the Housing Production Fund capitalized with an initial appropriation of $25 million. Of the initial allocation, $4 million has been made available for municipal technical assistance through the Municipality Technical Assistance Program. The Program is administered by RIHousing according to guidelines approved by the RI Housing Resources Commission's Coordinating Committee and in collaboration with the Department of Housing. Participation is subject to funding availability.

Source: RI Housing, February 2024

Project Approach

The project approach for addressing Charlestown's housing shortage and environmental concerns includes three main phases:

Background Review and Analysis: This phase included a review of zoning and subdivision and land development regulations, as well as the Charlestown Comprehensive Plan and other documents relevant to residential use and density options, particularly consistency with the CRMC Salt Pond Special Area Management Plan. Field review of various areas of Town were conducted to understand development patterns and land availability, and to evaluate the effects of increased density on groundwater and the salt ponds, focusing on nitrate loading and to identify critical areas for protection.

Identification of Additional Housing Opportunities: This phase involved exploring additional housing opportunities through reviewing best practices for additional density, researching nitrate-reducing water and wastewater treatment options, and investigating low impact development techniques for sensitive areas. The importance of social media marketing and public education were also evaluated in this phase. The outcome was shared with town officials and Planning Commissions members to gather local input.

Recommendations and Implementation: The final phase focused on developing policy and zoning recommendations, creating an implementation strategy, and producing a final report. As part of the final phase, proposed policy updates for zoning, housing, and environmental protection were recommended.

1.2 Planning Process

The Town has retained a consultant through the technical assistance services grant under the RI Housing MTAP. Town staff were involved throughout the project. The consultant, Weston & Sampson, worked with the Planning, Building/Zoning, Wastewater/Stormwater and Public Works Departments as well as the Planning Commission to find answers to the questions mentioned above. The Town's GIS Department was actively involved providing necessary project data such as delineation of zoning districts, property uses and environmental characteristics.

Three public workshops were held through the Planning Commission, one for each phase of the project. The first public workshop was March 7, 2024. The second public workshop was held on September 4, 2024. The third public workshop was held on January 15, 2025.

2 EXISTING CONDITIONS

2.1 Environmental

Glaciation shaped much of Charlestown's landscape. Remnants of the glacial moraine are still visible along Route 1 in its topography, soil composition and drainage patterns. This moraine divides the region, with steep hills to the north and a flat sandy coastal plain to the south, bordered by barrier beaches and salt ponds formed by coastal embayment. North of the moraine, the terrain comprises north-south ridges, wetlands like Indian Cedar Swamp, and waterbodies such as Watchaug Pond and Pasquiset Pond.

Significant natural features, including beaches, salt ponds, rivers, streams, aquifer recharge areas and many freshwater ponds, occur throughout Charlestown. In many ways, natural features define the character of the Town, but also present physical constraints to development. This section discusses both the aesthetic benefits and constraints to development associated with freshwater and saltwater ponds, soils and topography, and aquifer recharge areas.

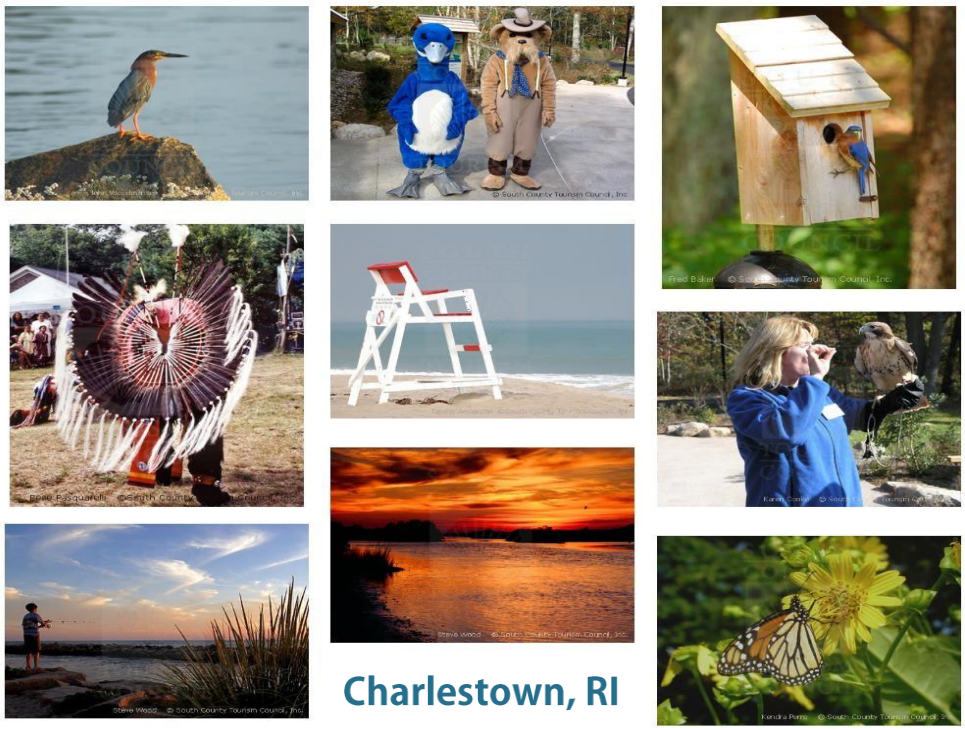


Figure 2-1. Natural Resources of Charlestown, RI
Source: South County RI, February 2024

Charlestown's geology, including sandy soils and an extensive aquifer, provides for accessible and plentiful potable water; however, that same geology leaves drinking water vulnerable to pollutants, like nitrate, that pass readily through sand. Nitrate, which measures near or even above federal safe drinking water standards in much of the Town's groundwater south of Route 1, presents a major drinking water concern. Coastal ecosystems are also highly sensitive to nitrate, even at relatively low

concentrations. Nitrate concentrations in groundwater and the salt ponds has led the Coastal Resources Management Council to declare significant areas of Charlestown as land developed beyond carrying capacity.

Fresh Surface Waters

The Pawcatuck River Basin covers around two-thirds of the Town's area and contributes significantly to its aesthetic appeal, recreational opportunities, and ecological richness. The river defines Charlestown's boundary with the Towns of Richmond and Hopkinton, originating from Worden's Pond in South Kingstown and emptying into Block Island Sound at Watch Hill in Westerly. Spanning nearly 18 miles within Charlestown, it passes through historic mill villages like Kenyon, Shannock, Carolina, and Burdickville, earning the distinction of a Wild and Scenic River due to its exceptional natural, cultural, and recreational significance.

The Town's GIS identifies approximately 90 freshwater ponds, with notable surface waterbodies like Watchaug Pond, School House Pond, and Pasquiset Pond, each offering unique recreational experiences, wildlife habitats, and groundwater recharge functions. While some ponds are surrounded by protected open spaces or owned by conservation organizations like The Nature Conservancy, many others are privately held.

The ecosystems of fresh surface waters are much less vulnerable to nutrification from nitrate than they are to nutrification from phosphorus; however, the presence of bioavailable nitrate does play an important role in eutrophication of freshwaters. Surface waters can be viewed as the expression of groundwater resources and, therefore, nitrate that is transported to fresh waterbodies passes into groundwater.

Estuarine Waters

The barrier beaches, spanning approximately six miles along Charlestown's southern shore, are essential for sustaining the salt ponds, marshes, and tidal flats ecosystems. Water quality is significantly impaired in the salt ponds by pollutants such as nitrate and pathogens. Charlestown's salt ponds, which include Ninigret Pond, the eastern portion of Quonochontaug Pond, and a small part of Green Hill Pond, constitute a rich ecosystem. The ponds are fed by freshwater springs, streams, and seawater through narrow breachways. Ninigret Pond, the largest among them, serves as a significant resource for local fisheries and recreational activities, while Quonochontaug Pond, although smaller and deeper, attracts motor boating, sailing, and fishing enthusiasts. Green Hill Pond, although primarily within the Town of South Kingstown, shares its beauty and recreational opportunities with Charlestown, although facing challenges from nutrient loading due to its developed watershed. Figure 2-2 depicts the estuarine resources along Charlestown's coast. Despite being ideal for supporting salt marshes, eelgrass, and phytoplankton, limited flow in the salt ponds makes them susceptible to water quality degradation.

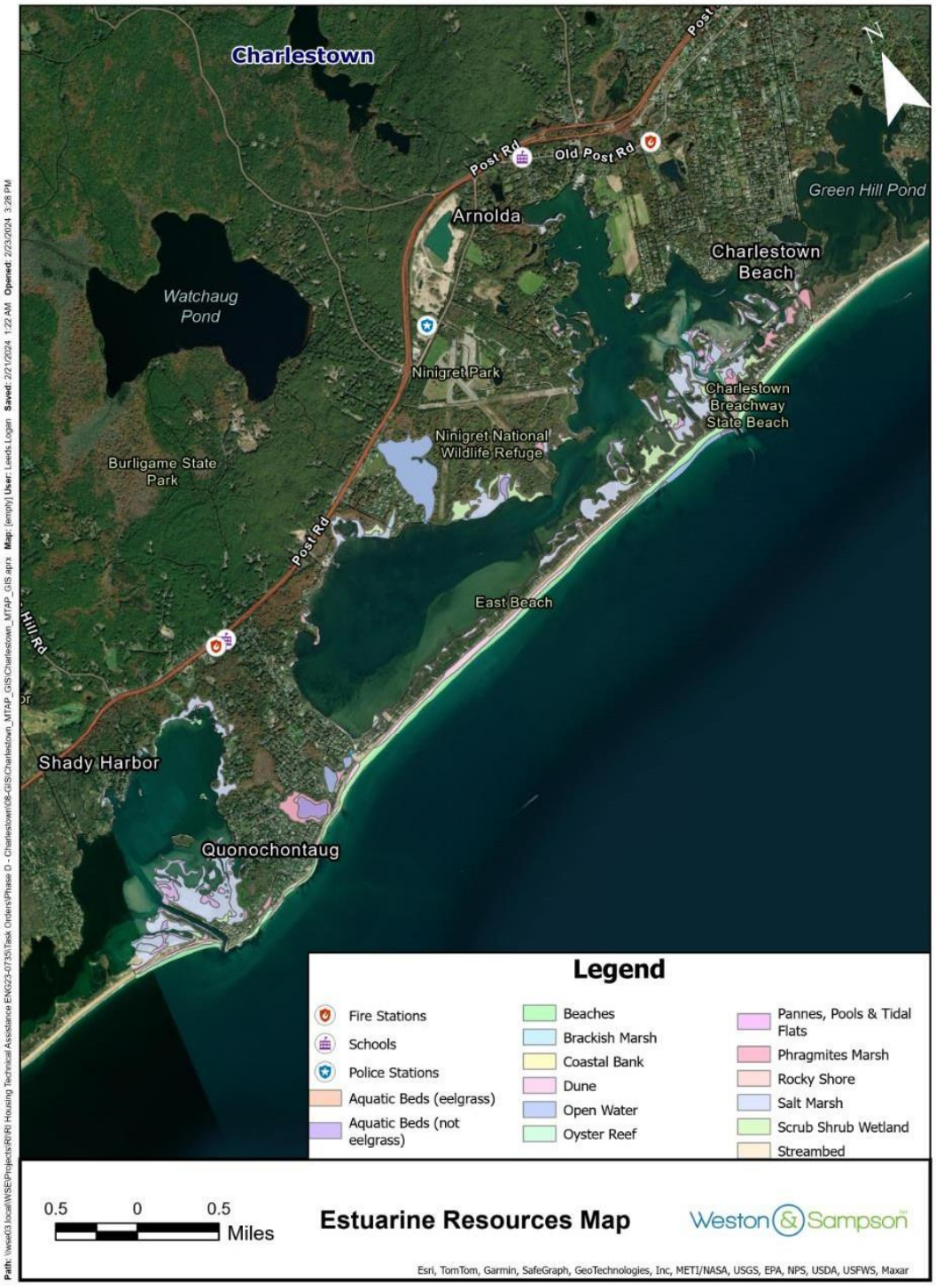


Figure 2-2. Estuarine Resources of Charlestown, RI
Source: RIGIS, February 2024

Soils

As noted above, the soils and overall geology of Charlestown reflects its glacial history. Figure 2-3 indicates the areas of Charlestown with moderate constraints to development, with seasonal high-water table and with ledge and slopes over 15%. The map also highlights areas with moderate limitations such as seasonal high-water tables and steep slopes, as well as those with significant constraints like hydric or subaqueous soils.[5]

The Soil Survey of Rhode Island conducted by the US Department of Agriculture offers a detailed inventory of the state's soils, outlining their potentials and limitations for development. Much of Charlestown's most arable soil has been developed for housing, particularly south of Route 1. Now, most active farms in Charlestown operate north of the glacier's moraine deposit, which consists of finer soils.

[5] *Hydric Soils*—Soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. *Subaqueous Soils*—Soils that occur in shallow freshwater and marine environments, such as ponds, lakes and the subtidal areas of estuaries and tidal embayments.

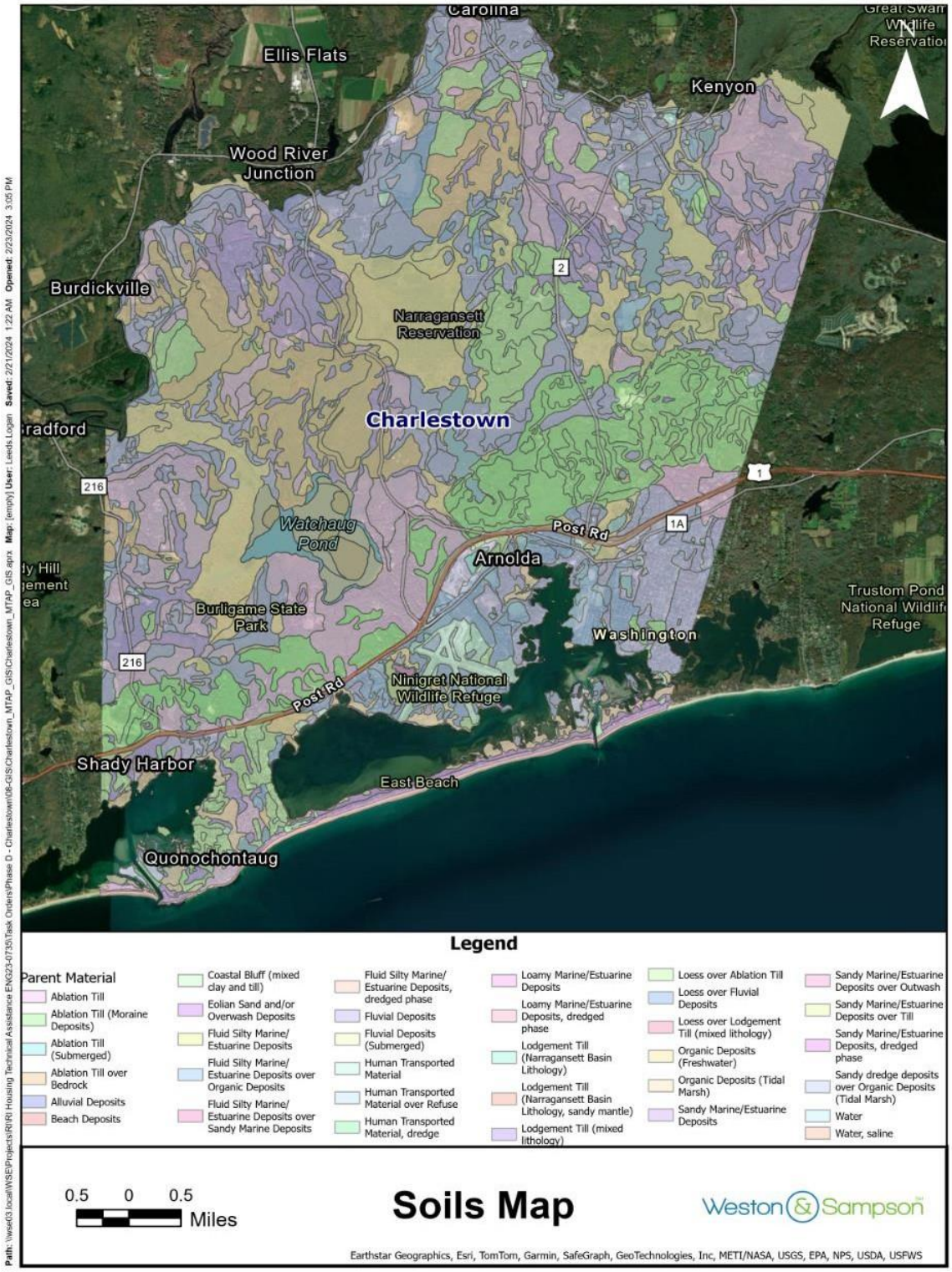


Figure 2-3. Soils of Charlestown, RI
Source: RIGIS, February 2024

Groundwater

The highest yielding groundwater sources in the Town lie beneath glacial sand and gravel deposits above bedrock, offering ample water for low-density development. Areas surrounding Pasquiset Pond, and northwest of Indian Cedar Swamp present fast draining soils that support deep aquifer reserves, replenished by rainfall and streams, and are crucial for water supply purposes.

Protecting these aquifers is critical for Charlestown's future ability to support new and existing housing development, as they contribute to the Town's relatively plentiful drinking water supply. Conversely, south of the moraine in the outwash plain, groundwater primarily relies on local rainfall for recharge, with shallow bedrock depths of less than 30 feet. This groundwater serves densely populated areas, including the Quonochontaug peninsula and Charlestown Beach Road vicinity, facing pollution and saltwater intrusion risks. The Pawcatuck River Aquifer, identified as a sole source aquifer by the US Environmental Protection Agency, serves as a significant water source for Charlestown and neighboring regions.

2.2 Land Use and Zoning Districts

Land use and landcover data were obtained from the Rhode Island Geographic Information System (RIGIS) and the Town. The Town’s dataset combines land use classifications from standardized assessor parcel information with land cover types derived from 2016 orthophotographs. As noted in the Comprehensive Plan and confirmed in land use and landcover, Charlestown is primarily made up of residential lots and public facilities with just 9% of the total land use dedicated to agriculture and commercial/industrial uses combined. Approximately 14% of total land use is categorized as undeveloped. Single-family structures make up most of the residential land in Charlestown.

Without careful management, developed land can significantly raise concentration of nitrate in surface water and groundwater. Agricultural, residential, commercial, and industrial uses each have the potential to contribute to nutrients to groundwater and local waterways.

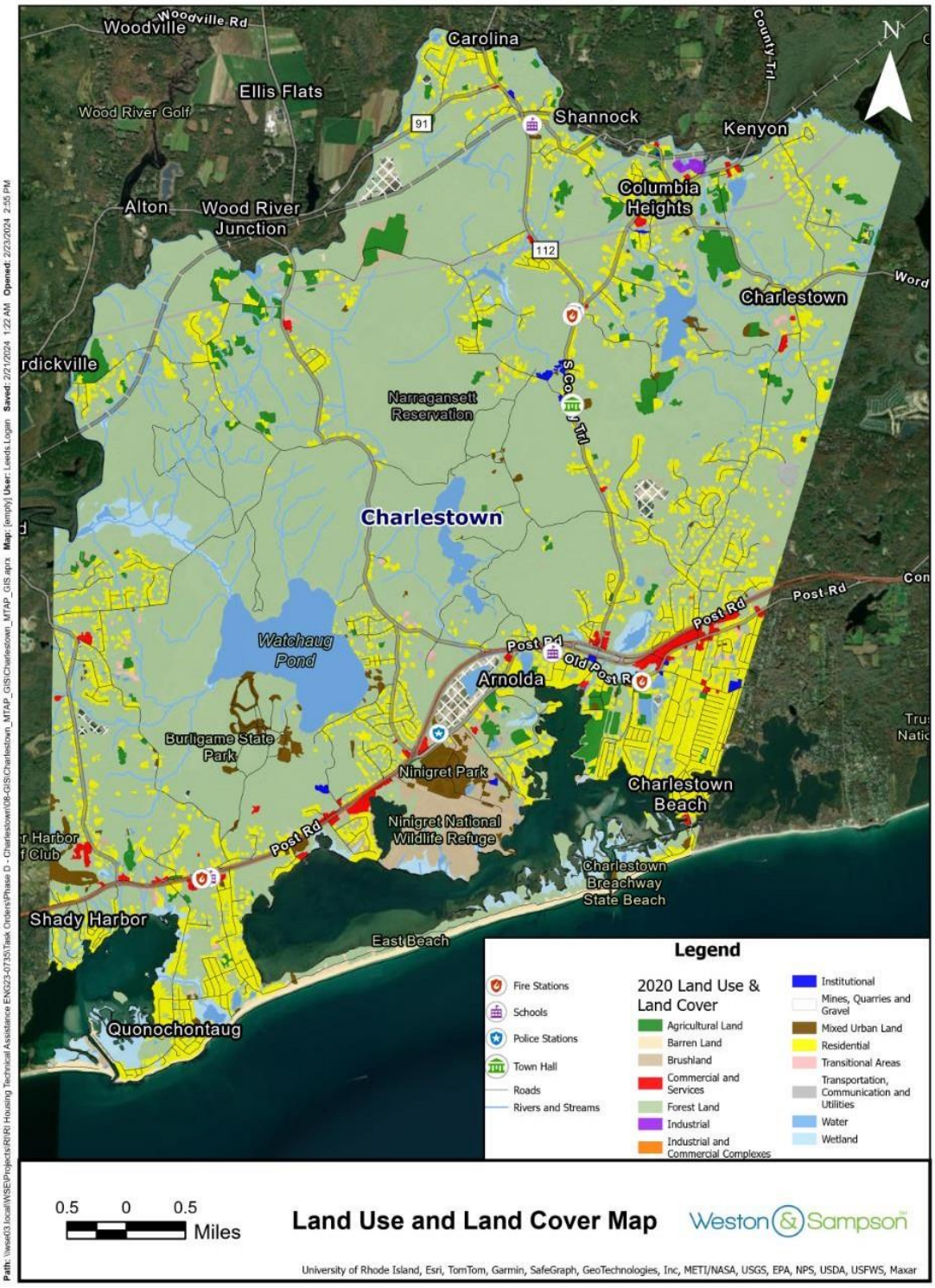


Figure 2-4. Land Use and Land Cover of Charlestown, RI

Source: RIGIS, February 2024

Current Zoning

Currently, Charlestown limits housing primarily to residential zones. With the exception of the Traditional Village District (TVD), there are no commercial districts that permit mixed use. Allowing for residential uses in commercial districts could provide for additional housing without adding residential density in sensitive environmental areas. The Town has small village areas that are zoned for commercial and may be appropriate for rezoning to mixed-use. The TVD could also be less restrictive in terms of allowing new residential-only development.

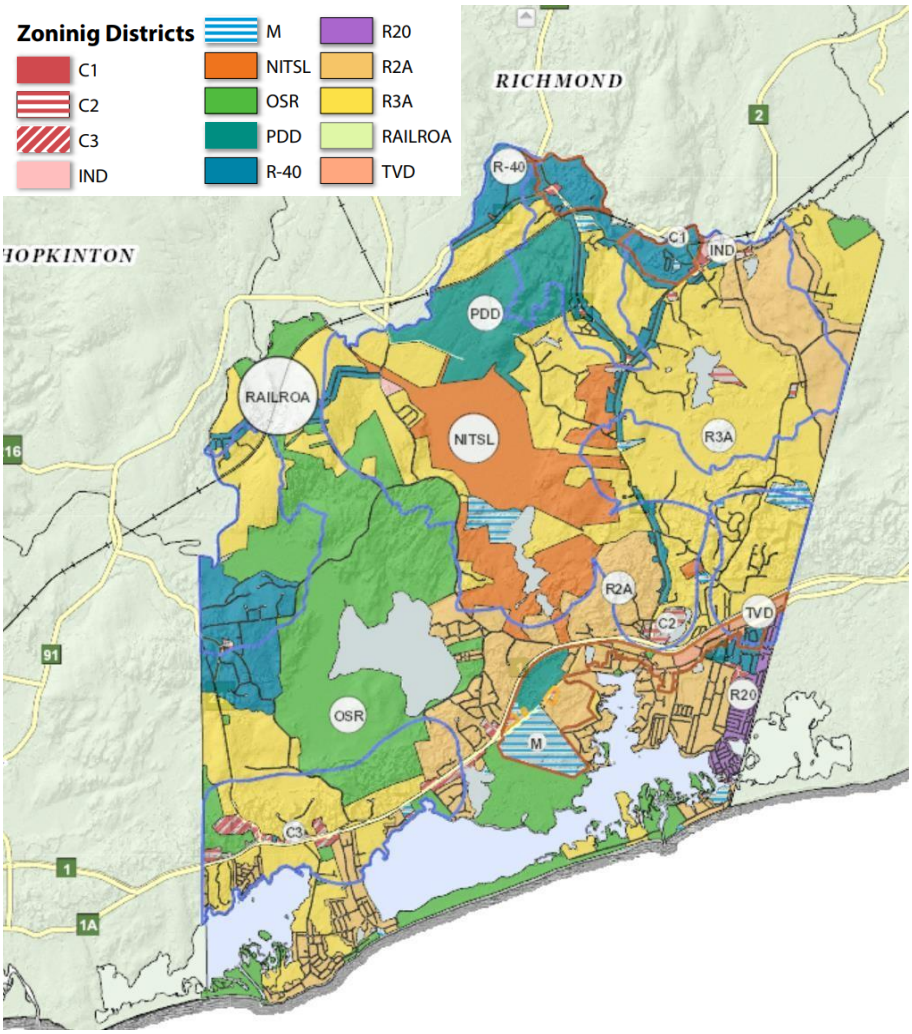


Figure 2-5. Zoning Districts of Charlestown, RI: C represents commercial zoning, R residential, M municipal, IND industrial, PDD planned development district, OSR open space, NITSL Narragansett Indian Tribe Settlement Lands, and TVD is Traditional Village District

Source: Charlestown GIS, February 2024

Housing Trends and Household Economics

The nature of Charlestown's land development, consisting primarily of single-family residential use with individually owned onsite wastewater treatment systems (OWTSs) and high density of hardscapes over sandy soils, creates significant risk for pollution of groundwater by nitrate. Figure 2-6 compares housing density across Charlestown with nitrate concentration to identify potential locations for future development.

Establishment of seasonal housing in Charlestown has increased steadily since the early-2000s, especially in areas closest to the shore. Although most of Charlestown's households are middle income, proximity to the tri-state area and easy ocean access has attracted wealthy homeowners, especially south of Route 1. Many of the cottages that once comprised nearly all of Charlestown have been demolished or converted in favor of larger houses for new residents and second-home owners.

The 2021 Comprehensive Plan indicated that development pressure has resulted in an increase in year-round housing as well. Charlestown's densest residential development occurs around the eastern- and westernmost portions of Ninigret Pond to the south of Route 1. Outside of the historic village areas, Charlestown is mostly comprised of single-family homes along various roads with several major subdivisions scattered throughout the Town.

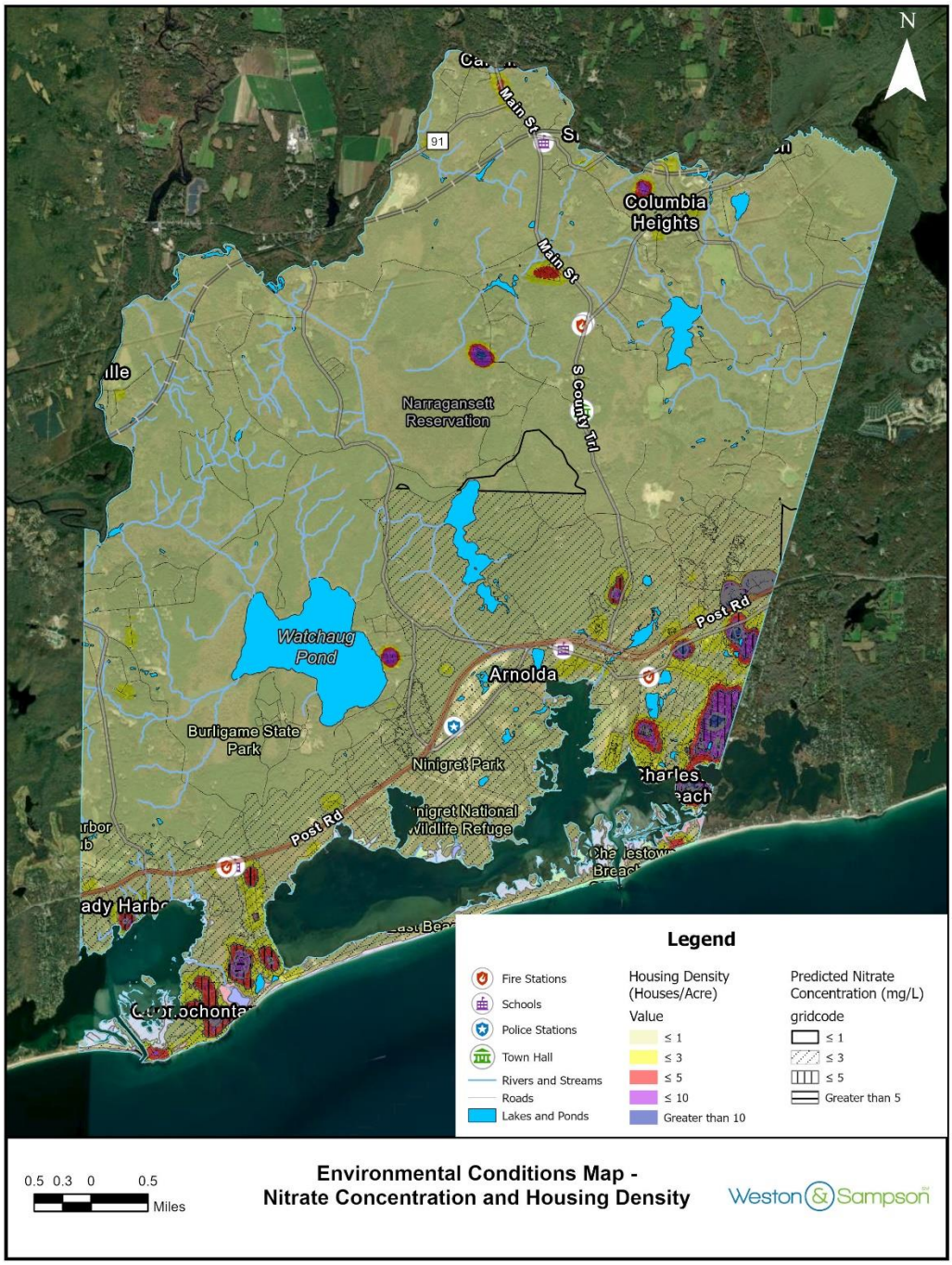


Figure 2-6. Predicted Nitrate Concentration and Housing Density of Charlestown, RI

Source: RIGIS, February 2024

2.3 Field Review and Observation

A field review was conducted on January 18, 2024, to understand Charlestown's land patterns, identify sites worthy of additional development and locations in need of development restrictions. Appendix A contains the notes taken during the field review. Figure 2-7 shows photographs taken during the field visit. The following are some of the key observations collected during the visit:

- Historic village development has resulted in many areas of Town being built at medium (lots at 1/4-acre to 1/2-acre) to high (lots at greater than 1/4-acre) residential density. All areas of Town are served by OWTSs and private groundwater wells for drinking water. As defined by CRMC, land developed beyond carrying capacity includes residential areas with housing densities of one or more dwellings per half acre. **By this definition, much of Charlestown is comprised of land developed beyond carrying capacity.**
- Several areas (e.g., Carolina Village) of Town are built at higher densities than is currently allowable by zoning, making many of the lots nonconforming. As discussed during the field review, this is because the areas were built out and then rezoned—aspirationally—in an attempt to encourage lower density. Zoning is primarily a prospective tool. It does not generally work well retroactively. The village areas are built out already, and their density can no longer be managed through zoning; therefore, **the Town should consider a zoning update to reduce the prevalence of zoning nonconformities and the potential appearance of regulatory instability.**
- Some areas of Town, especially near the coast, are undergoing teardown-rebuild, which is resulting in larger homes with more extensive footprints. Cumulatively this will create a significant increase in pollution (e.g., nutrients) from stormwater. While field visit participants observed soil erosion being managed with construction stormwater management practices such as silt fence and haybales, no postconstruction best management practices (BMPs) (e.g., bioswales, stormwater ponds, and bioretention systems) were seen being installed.[6] **The Town should consider revising its approach to regulation of construction and postconstruction runoff to better control nitrate pollution.**

[6] Postconstruction BMPs will help to reduce postconstruction stormwater pollution; BMPs will not eliminate pollution. BMPs are only reduction strategies. Impervious surfaces in these areas appear to be well beyond typical for 1/2-acre to 2-acre density.

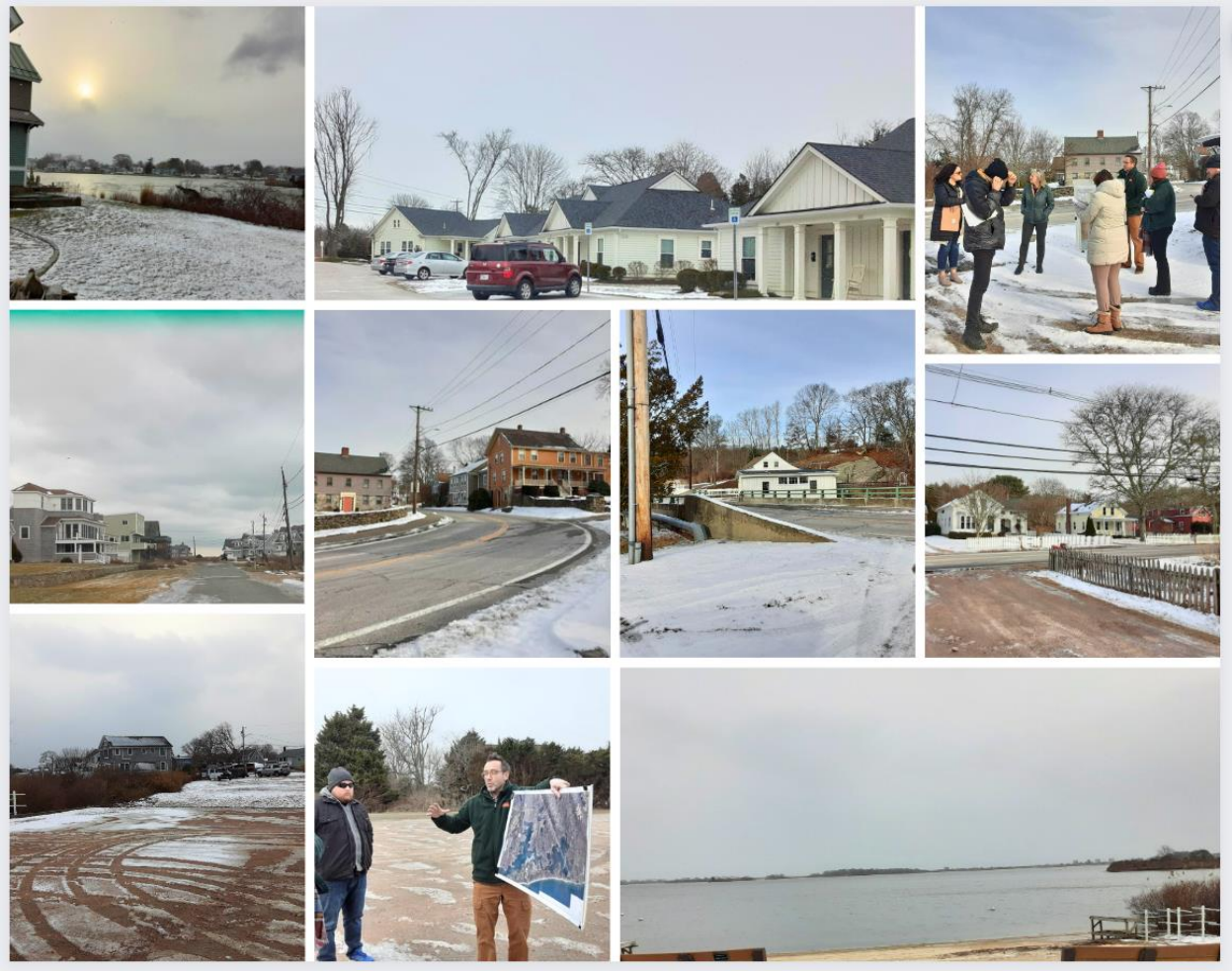


Figure 2-7. Photos from Field Visit in Charlestown, RI
Source: RIGIS, February 2024

2.4 Analysis of Existing Conditions for Increased Density

The background analysis found that Charlestown is primarily made up of residential lots and public facilities with just 9% of the total land use dedicated to agriculture and commercial/industrial uses combined. The analysis conducted for this section of the report uses GIS overlay analysis to categorize existing housing densities based on lot sizes and nitrate concentrations.

CRMC Land Use Classifications

Numerous scientific studies link elevated nitrate with density of residential development and with degradation of the salt ponds. This led the Rhode Island Coastal Resource Management Council (CRMC) to classify areas in the watershed of the salt ponds according to their development density including lands developed beyond carrying capacity as well as lands of critical concern and self-sustaining lands. See Figure 2-8 which shows the CRMC land use classifications in the salt pond

watershed in Charlestown. Lands developed beyond carrying capacity are described in the SAMP as follows:

> Lands which were developed at … one residential or commercial unit per 1/8 to 1/2 acre. Such intense development was the major source of contamination to groundwater and the salt ponds. High nutrient loadings and contaminated runoff waters were resulting in a high incidence of polluted wells and increasing evidence of eutrophic conditions and bacterial contamination in adjoining salt pond waters. Most of the individual sewage disposal systems in these areas predated state-enforced siting and design standards and were approaching their expected life span. (CRMC, 1999, page 9 of 13).[7]

These densely developed areas are identified as major sources of contamination to groundwater and the salt ponds, indicating a potential constraint to increasing density.

Many areas in Charlestown along the coast have been identified as lands developed beyond carrying capacity, suggesting limited suitability for denser development made evident by correlation to high nitrate levels in groundwater. Although the USEPA's maximum contaminant level (MCL) for nitrate in drinking water is 10 mg/L, concentrations as low as 2.5 mg/L have been shown to have adverse health effects, including different types of cancer (Nolan and Hitt, 2006).[8] Based on the nitrate concentration in the groundwater and densely developed areas, the Town's residential and commercial lands could be categorized into three groups:

Areas with Available Carrying Capacity for Development

These are areas where additional development may be acceptable under existing development standards as nitrate concentrations are within acceptable limits. Examples include areas with groundwater nitrate concentrations less than 3 ppm and areas with development at densities below one home per two acres.

Areas where Additional Density is Only Appropriate with Regulatory Mitigation

In these areas, future development may be permissible, but stringent regulatory actions need to be imposed to mitigate the impact of high nitrate concentrations and potential for environmental and public health risk. Examples include areas with groundwater nitrate concentrations of 3 ppm to 5 ppm and areas with development at densities of greater than one home per two acres but less dense than one home per half acre. A nitrate-reduction overlay district could help to manage nitrate from new development in these areas.

[7] Salt Pond Region Special Area Management Plan. (n.d.). Retrieved September 11, 2024, from http://www.crmc.ri.gov/regulations/SAMP_SaltPond.pdf.

[8] Nolan, B. T., and H. J. Hitt. 2006. "Vulnerability of shallow groundwater and drinking-water wells to nitrate in the United States." Environ. Sci. Technol. 40 (Mar): 7834–7840. https://doi.org/10.1021/es060911u.

Areas where Additional Density is Inappropriate

These are areas where further development is not advisable due to existing high nitrate concentrations and density of development beyond carrying capacity. Examples include areas with groundwater nitrate concentrations above 5 ppm and areas with development at densities over one home per half acre.

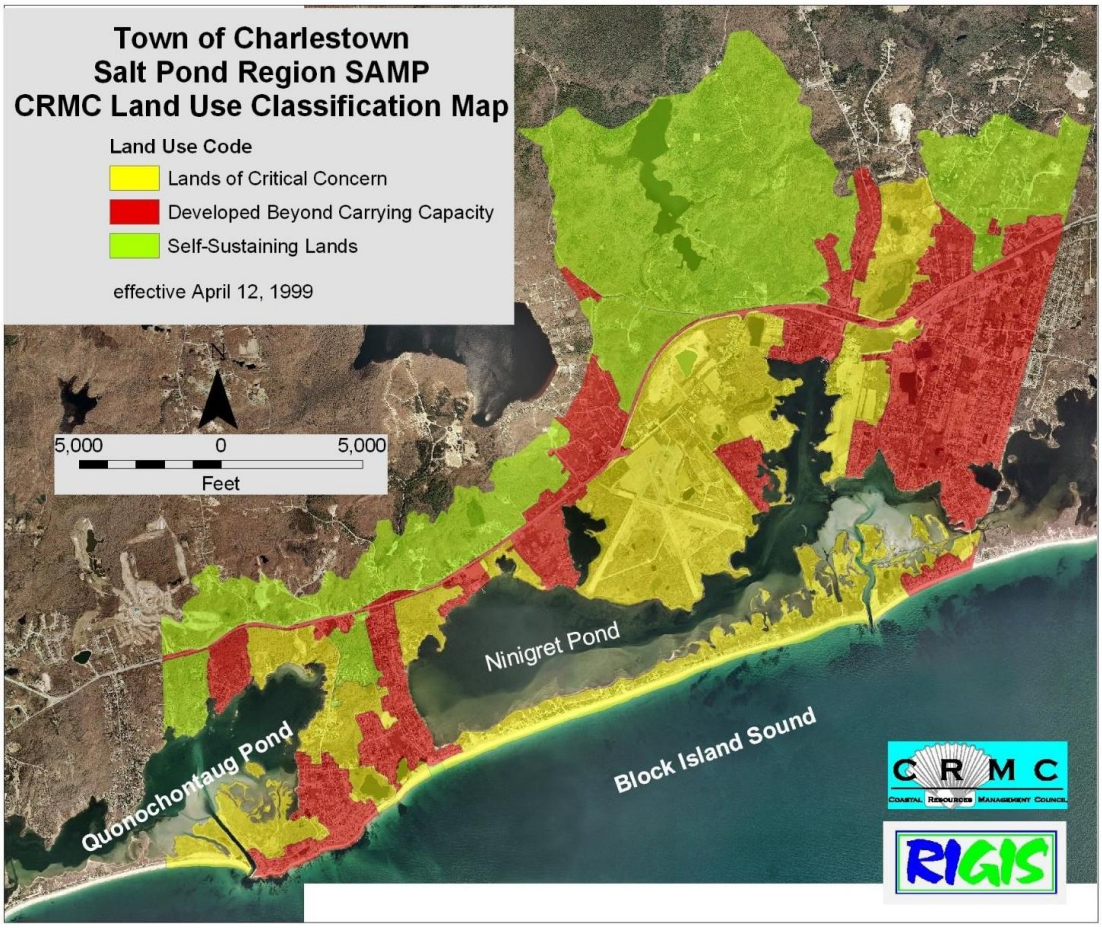


Figure 2-8. CRMC's Mapping of Residential Lots Developed Beyond Carrying Capacity in Charlestown, RI

Source: CRMC; RIGIS, 1999

Nitrogen Concentration Mapping

Below is a five-map series (Figure 2-9 - Figure 2-13) depicting the relationship between predicted nitrate concentration and density of development. It is important to clarify that the nitrate data shown on the maps is based on the predicted nitrate concentration. The data was developed by Dowling et al. (2024) using a linear regression as a function of OWTS density in both till and glacial fluvial soil aquifers combined and separately. The study shows that measured nitrate concentrations correlate well with the predicted nitrate concentration.

A review of the maps demonstrates that most of the areas with high nitrate concentration overlay lands developed beyond carrying capacity, as shown in the CRMC map in Figure 2-8, which implies a direct correlation between housing density and nitrate level.

Comparing the CRMC map to groundwater-nitrate sampling helps to show the relationship between nitrate and development density.[9] However, CRMC's map was developed approximately 30 years ago using land-use data that was available at that time. Development density and the risk to water quality has increased in Charlestown since that time. The Town may wish to consider how to address the increased risk as part of changing land-use regulations.

Figure 2-9 depicts developed lands built at a density of one unit per half acre or greater based on 2018 housing data from RIGIS overlaid on present day parcel data and zoning districts. Comparing this map to areas of Town identified as beyond carrying capacity and nitrate concentration in groundwater provides a context for adjustments needed to effectively manage environmental concerns while providing opportunities for new development and redevelopment.

Figure 2-10 depicts areas where predicted nitrate concentration was found to be less than 3 ppm. Nitrate concentrations below this threshold may be somewhat elevated above natural background levels but are significantly below the preventative action limit (PAL).[10] In the context of development planning, these areas could be considered suitable for additional development under existing regulatory standards for wastewater and stormwater. However, even at this level, continuous monitoring and appropriate management practices would remain advisable to prevent potential degradation of groundwater quality over time. In the case of Charlestown, these areas are concentrated in developed areas along the salt ponds (Quonochontaug and Charlestown Beach), and scattered areas north of Route 1, where new development will require nitrate-reducing septic systems. It would be best to maintain existing zoning and land-use density to maintain current water quality.

Figure 2-11 depicts areas where predicted nitrate concentration was found at 3 - 5 ppm. This level of nitrate is clearly elevated above natural background and begins to present a management concern. **Groundwater nitrate levels in the 3 – 5 ppm range in developed areas that are not actively managed to reduce nitrate are likely trending up toward the PAL.** In Charlestown these levels closely correspond to the densely developed areas of Quonochontaug and Charlestown Beach.

Figure 2-12 depicts areas where predicted nitrate concentration exceeds 5 ppm, which is the PAL for nitrate concentration under the Federal Safe Drinking Water Act. Nitrate concentrations at 5 ppm

[9] "Relationship between Groundwater Nitrate Concentration and Density of Onsite Wastewater Treatment Systems: Role of Soil Parent Material and Impact on Pollution Risk" (Dowling et al, 2024, *Journal of Sustainable Water Built Environment*) discusses groundwater sampling for nitrates collected from 367 individual private wells in Charlestown in the vicinity of the Salt Ponds watershed.

[10] A preventative action limit (PAL) is a pollution concentration threshold used to trigger actions to avoid major loss of a resource. A PAL is used to prevent consequences of contamination from getting to a point where recovery of a resource is no longer economically practical or technically feasible—that is a point of no return.

and above signal potential concerns for eventual exceedance of the 10-ppm standard. Many water quality managers look at the PAL as approaching a "point of no return." In such areas, there is a need for restrictions on future developments and the imposition of regulatory actions to mitigate further degradation of groundwater quality. These actions may include stricter zoning regulations, enhanced wastewater management practices, and pollution control measures to limit the input of nitrate into the groundwater system. In the case of Charlestown, these areas are concentrated closer to the salt ponds, and north of Route 1 on the East side of the Town. New development in these areas is not recommended without nitrate mitigation.

Figure 2-13 depicts areas where predicted nitrate concentration exceeds 10 ppm under no action scenarios. Measured nitrate data is not available in this part of the town. Nitrate levels at or above 10 ppm, indicate an exceedance of drinking water quality standards and pose serious risks to both human health and the environment. In high-nitrate concentration zones, strict restrictions on future developments are needed to prevent exacerbating the problem. Additionally, strong regulatory actions need to be imposed on existing developments to mitigate the sources of nitrate pollution and safeguard groundwater resources. Such actions may involve remediation efforts, enforced pollution control measures, and possibly even land use restrictions to prevent further deterioration of groundwater quality.

In Charlestown, the area where predicted nitrate concentration in groundwater is above the 10-ppm threshold coincides with densely developed condominium complex, known as Kingsland Village and Castle Rock, north of Route 1. This area should not be further developed without significant nitrate mitigation.

By identifying areas with varying levels of nitrate concentration, stakeholders can make informed decisions to ensure sustainable management of land and water resources, while considering needed housing development.

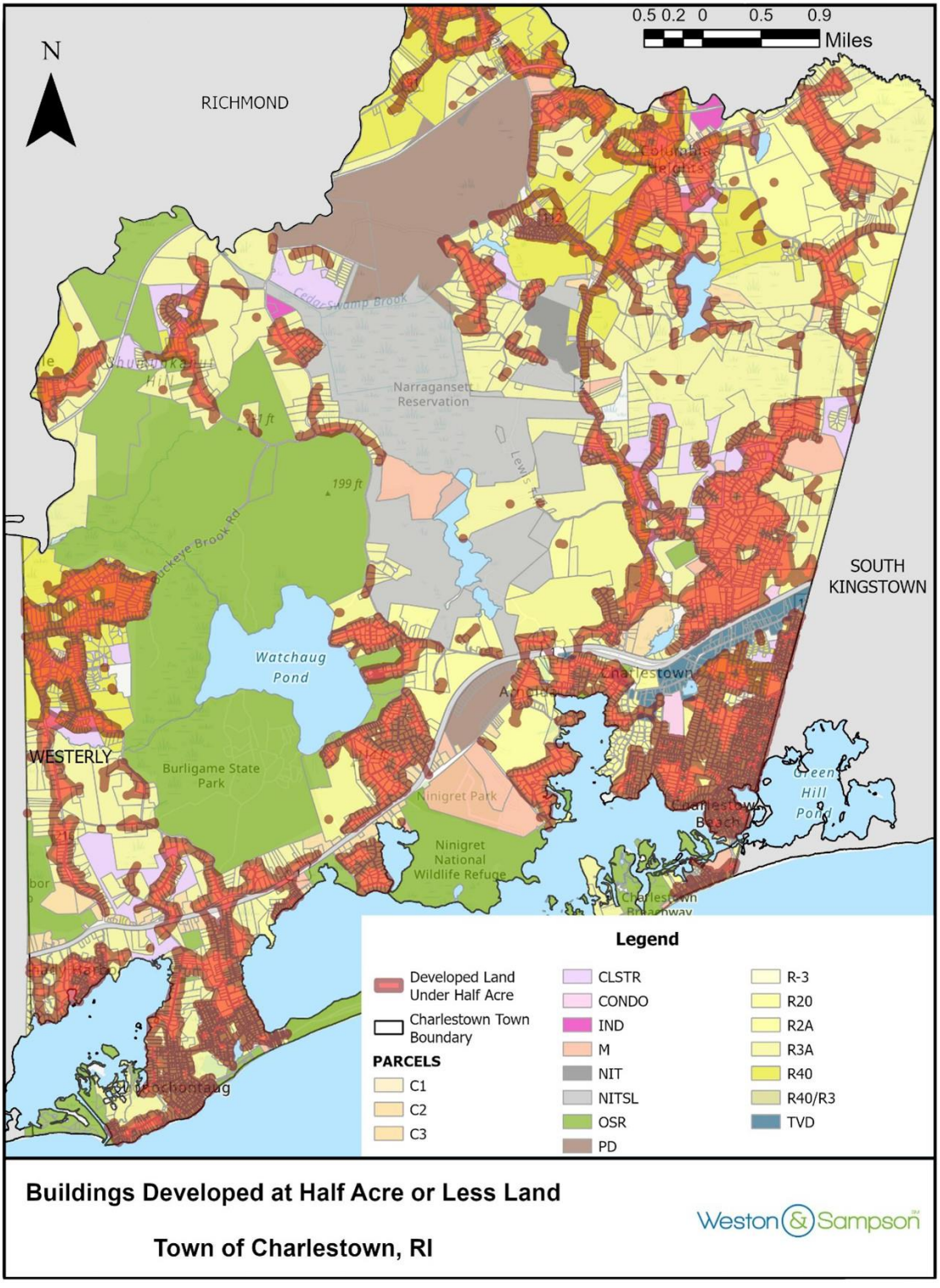


Figure 2-9. Lands Developed at Density of One Unit Per Half Acre or Less

Source: Town of Charlestown; RIGIS, 2024

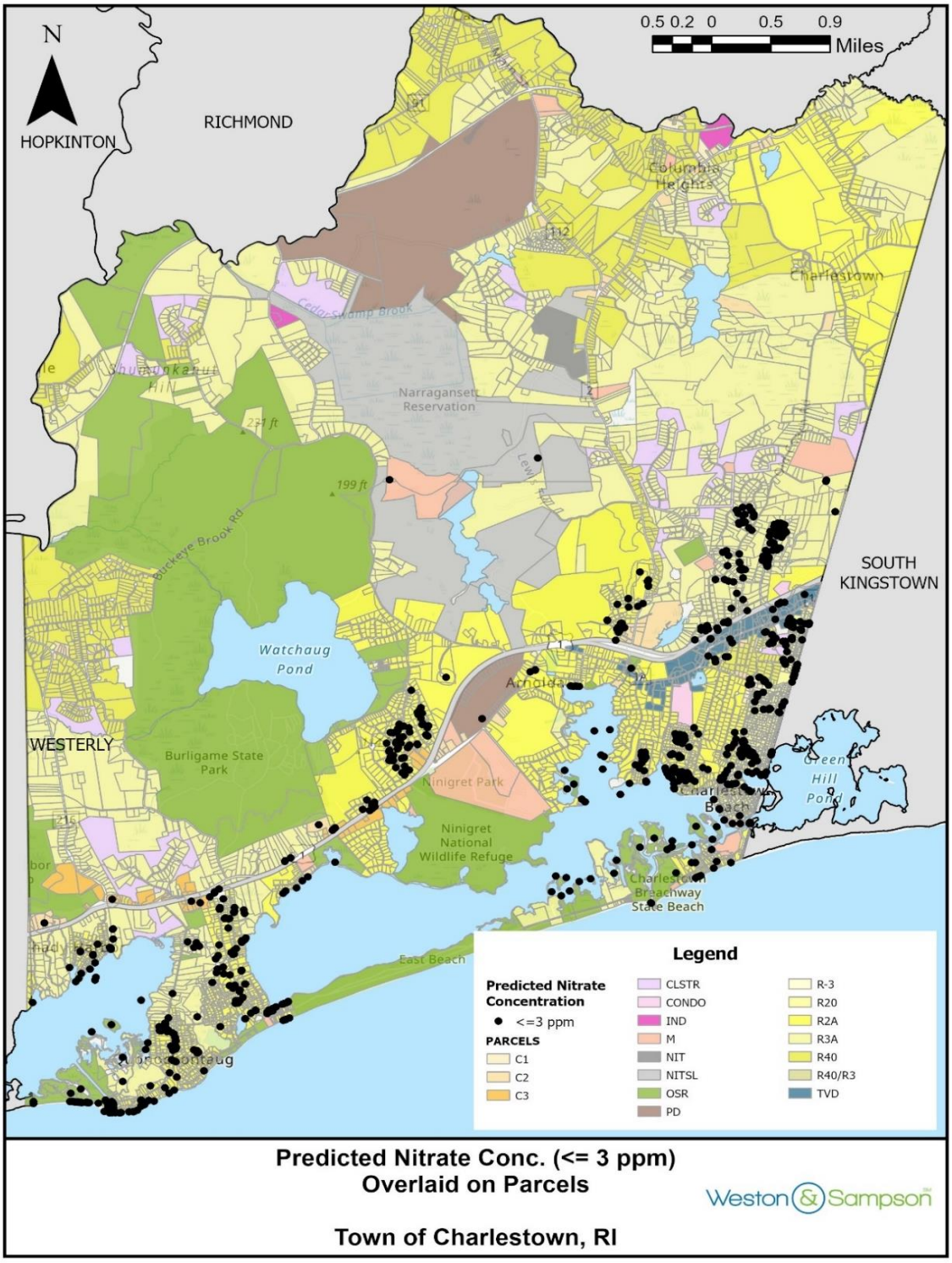


Figure 2-10. Predicted Nitrogen Concentration Below 3 ppm

Source: Town of Charlestown; RIGIS, 2024

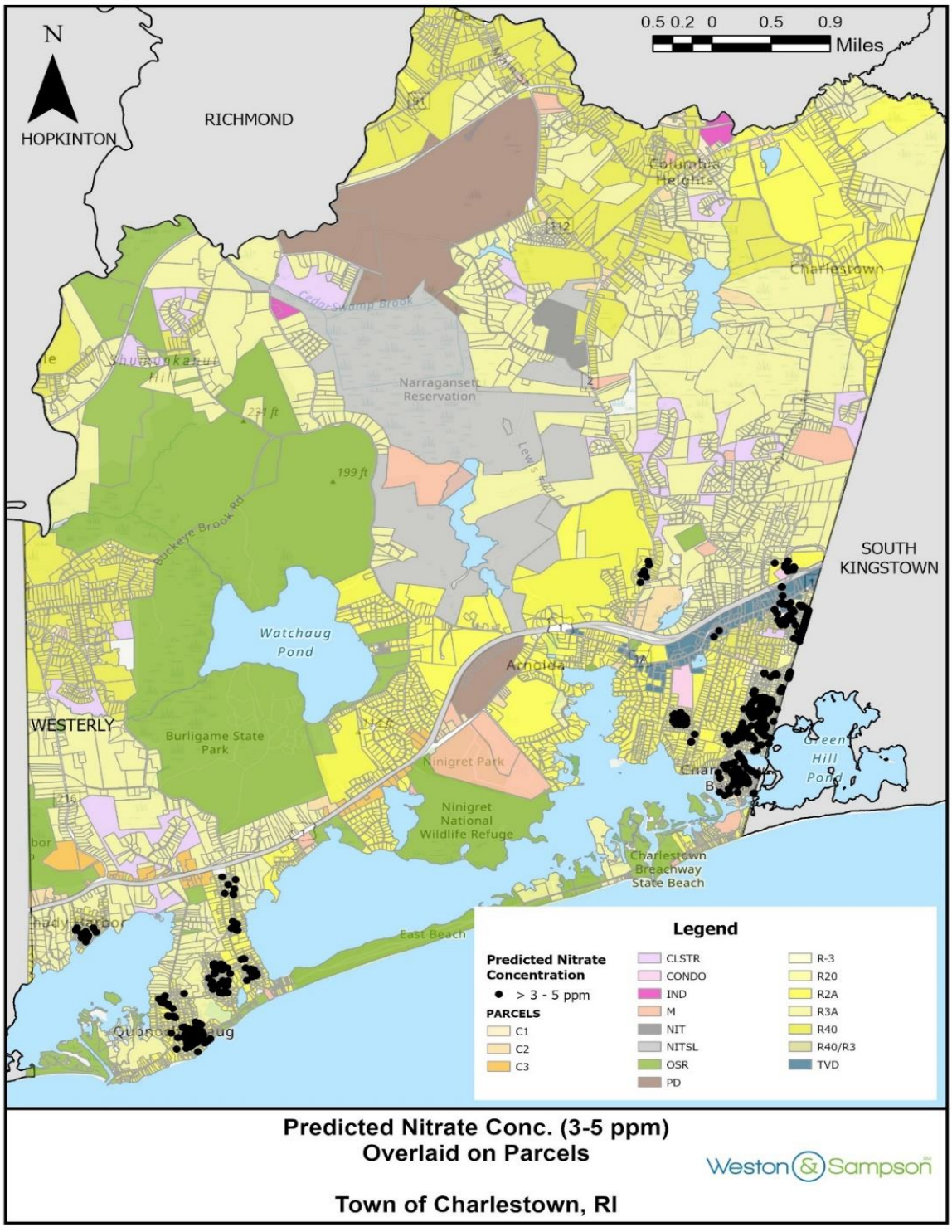


Figure 2-11. Predicted Nitrogen Concentration Between 3 – 5 ppm
Source: Town of Charlestown; RIGIS, 2024

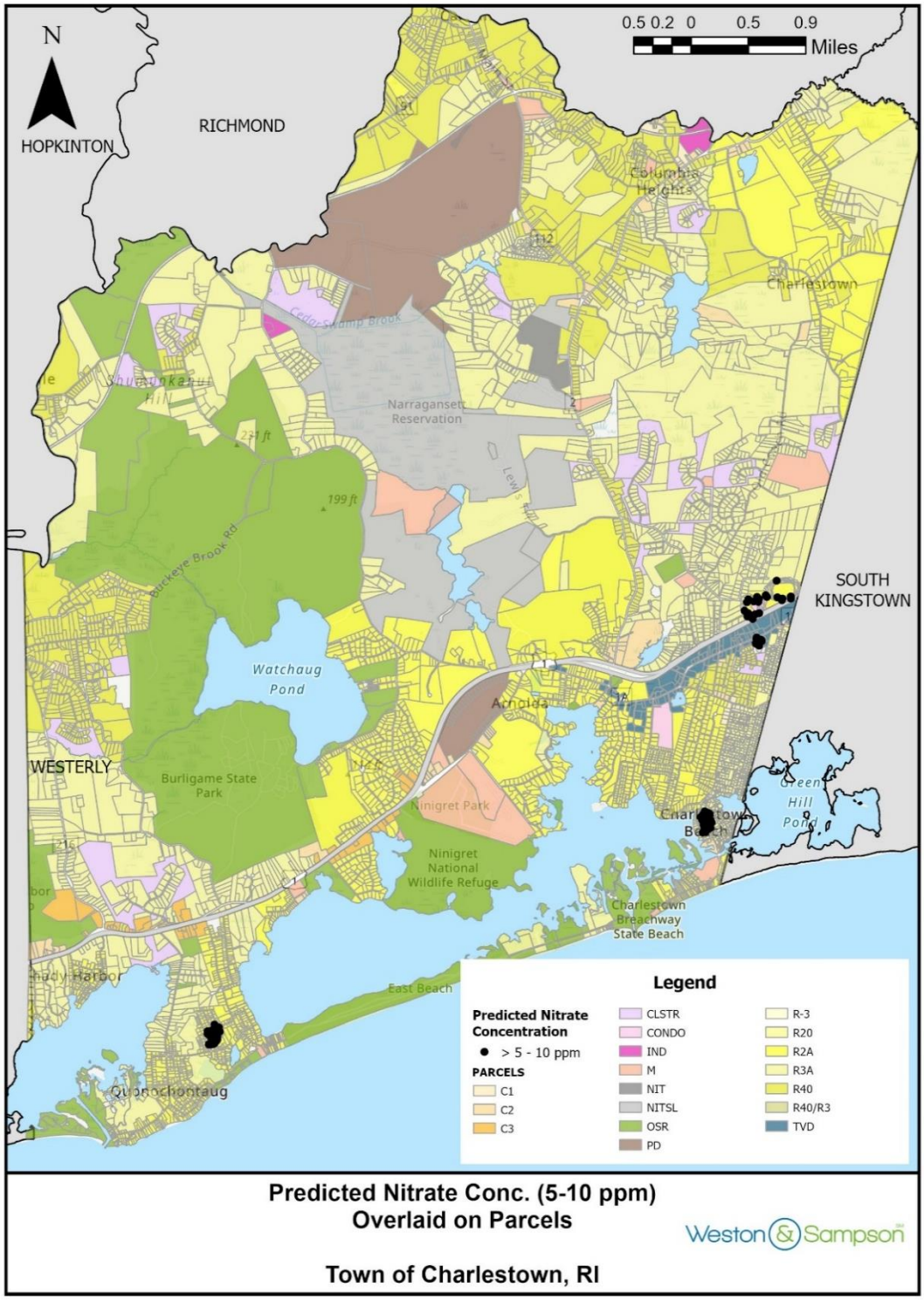


Figure 2-12. Predicted Nitrogen Concentration between 5-10 ppm

Source: Town of Charlestown; RIGIS, 2024

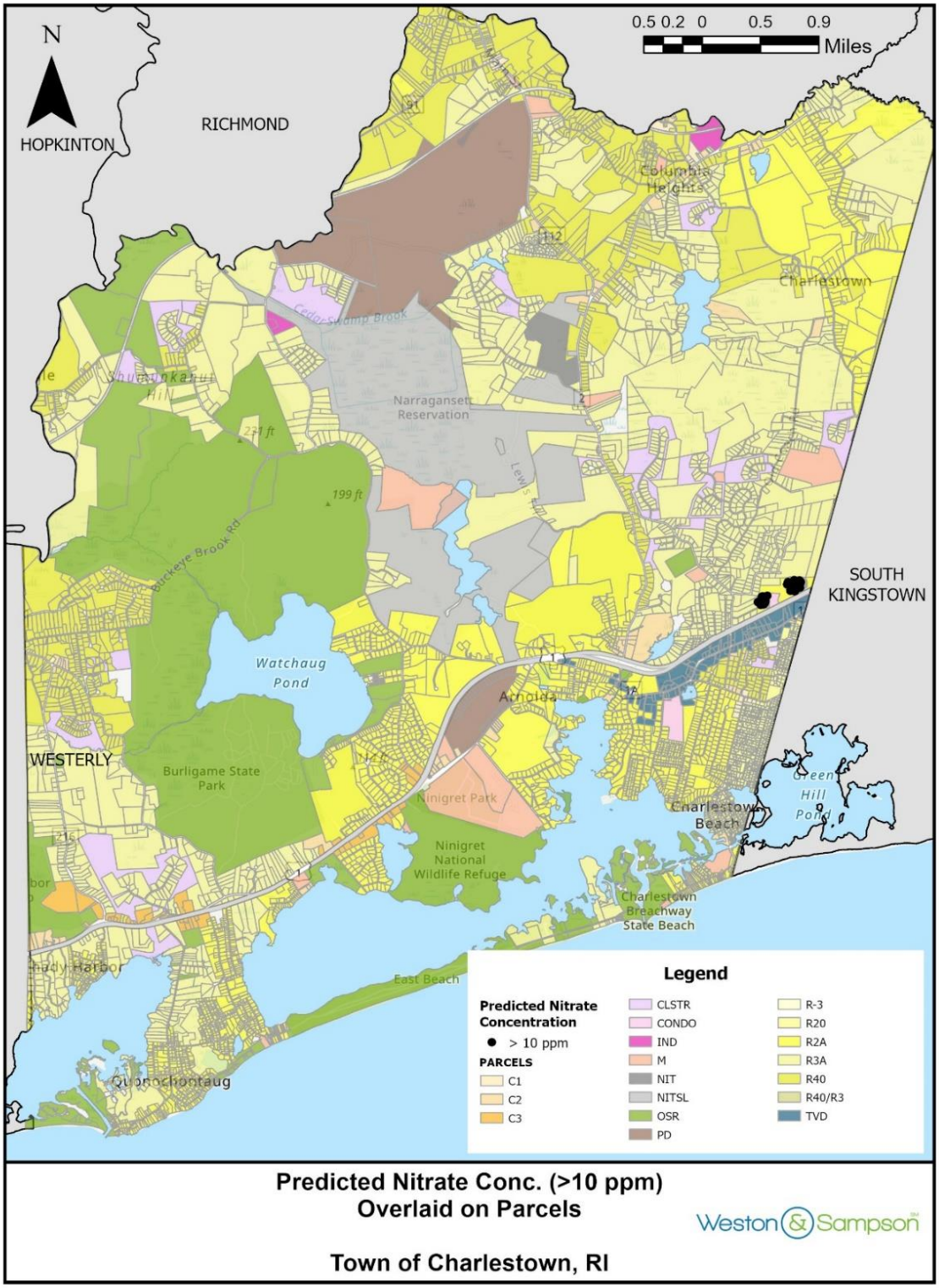


Figure 2-13. Predicted Nitrogen Concentration Above 10 ppm

Source: Town of Charlestown; RIGIS, 2024

3 STATE AND LOCAL DOCUMENTS AND ENFORCEABLE STANDARDS

As part of this project, a review was conducted of state and local development policies with a focus on local ordinances and regulations. The purpose of the review was to identify opportunities to enhance management of nitrate pollution through better management of land development. Wastewater and stormwater are primary focuses of the review since they are two principal contributors of nitrate pollution in Charlestown. The review also examines fertilizer-use policy and pet-waste management, since improper pet-waste management and fertilizer applications present significant contributors of nitrate. Each of these pollutant sources can be addressed through planning, thoughtful design, and good community stewardship.

3.1 Land Use Standards

A review of local regulations was performed to evaluate opportunities for enhancing nitrate management by means of natural vegetation, installed landscaping, minimization of land disturbance during development, and long-term management of impervious surfaces (i.e., hardscapes). Specifically, the review considers local zoning, and subdivision regulations, and the Town's comprehensive plan.

The discussion of each subject area begins with a summary of issues of concern and a general statement of how existing policy might be enhanced. The review then identifies specific aspects of zoning, subdivision regulation, and the comprehensive plan that help to support effective nitrate management as well as where enhancements might be made.

Vegetation, Landscaping, Land Disturbance, and Impervious Surface

Impervious areas are hard surfaces such as roads, sidewalks, and rooftops that are impenetrable to water and prevent rain and snowmelt from absorbing into the ground the way it would on undeveloped land. Stormwater pollutants such as nitrate tend to accumulate on impervious surface and most runoff is generated from impervious surfaces. These aspects of impervious surface make it a principal stormwater management issue. Development across Charlestown in recent decades has significantly increased the area of impervious surface as well as the water quality impact associated with stormwater.

Vegetation absorbs nutrients such as nitrates. Natural vegetation and constructed vegetated buffers help to improve runoff and groundwater quality by taking up nutrients. Conversely, removal of vegetation and land disturbance during land development means that natural vegetation is no longer available to provide nutrient uptake.

To effectively manage stormwater and water quality, naturally vegetated areas and constructed vegetated buffers must be designed to certain standards and then maintained properly. Impervious surfaces such as roadways should be minimized, and disturbance of naturally vegetated areas should be limited to the maximum extent practicable in order to preserve the vegetated areas for nutrient uptake. The Rhode Island Stormwater Design and Installation Standards Manual (RISDISM) discusses

KEY TAKEWAYAYS

- Impervious surface tends to collect pollutants. It also interrupts the natural absorption of stormwater runoff. Minimization and management of impervious surface is an essential element of effective stormwater management.
- LID as described in the RISDISM can be used to reduce impervious surface. QPAs should be used to better manage the adverse effects of impervious surface.
- Vegetated and landscaped buffers can be effective natural solutions for filtering nutrient pollution such as nitrate, but to be most effective, must be designed in accordance with state stormwater standards.
- Land disturbance should be minimized to the maximum extent practical to preserve the capacity of naturally vegetated areas for nutrient uptake.
- Charlestown's zoning standards include 20- to 50-foot vegetated buffers. Conservation developments require open space plans; expand this requirement to include all future development. Consider adding requirements to design these areas in accordance with RISDISM standards BMPs such as qualified pervious areas or vegetative filter strips.

standards for minimizing land disturbance as well as the use of stormwater practices such as qualified pervious areas (QPAs)[11] and vegetated filter strips that are essentially vegetated areas and buffers. The RISDISM also presents specific standards for the use of QPAs and vegetated filter strips. Other techniques for managing stormwater using engineered vegetated landscapes include bioretention and vegetated stormwater channels. Standards for these types of systems are discussed in the RISDISM.

To get the most stormwater management and water quality benefit from vegetated buffers and open spaces, vegetated features should be designed in accordance with the RISDISM standards. Additionally impervious surfaces, building envelopes, and limits of disturbance should be constrained in accordance with RISDISM standards to the smallest areas practicable. Low impact development (LID) and QPAs

[11] Rhode Island defines QPAs as natural or landscaped vegetated areas fully stabilized, with runoff characteristics that match natural conditions. QPAs must have a minimum of 4 inches of topsoil or organic material and must be located outside of regulated wetland areas and regulated buffer to a waterbody or wetland. Excessively fertilized lawn areas are not considered QPAs; in order for lawns to be considered as QPAs, they must consist of low-maintenance grasses adapted to the New England region.

should be required as the stormwater management practices of choice wherever impervious surface is proposed.

Zoning Ordinance

The Charlestown Zoning Ordinance outlines minimum setback requirements of 20- to 50-foot buffers for all sites and requires street trees to be included for any development where forested areas do not presently exist. Adding requirements to design and preserve vegetated buffers to meet stormwater standards whenever practicable would allow them to provide stormwater management benefits as well as screening and aesthetic benefits. Specifically, buffers could be designed as qualifying pervious areas, bioretention, or vegetated filter strips. Limits of disturbance should be established in a way that preserves the capacity of naturally vegetated areas to take up nutrients.

Subdivision and Land Development Regulations

Under the current Subdivision and Land Development regulations, the Planning Commission authorizes plans for open space ownership, use, management, and maintenance within conservation developments (a type of cluster development). To reduce stormwater impacts, the regulations also recommend maximizing protection of natural drainage areas, streams, surface water, wetlands, and adjacent vegetative buffers. Stormwater management benefits could be further enhanced by requiring open spaces to meet QPA standards in RISDISM.

Figure 3-1. Photo Depicting Bare Soil and Lack of Vegetative Features in Charlestown
Source: Town of Charlestown, 2024

Figure 3-2. Photo from Field Visit of Affordable Housing Development in Charlestown, RI
Source: Town of Charlestown, 2024

Pet Waste Management

Much like wastewater, unmanaged pet waste can be a significant contributor of water pollutants such as nitrate. In Charlestown, commercial dog day care and training centers collect pet waste and are required to dispose of it properly, but pet owners also have a responsibility to ensure pet waste is disposed of properly. Regulation of waste from pet care facilities can generally be accomplished through licensure because there are relatively few facilities in discrete locations; however, pet owners are much more difficult to regulate given their number and the uncertainty of their location at any given point in time. A pet waste ordinance makes sense for addressing the most extreme situations and for the purposes of clarifying appropriate public behavior, but regulating an occasional bad actor on a dog walk is not typically practical. However, environmental managers have found success through behavior-change programs that combined legal authority, such as a pet-waste ordinance, establishment of well-managed and convenient dog-walking locations with disposal facilities (e.g., waste stations), and public education for on establishing appropriate social mores. The Town's Wastewater Management Department

KEY TAKEWAYS

- Pet waste is a direct contributor of nutrient pollution when disposed of improperly.
- Charlestown does not currently have regulatory provisions for pet owners disposing of pet waste.
- Educating pet owners on best practices and requiring proper disposal of pet waste can help to reduce nutrient pollution.

publishes and promotes a small brochure on proper pet waste management: "Do You Scoop the Poop?"

Zoning Ordinance

Charlestown's zoning ordinance specifies that dog day care and training centers are required to scoop all waste daily before the close of business and that the operator or a contracted hauler will remove solid pet waste from the site at least twice per week. Such provisions are important for health and safety as well as mitigating the risk of harmful microbes and nutrients from entering the water supply. No provisions for pet owners disposing of waste exist. The Town should consider a townwide pet-waste ordinance.

Fertilizer Application

Nitrogen is typically a part of fertilizer used commercially or residentially for lawn and grounds management. Nitrate that is used by plants (e.g., grass) stays in the plant or root zone unless the plant dies and decomposes. Excess fertilizer application, however, will generally result in the release of nitrates to surroundings soils and ultimately groundwater or even runoff during wet weather to nearby waterbodies. As part of our review, we looked at how the Town is addressing fertilizer application, particularly near the salt ponds.

KEY TAKEWAYS

- Fertilizer can seep into the groundwater supply or runoff, resulting in nutrient pollution.
- Bylaws require nurseries and greenhouses to operate to minimize pollutant runoff.
- Charlestown has no regulations pertaining to household fertilizer application.
- The Town may want to consider adding a zoning standard that includes limitations on fertilizer usage especially south of Route 1 or in other nitrogen-sensitive areas. Another alternative might be a prohibition or other restriction on fertilizer sales and use in Charlestown except in accordance with Charlestown's recommended landscaper process.

Zoning Ordinance

The zoning ordinance requires nurseries and greenhouses to operate in a manner that does not pollute waterways or contribute to contamination by fertilizers. Beyond this, there are no additional requirements found within the zoning ordinance, so individual homeowners and commercial entities are generally permitted to apply fertilizer as they deem necessary. This lack of regulatory control limits the Town's ability to control fertilizer application and may contribute directly to high nitrate levels in groundwater and runoff. The Town may want to consider adding a zoning standard that includes limitations on fertilizer usage especially south of Route 1 or in other nitrogen-sensitive areas. Another alternative might be a prohibition or other restriction on use in Charlestown except in accordance with Charlestown's recommended landscaper process.

Subdivision and Land Development Regulations

The current Subdivision and Land Development Regulations do not contain extensive guidance for properly applying fertilizer. This lack of regulatory control limits the Town's ability to control fertilizer application and may contribute directly to high nitrate levels in groundwater and runoff. The Town may

want to consider adding new requirements that outline locations where fertilizer can be applied as well as the types of fertilizer that are best at preventing further nutrient pollution.

Comprehensive Community Plan

Charlestown's 2021 Comprehensive Plan supports education on fertilizer use and the importance of minimizing nutrient runoff. However, policy decisions on restricting fertilizer applications may be necessary to ensure nitrate concentrations do not increase to dangerous levels. The Town may wish to add specificity regarding nutrient pollution management to its comprehensive community plan.

CHARLESTOWN RECOMMENDED LANDSCAPER PROCESS

Charlestown recommends that landscapers conducting business within the Town utilize and agree to a specific process to minimize the impacts of nitrate. As part of the guidance, landscapers are asked to utilize a soil test for nutrients for the application of nitrate to not exceed 2 pounds per 1,000 square feet. The Town also offers to work with companies to make slow-release nitrate fertilizers readily available. These are important for incentivizing and educating landscaping companies, but additional steps may be necessary in areas already experiencing impacts from high levels of nitrate in their drinking water and local ecosystems. Incorporating compost and manure instead of nitrate fertilizer, green infrastructure, and accountability for proper fertilizer application should be considered going forward.

Agriculture

Agriculture in Charlestown is primarily limited to north of Route 1. Many of the same considerations with fertilizer apply to agricultural properties, but there are some additional concerns. Due to the cost and labor associated with fertilizer application, farmers are generally quite frugal with fertilizer use. USDA/NRCS provides programs and financial assistance to farmers to ensure they implement state-of-the-art fertilization practices. This report recommends that the Town support farmers in accessing these services. No change in regulation is recommended by this report.

KEY TAKEWAYS

- Similar concerns related to fertilizer contamination apply to agricultural settings.
- USDA/NRCS provides programs and financial assistance to farmers to ensure they implement state-of-the-art fertilization practices. This report recommends that the Town support farmers in accessing these services.

3.2 Onsite Wastewater Management

The *RIDEM Onsite Wastewater Treatment System (OWTS) Program* manages Rhode Island's septic system permitting process, focusing on protecting public health and the environment. It involves three main stages: assessing site suitability, reviewing treatment system designs for compliance with state standards, and overseeing system installation through field inspections.

The Town of Charlestown's On-Site Wastewater Management Plan (1999) includes strategies to ensure the effective operation and maintenance of OWTSs, which can play a valuable role in maintaining property values while safeguarding surface water and groundwater quality. Its fundamental components include encouragement of inspection and maintenance through regulatory requirements, funding for repair and replacement of failed and substandard systems, and public education to ensure the regulated community is aware of need for proper onsite wastewater management.

KEY TAKEWAYS

- OWTS are the leading contributor of nitrogen pollution in Charlestown's waterbodies.
- New development and ADFUs will need to be regulated to minimize further environmental degradation.

As discussed in Charlestown's 2021 Comprehensive Plan, properly functioning OWTSs are very effective at eliminating pathogens from wastewater, but not as effective at removing nitrate and phosphates. In areas of Town where housing densities are greater than one dwelling unit (i.e., home or apartment) per half acre, nitrate levels in the groundwater are frequently elevated, often greater than 5 parts per million (ppm). Depending upon actual housing density and levels of occupancy, these groundwater nitrate levels can sometimes exceed the EPA drinking water limit of 10 ppm. The elimination of cesspools and substandard OWTSs, and the progressive upgrade of conventional OWTSs to denitrification systems over time may reduce nitrate loadings if housing occupancy levels do not increase.

State Onsite Wastewater Treatment Regulations

The OWTS regulations of the state are detailed in the "Rules Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Onsite Wastewater Treatment Systems." The purpose of these regulations is to safeguard public health and the environment through proper OWTS design and installation.

For critical areas like the salt ponds, where nitrogen loading from OWTSs are estimated to contribute approximately 80% of the nitrate pollution, these regulations play a crucial role in reducing nitrogen inputs. The use of nitrate-reducing technologies, which are mandated for new construction, alterations, and repairs in these areas, reduces nitrate concentrations in wastewater effluent by approximately 50%. Such measures are particularly focused on critical resource areas that are essential for public water supplies, fisheries habitats, or recreational purposes.

Charlestown Onsite Wastewater Standards and Program

Similar to many rural areas in the state, Charlestown primarily relies on OWTSs for wastewater management, as there is no public sewer service available or planned within the Town's 20-year planning horizon (Comprehensive Plan 2021). Charlestown's reliance on OWTSs for wastewater makes nitrogen loading a critical environmental issue. The Town's Wastewater Management District, established in 1994, addresses this challenge by focusing on maintaining and upgrading OWTS to protect groundwater quality and other natural resources. The plan's goals emphasize minimizing nitrate loading and system failures, which is essential for preserving the coastal ecosystems, such as salt ponds, that are highly susceptible to nitrogen pollution. By qualifying for the state's Community Septic System Loan Program, Charlestown provides financial assistance to homeowners for cesspool replacements and OWTS repairs, aligning with the town's broader environmental protection goals. Over a thousand cesspools have been upgraded, reflecting substantial progress in nitrogen reduction.

Figure 3-3. Onsite Wastewater Treatment Systems Example from RIDEM

Source: Town of Charlestown, 2024

Despite the plan's achievements, gaps remain. While initiatives like voluntary well testing and the implementation of nitrate-reducing technology offer positive strides, the scale of nitrogen reduction may not be sufficient in densely developed areas. The Town's 20-year planning horizon, which does not foresee public sewer infrastructure, places continued reliance on OWTSs, raising concerns about long-term nitrogen mitigation. Moreover, while newer technologies and landscaping practices are being monitored, widespread adoption and rigorous enforcement of performance-based standards in critical areas might be necessary to fully address nitrogen pollution. More comprehensive collaboration with neighboring towns, combined with improved data tracking and community education, could help bridge these gaps and ensure more robust nitrogen management across the region.

Charlestown's existing regulation of OWTS includes proper operation and management of existing systems as well as ensure upgrade of failed and substandard systems with nitrogen-reduction technologies. The Town fully exercises its available authority under current state law. No change in regulation is recommended by this report; however, if state programs were to be changed to allow additional local authority, the Town might wish to consider requiring greater levels of nitrogen treatment

then required by RIDEM regulations. Additionally, the Town may wish to use zoning policy to encourage zero-wastewater discharge or enhanced nitrate reduction in areas of Town that are currently comprised by high levels of nitrate. Section 4.2 discusses this further.

3.3 Stormwater Management

Nutrient pollution from stormwater is a major concern in Rhode Island. Estuarine resources, like the salt ponds, are particularly vulnerable to the pollutants in stormwater, including nitrate. Town policy identifies low impact development as an effective means of stormwater management as noted in the comprehensive plan: "LID can be used to accommodate growth while reducing the environmental impact of site development and needs to continue to be an integral part of the design of all future development" (Town of Charlestown Comprehensive Plan, 2021, page 5-22).

KEY TAKEWAYS

- Stormwater from unmanaged land development is a major source of nitrates in Charlestown.
- LID as described in the RISDISM can be used to reduce the adverse effects of land development.
- The Town may wish to integrate stricter standards into its zoning and land development policies to ensure that the most effective stormwater nitrogen-reduction strategies are implemented. Use of a nitrogen management overlay district is recommended as an approach that could work well for the Town.

In Rhode Island, the principal enforceable stormwater policy is the RISDISM. From the Stormwater Manual (RIDEM, 2015, page 3-3):

> Structural BMPs are generally required to achieve the following minimum average pollutant removal efficiencies: 85% removal of total suspended solids (TSS), 60% removal of pathogens, 30% removal of total phosphorus (TP) for discharges to freshwater systems, and 30% removal of total nitrate (TN) for discharges to saltwater or tidal systems.
>
> …
>
> BMPs targeted to remove other pollutants of concern and/or to achieve higher pollutant removal efficiencies may be required for impaired receiving waters, drinking water reservoirs, bathing beaches, shellfishing grounds, Outstanding National Resource Waters, Special Resource Protection Waters, tributaries thereto, and for those areas where watershed plans, including Special Area Management Plans (SAMPs) or Total Maximum Daily Load (TMDLs), have been completed. In some cases, the permitting agencies may require that an applicant prepare and submit a pollutant loading analysis developed in accordance with the provisions of Appendix H.

Although the Town currently recognizes LID and the RISDISM as its primary standards for regulating stormwater, it is clear from a review of existing development practices and environmental conditions that more should be done. The Town may wish to integrate stricter standards into its zoning and land development policies to ensure that the most effective stormwater nitrogen-reduction strategies are

implemented. **Use of a nitrogen management overlay district, which is discussed in Section 4 of this report, is recommended as an approach that could work well for the Town.**

3.4 Water Supply

As noted in the Town's Comprehensive Plan, "all drinking water in Charlestown, whether delivered through public or private wells, depends on groundwater" (p. 5-15), but nitrogen is a significant concern for the delivery of high-quality potable water. The plan recommends encouraging land use with a lower potential to impact quality of groundwater and available quantity and goes on to note that:

> The future plan for land use and the regulatory approach regarding new development or substantial redevelopment must include measures that provide adequate protection for the salt ponds, freshwater bodies and groundwater quality. This approach is critical to provide potable water supply for existing development and to protect the natural environment. As such, local regulatory requirements must be aligned with the goals and policies articulated in the SAMP for the salt pond region, which attempts to maintain and preferably reduce, overall development density in areas designated as "self-sustaining lands" and "lands of critical concern". Any future program of transfer of development rights (TDR) will not send developments rights (as receiving areas) to lands under these SAMP designations.
>
> Source: Town of Charlestown Comprehensive Plan, 2021, p. 5-24

While Charlestown already implements strong policies and programs for the direct protection and management of water supply, the Town may wish to integrate stricter standards into its zoning and land development policies to ensure that the most effective nitrogen-reduction strategies are implemented. **Use of a nitrogen management overlay district in combination with transfer of development rights (TDR), which is discussed in Section 4 of this report, is recommended as an approach that could work well for the Town.**

4 PROPOSED APPROACH

Effective management of nutrient pollution will require a combination of techniques, including wastewater and stormwater technologies, land-use regulations, proper fertilizer and pet waste management, and public education. The regulatory approaches proposed in this section are structured to ensure the application of effective technology where land development has resulted in nitrate pollution and where it will likely create risk. Social marketing is proposed to educate landowners about impactful land-use development and encourage low-risk development.

While Charlestown needs to control density of development to manage nitrate pollution, the Town also needs to provide for housing opportunities for middle-income households. Enactment of a nitrogen management overlay district is one regulatory approach to mitigate the negative environmental impacts of new development. Transfer of development rights is another proposed regulatory approach that would allow for increased density of development in areas of the Town that are less susceptible to nitrate contamination. Density bonuses can be granted to landowners that voluntarily incorporate proper nitrate management with affordable housing proposals.

4.1 Recommendations for Managing Nitrate Through Land-Use Regulation

There are two basic approaches to managing nitrate through land-use regulation. One approach is to revise aspects of existing zoning that enable land-use development that results in unnecessary nitrate discharge. A second approach is to create special requirements for nitrate management. This second approach can be accomplished through an overlay district that is specifically written to manage nitrate discharges from development.

What's a Nitrogen Management Overlay District?

A nitrogen management overlay district is a specialized overlay district that uses techniques such as limiting development footprint size, area of impervious surface, reducing lawn size and fertilizer use, installation of enhanced nitrogen-reduction wastewater technologies, and stormwater treatment systems to effectively limit nitrogen discharge.

Nitrogen Management Overlay District

An overlay district is a geographic zoning district layered on another zoning district, or districts, that implements additional regulations. Overlay districts are frequently used in zoning ordinances to protect sensitive environmental features, preserve historic buildings, prevent development on unstable or vulnerable land features, or promote specific types of development such as transit-oriented development.

Zoning overlays are intended to supplement underlying zoning, not supplant it, and can be mandatory or non-mandatory. Mandatory overlays are generally enacted to address features that are distributed throughout a community and need additional regulations to address and protect equitably throughout

the municipality (i.e. floodplains, aquifers, etc.). Non-mandatory overlays generally involve additional uses and/or lot and bulk requirements to encourage defined land use objectives desired by the municipality. Municipalities can ensure zoning overlays are appropriately scaled and targeted through implementation of planning goals and through education of the public regarding their benefits and the need for regulation.

A nitrogen management overlay district would require specific nitrate reduction techniques for new development using approaches such as limiting areas of impervious surface, reducing lawn size and fertilizer use, installation of enhanced nitrogen-reduction wastewater technologies, and stormwater treatment systems.

Nitrogen-reduction overlay districts or closely related approaches are currently in force in communities around New England including Wareham and Seekonk, Massachusetts as well as in North Kingstown, Rhode Island as part of their Compact Village Development Ordinance. A nitrate overlay district could be adopted for areas that are already experiencing nitrate levels significantly above background levels (e.g., over 3ppm) or areas that are anticipated to experience high nitrate levels from future developments without enhanced management.

A nitrogen overlay district offers significant flexibility. It can be targeted to certain conditions such as density of development that are known to contribute to nitrate pollution. It can be written to allow flexibility in application of various nitrogen-reduction technologies to achieve the desired results while leaving the existing, underlying zoning intact. **For these reasons, this report recommends the use of a nitrogen overly district to address nitrate concerns related to development in Charlestown and mandate nitrogen management. The techniques required should be designed to achieve a net nitrogen output of no greater than 2 mg/l.**

Transfer of Development Rights

Transfer of development rights (TDR) is a zoning technique that conserves land by redirecting development that would otherwise occur on the land (the sending area) to another area suitable for denser development (the receiving area). The technique operates so that owners in the sending area can be compensated for their redirected development rights. TDR programs financially compensate landowners for choosing not to develop some or all of their land. Landowners who activate TDR opt to give up development rights from their land and sell or transfer the rights to another landowner of a property in a different location.

Figure 4-1. Sending and Receiving Areas with TDR

For the purposes of nitrate reduction, landowners in the nitrogen overlay district would be allowed to transfer their development rights to parts of Charlestown developed at densities of less than one dwelling unit per half acre. Transferred rights would be required to comply with the zoning requirements of the receiving zone. For example, the Town could make the use of TDR available in areas over or nearing carrying capacity. TDR in Charlestown could include areas with a certain threshold of nitrate in the groundwater (e.g., above the 5-ppm nitrate PAL) as "sending zones" and areas below a certain groundwater-nitrate threshold as "receiving zones."

Dimensional Regulations

Zoning dimensional standards are applied on a lot by lot basis according to the regulations of the given zoning district. These include building setbacks from streets and property lines; building lot coverage, as a percentage of total lot area; and building height. Such regulations define the area that can be built on and the size of the dwelling. Adjusting these standards for undersized lots or lots with constraints to development can reduce the area of the lot that is disturbed or developed with impervious surfaces, thereby decreasing the amount of runoff that goes into local waterways. While stormwater only accounts for a small portion of the nitrate that reaches groundwater and surface waterbodies, the cumulative impact of various efforts to reduce run-off can be significant.

Impervious Surfaces Limitations

Dimensional regulations that limit total impervious surfaces on a parcel can be particularly effective in reducing nitrate contamination. Limiting the area of total lot coverage, which includes both building footprint and paved or other hardscape surfaces limits the amount of runoff and preserves areas for infiltration. These limits, as a percentage of lot area can result in smaller buildings as well as less pavement. *Maintaining Building Setbacks*.

Recent state amendments to the law that governs development on substandard lots mandates a proportional decrease in building setbacks and increase in building lot coverages for lots that do not meet the area requirement for the district in which they are located. The more non-conforming in area the lot is, the more pronounced the impact is. Allowing development to a greater degree on these lots compounds the environmental impacts, resulting in more impervious surface area and more run-off. It also encourages teardowns and rebuilds in areas where land is already developed beyond carrying capacity because of the value of the land. Increasing or at least maintaining setbacks on highly constrained lots also reduces the size of the structure, meaning there are fewer bedrooms and less overall nitrate production.

Developable Area Restrictions

A step beyond total lot coverage is a regulatory approach that limits or defines the area of lot disturbance ensuring that the remainder of the lot retains its natural condition. Also referred to as "limits of disturbance," this technique not only reduces the area generating stormwater runoff but leaves more undisturbed land which generally helps with nitrate uptake. The most important aspect of this type of regulation is that lot sizes remain unaltered, as do building setbacks and height, but the amount of

developable area is reduced. By minimizing the limits of construction on a given lot, more green space is available, which has multiple environmental benefits.

4.2 Recommendations for Wastewater Management

Charlestown's existing regulation of OWTSs includes proper operation and management of existing systems as well as ensuring upgrade of failed and substandard systems with nitrogen-reduction technologies. The Town fully exercises its available authority under current state law. No change in wastewater regulation is recommended by this report; however, the nitrogen management overlay district can be leveraged to support preferences for certain technologies.

An OWTS that meets one of the following criteria is recommended:

- Nitrogen reduction system listed by RIDEM that is a "technology type" with total nitrogen discharge less than or equal to 10 mg/ l via a shallow narrow drainfield.
- Zero discharge system such as a waterless toilet.

As an alternative to an OWTS, a community treatment system may be used for wastewater treatment provided that such treatment system can achieve a discharged effluent of total nitrogen of 10 mg/ l or less that utilizes a shallow discharge system. RIDEM must permit the system prior to it being accepted by Charlestown.

4.3 Recommendations for Stormwater Management

Untreated and poorly managed stormwater can lead to a wide range of water quality issues, including higher nitrate levels in groundwater and surface waterbodies; however, BMPs can significantly reduce those concerns. Charlestown's water quality would benefit from more effective nitrate reduction. The RISDISM requires the use of "treatment" BMPs, such as infiltration practices, filters, green roofs, and open channels, as part proposed stormwater treatment trains.[12] Treatment BMPs provide at least 50% nitrate removal, which is a relatively high level of TN removal efficiency; however, infiltration practices are noted to provide the best removal efficiency (65%). Therefore, infiltration BMPs may be preferred for TN reduction in the vicinity of resources that have been comprised by nitrate contamination.

The RISDISM gives preference to the use of LID and particularly QPAs over structural BMPs. LID includes a combination of flow reduction and small-scale vegetative treatment to control stormwater. The RISDISM does not provide pollutant removal efficiencies for LID, but since LID receives primacy in the RISDISM it can generally be assumed to work as effectively as structural stormwater treatment BMPs.

This report recommends provisions in the nitrogen overlay district to target reduction of nitrogen from stormwater by requiring stormwater treatment that provides for onsite infiltration of the water quality volume using LID and QPAs as defined by RISDISM with the following stipulations:

[12] A "treatment train" is a combination of pretreatment and treatment BMPs that are sequenced to provide the required levels of stormwater management pursuant to the RISDISM.

- Rooftop runoff may be discharged directly to the ground since it is generally considered to be clean.
- All non-rooftop discharge must be treated by a vegetative treatment system prior to being infiltrated. LID and QPAs are the preferred approaches and should be used unless demonstrated to be infeasible due to specific site conditions.
- As an alternative to the aforementioned stormwater treatment requirement a development application may demonstrate zero net increase in annual total nitrogen loading using the "Pollutant Loading Analyses" in Appendix H.3 of the RISDISM, as amended.

4.4 Recommendations for Managing Fertilizer and Lawn Care

To address nitrogen loading from fertilizers, Charlestown has developed a program to promote BMPs in lawn care. This includes certifying landscapers who adhere to these practices and providing tools like a Fertilizer Calculator to help manage fertilizer applications effectively. This report recommends incorporating the existing landscaper program into the proposed nitrogen overlay district. Specifically, this would involve a prohibition on the use of nitrogen fertilizers in the nitrogen overlay district except in accordance with Charlestown's landscaper process.

4.5 Recommendations for Housing Density while Managing Environmental Impacts

Charlestown is committed to providing for its share of new housing to help alleviate the state shortage. However, the Town must consider the management of nitrate and other environmental impacts while accommodating additional density. In addition to the nitrogen overlay district and the consideration of transfer of development rights, the Town can consider several other regulatory changes to broaden housing opportunities. These include density bonuses as a form of non-mandatory inclusionary zoning and allowing residential uses in districts presently restricted only to commercial use or mixed use. These opportunities could be focused on the areas outside of the SAMP.

Density Bonuses

Generally, a density bonus provides an increase in allowed dwelling units per acre or per lot to achieve specific objectives such as the provision of affordable housing. Typically, programs allow increases of between 10 percent and 20 percent over baseline permitted density in exchange for the affordable units. However, the provision of affordable, or low and moderate income (LMI) housing, requires that the owner or developer meet several requirements including use of a public subsidy, rental to a person or persons who meet income limits, and the recording of a deed restriction on the property. Charlestown could achieve the addition of rentals units that are not qualified LMI by expanding housing options provided that appropriate restrictions are added to zoning to reduce nitrate and other environmental impacts. This report proposes an increase in one or more housing units on a given property in exchange for nitrate reduction in accordance with the provisions of the nitrogen overlay district.

Accessory Dwelling Units

Recent amendments to state law governing accessory dwelling units (ADUs) mandate that these be permitted by right on lots of at least 20,000 square feet in area, or if constructed within the footprint of an existing house or accessory structure. There are no "carve-outs" for lots developed beyond carrying capacity or on lots constrained by the presence of wetlands or floodplains. While the Town cannot prohibit this additional density in the most sensitive areas of its salt pond region, it can apply the development standards contained in the nitrogen overlay district to mitigate, to the degree possible, the likely negative impacts of this additional density. **This report recommends that the nitrogen overlay district be used as a tool to limit the potential negative development impacts of the construction of mandatory dwelling units in the salt pond region.**

Allowing Residential Uses in Commercial Districts

Mixed-use development generally refers to some combination of office, housing, and retail perhaps in combination with other uses. The mixed-use projects help activate the public realm by including open space, pedestrian, ground-floor retail and dining options. Dwelling units are typically provided at a relatively high density. One additional advantage of mixed-used development is that it can leverage shared wastewater and stormwater technology to provide for higher levels of treatment than might normally be practicable for individual residential uses (i.e., single-family homes). **This study proposes allowing for expansion of mixed-use development in the Town's Traditional Village District in accordance with the provisions of the nitrogen management overlay district. Conversion from commercial to mixed use or addition of residential only will require enhanced wastewater treatment in the lands beyond carrying capacity in the form of the nitrogen overlay district. Most of the TVD parcels would be folded into the overlay district.**

Inclusion of mixed uses into the other commercial only districts would be dependent upon the carrying capacity of the land. This is a step requiring additional review and analysis beyond the scope of the present study.

4.6 Public Education and Social Marketing

Public education makes people aware of behavior that is preferred to meet a goal (e.g., use and management of one's home and grounds in a manner that prevent nitrate from reaching groundwater). Public education may help to show people the connection between their behavior and some resulting effect. Unfortunately, people may be less concerned about the undesirable effect of their behavior to a public resource (e.g., drinking water supply) than they are to the inconvenience of the preferred behavior (e.g., properly managing pet waste).

The watershed council for the Rhode Island salt ponds, including those ponds in neighboring Westerly, South Kingstown and Narragansett, the Salt Ponds Coalition,[13] has a robust program of public education and water quality monitoring involving many volunteers. Its community outreach events are targeted

[13] Note: add link to the webpage as a replacement footnote: https://saltpondscoalition.org.

specifically to members who own property in the watershed, with materials and presentations to address the link between homeowner actions and water quality.

People tend only to change their behavior when the new behavior is convenient and socially desirable. Social marketing leverages peer pressure, social mores, and improved convenience to redirect behavior. The approach requires effective messages as well as an examination of what makes a habitat convenient or inconvenient. Developing a social marketing campaign involves a multistep approach including the following:

- Identifying the barriers to a behavior
- Developing and piloting a program to overcome these barriers
- Implementing the program across a community
- Evaluating the effectiveness of the program

This report recommends use of public education, including social marketing to encourage landowners to adopt of desirable practices such upgrading OWTSs to nitrogen-reduction systems, upgrading landscaping to include vegetated stormwater management practices, adoption of proper pet waste management, and reduction in fertilizer use.

4.7 Combining Approaches and Adapting to Changing Conditions

Combining Approaches

A multi-pronged approach will be the most effective method for limiting nitrate pollution in Charlestown's waterways. Adopting a combination of regulatory and technical options townwide and by individual property owners will reduce existing groundwater and surface water contamination while providing a framework for future mitigation solutions.

Adaptive Management

Adaptive management is a structured process to adjust management over time. Another way to think of this is "course correction." Charlestown could adopt certain standards and regulations that are expected to be effective in reducing nitrate pollution and then make standards stronger or more flexible as needed.

Adaptive management involves a five-step, recurring approach:

- Concept building, which involves defining a scope and a vision, and identifying target actions and threats to effectiveness.
- Action planning, which involves developing actions, a monitoring plan, and an operational approach.

Figure 4-2. The Adaptive Management Cycle

- Implement the plan, which includes executing the plan as well as budgeting resources.
- Analyze results, which includes collecting data on the results of implementation and adjustments to maximize effectiveness.
- Teach lessons learned, which involves sharing the lessons with others involved in allied management efforts.

Generally, an approach like this is set up through an implementation committee that meets regularly (e.g., twice a year) to discuss progress and adjust scheduling.

APPENDIX A

FIELD REVIEW

Location	Site Visit Observations
Stop 1: Carolina Village	
Housing Density	• Good reference point for density • ¼ acre density • Consider upzoning the area for TDR from elsewhere • Zoned after most development occurred. Zoned to be a lower density than currently exists. Currently nonconforming. The Town noted that zoning updates are being considered to bring existing land use and zoning to be in closer alignment.
On-Site Wastewater Management and Water Supply (Over/Undercapacity)	• See notes at bottom of table
Impervious Surface	• See notes at bottom of table
Stormwater Systems	• See notes at bottom of table
Additional Comments	• Zoning is currently not addressed to reflect this ¼ acre density in other locations across Town

Location	Site Visit Observations
Stop 2: Shannock and Columbia Heights Subdivision	
Housing Density	• Heavily built-up area • Village Cottages
On-Site Wastewater Management and Water Supply (Over/Undercapacity)	• See notes at bottom of table
Impervious Surface	• See notes at bottom of table
Stormwater Systems	• See notes at bottom of table
Additional Comments	• Water system serviced by private wells • Lots of low- to moderate-income (LMI) (i.e., workforce) housing in this area

Location	Site Visit Observations
Stop 3: Churchwood Senior Affordable Housing	
Housing Density	• Senior affordable housing with 100% LMI requirements
On-Site Wastewater Management and Water Supply (Over/Undercapacity)	• See notes at bottom of table
Impervious Surface	• See notes at bottom of table
Stormwater Systems	• See notes at bottom of table
Additional Comments	• 5 acres of vacant land located behind the senior housing area

Location	Site Visit Observations
Stop 4: Ram Island Road, near SK border	
Housing Density	• Can't handle more density—at or over carrying capacity
On-Site Wastewater Management and Water Supply (Over/Undercapacity)	• Overcapacity and very high (i.e., 5 – 7 ppm) nitrate levels • Everyone has septic and shallow wells. Shallow wells are more susceptible to contamination by wastewater (e.g., nitrate) • See notes at bottom of table
Impervious Surface	• See notes at bottom of table
Stormwater Systems	• See notes at bottom of table
Additional Comments	N/A

Location	Site Visit Observations
Stop 5: Cross Mills	
Housing Density	• 10-acre density throughout
On-Site Wastewater Management and Water Supply (Over/Undercapacity)	• See notes at bottom of table.
Impervious Surface	• See notes at bottom of table.
Stormwater Systems	• See notes at bottom of table.
Additional Comments	N/A

Notes:

- OWTS carrying capacity to be determined under a separate task. Town reports about 61% of installed systems are nitrate- reduction systems.
- General density and imperviousness surface was observed to be consistent with land-use types in the area. Percent imperviousness will be quantified using GIS.
- No stormwater systems were reviewed as part of the field visit.

APPENDIX B

REGULATORY DIAGNOSTIC

Zoning Ordinance

Vegetation and Landscaping

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Preservation of Natural Areas	Various articles and sections within zoning ordinance.	Open space and recreation district is intended for open space, conservation and recreation.	Growing development, especially south of Route 1, is increasingly dangerous to ecosystems and wildlife around Charlestown.	Expand residential conservation development and enforce stricter open space requirements.
Tree Protection	Article XIII, §218-74 (C)(3), Planting and Cultivation.	Where there is no existing forested area, trees along streets are required as part of all development activity in accordance with the Zoning Ordinance.	The regulations appropriately outline tree spacing, maintenance procedures and other landscaping requirements, but they fail to specifically mention nutrient-reducing species.	When combined with permeable pavement, street trees often live healthier lives and serve a greater role in stormwater reduction and
Landscaping Islands for stormwater management	N/A	N/A	N/A	N/A
Riparian Buffers	Various locations within the zoning ordinance, but if not specified, it's located under Article XIII, §218-74 (E), Buffer Areas.	Required buffers. Unless otherwise specified in another section of the Zoning Ordinance, the following buffers shall be provided (which include everything from twenty-foot setbacks to 50).	Required buffer setbacks may not be adequate in some areas, though they often vary based on district.	Additional recommendation/requirement to have at least one form of green infrastructure in addition to a required buffer anywhere south of Route 1 might be worth consideration.

Minimizing Land Disturbance

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Limits of Disturbance	N/A	N/A	N/A	N/A
Open Space and Cluster Development	Article IX, §218-52 (A), Residential Conservation Development	Minimum lot size. The minimum lot size for a residential conservation development lot in the R-40, R-2A and R-3A Districts shall be 20,000 square feet of land considered suitable for Development.	Conservation development is an excellent method for incentivizing LID around Charlestown and may run into issues if it's limited to only certain districts and lot sizes.	Expand the reach of conservation development to include smaller lot sizes and other districts. Potential for commercial/industrial/mixed-use lots as well.

Impervious Area Management

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Streets and Driveways	Article XIII, §218-72, Erosion and Sediment Control	A soil erosion and sediment control plan shall be submitted as part of an application for Development Plan Review when any activity has a disturbed area proposed of more than one-half acre.	Runoff is a major concern in locations where stormwater cannot drain properly, even when a soil erosion and sediment control plan is submitted.	Impose stricter restrictions or set up a zoning overlay district in heavily developed areas that requires additional steps for addressing stormwater drainage.
Parking Areas and Sidewalks	Article X, §218-58 (2)(i) Off-Street Parking and Loading	Raised islands shall be required to protect landscaping and to channel traffic safely. Where depressed landscaped islands are proposed to be used as part of the overall stormwater treatment approach, perforated curbing or some similar protective measure shall be used to ensure automobiles do not trespass into these areas.	Although raised islands and nursery-certified trees are useful tools for stormwater management, there are no requirements for specific standards aimed at reducing stormwater runoff velocity.	Requirement to utilize permeable pavement in all new parking designs (special provision to prohibit the use of subsoil-infiltrating designs anywhere south of Route 1 due to groundwater infiltration concerns); alternatively, enhanced channelization to catch-basins and other natural stormwater management tools could help.
Unconnected Impervious Areas	N/A	N/A	N/A	N/A

Onsite Wastewater Management

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
	Article IX, §218-53, Accessory Dwelling Units	One accessory dwelling unit (ADU) shall be permitted by right on a residentially zoned lot with an area of 20,000 sq. ft. or greater or the ADU is constructed within the footprint of an existing dwelling or accessory structure.…	ADUs are permitted by right even if the lot is substandard in area and environmentally constrained, which could increase pressure on the local septic systems and increase nutrient loads in coastal areas even more significantly.	Expand ADU development potential in portions of the Town that have minimal development while tightening restrictions in areas with heavy development and significant concern for further water quality.
	Article IX, §218-52 (D)(6), Residential Conservation Development	Individual private wells and onsite wastewater treatment systems (OWTS) are to be located on the house lots they serve. Shared private wells are to be discouraged. Public wells, which are defined as wells serving more than 24 persons, shall be properly installed in compliance with RI Department of Health (DOH) public drinking water regulations and all other applicable state regulations.	This provision is only found within the residential conservation development section. Assuming there are no changes to the extent of residential conservation development, there maybe a lack of oversight within the zoning ordinance regarding onsite wastewater management.	Expand this provision to include other zoning districts to ensure that all locations adhere to strict local standards for onsite wastewater management.

Pet Waste Management

	Article VI, §218-37 (I)(11), Dog Day Care/Training Center.	Where permitted by Special Use Permit, Dog Day Care/Training Center(s) are subject to the following performance standards… Pet waste shall not be disposed of into drains or into the septic system of the facility… Pet waste shall not be disposed of into drains or into the septic system of the facility… Solid pet waste onsite must be scooped up daily before the close of business… Solid pet waste shall be removed from the site, by the operator or by a contracted hauler, at a minimum of two times a week.	Pet waste being removed from the site and sent through an operator or contracted hauler does not ensure that it's removed from the Town boundary or that they are being properly disposed of.	Confirm that any operators and contracted haulers being hired by the Town directly bring pet waste out of the town boundary and/or properly dispose of waste to eliminate concern for nutrient leakage into groundwater. Impose stricter regulations on operators and contracted haulers that operate within the town boundary to ensure they are implementing robust practices to prevent waterway contamination.

Fertilizer Application

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Best Practices for Use	Article VI, §218-37 (I)(29), Nursery/greenhouse.	Nursery or greenhouse shall operate in a manner that causes no harmful effects upon abutting property, including but not limited to… The pollution of any waterways or waterbodies, and… The contamination of abutting property from any insecticides, fertilizers or similar chemical agents… Outdoor storage of fertilizers or chemicals is prohibited.	Most design guidelines are located in the subdivision and land development regulations, rather than the zoning ordinance, but best practices for limiting nutrient runoff/leakage from fertilizers is minimal within both regulations.	Add a section in the subdivision and land development regulations that specify guidelines for fertilizer usage in each zoning district with specific requirements for any lots south of Route 1 or along salt marshes.

Agriculture

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Farming	Article VI, §218-37 (C)(1), Agricultural Operations.	No agricultural operation shall operate in a manner that causes harmful effects upon abutting property including, but not limited to: (a) The pollution of any waterways or waterbodies, and, (b) The contamination of abutting property from improper application of insecticides, fertilizers, or similar chemical agents.	Language does not specify mechanisms necessary for reducing nutrient loading.	Potential restrictions on fertilizer applications or reuse of manure.
Irrigation	N/A	N/A	N/A	N/A
Manure Deposition	Article VI, §218-37 (I)(5), Riding Stables.	Manure must be collected and maintained in a sanitary manner to prevent offensive odors, fly breeding or other nuisances.	Fails to specify in a detailed manner any requirements for reducing runoff and nutrients from seeping into groundwater.	Require measures for reducing runoff and nutrient loading in waterways/groundwater, including impaction or other measures

Subdivision Regulations

Vegetation and Landscaping

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Preservation of Natural Areas	Section 4.5 (A)10(c), Open Space Plans Required	The Planning Commission shall specifically authorize plans for the ownership, use, management and maintenance of all open space areas within any conservation development. Areas proposed to fulfill the minimum open space requirement within a conservation development shall not be excavated or re-graded, except as permitted by the Planning Commission. Disturbance to the natural contours of the land shall be minimized to the greatest extent possible. Existing natural vegetation and any significant natural or man-made features shall be preserved except as permitted by the Planning Commission to create or enhance areas of landscaping, parks, recreation, conservation, forestry or wildlife habitat.	Open space plans are limited to conservation developments.	Consider offering this same provision for non-conservation development subdivisions and all land developments as well.
Tree Protection	N/A	N/A	N/A	N/A
Landscaping Islands for stormwater management	N/A	N/A	N/A	N/A
Riparian Buffers	Section 4.5 (A)(9) Low Impact Stormwater Management	Maximize the protection of natural drainage areas, streams, surface waters, wetlands, and their buffers	N/A	N/A

Minimizing Land Disturbance

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Limits of Disturbance	N/A	N/A	Requirements for limits of disturbance (LOD) are not specifically referenced in the subdivision regulations, although the Planning Commission enforces these when part of a RIPDES from DEM	Add language in the stormwater management section (11.8) of the subdivision regulations regarding the delineation and enforcement of limits of disturbance on newly created lots
Open Space and Cluster Development	Section 4.5 (A)10(a), Open Space Plans Required	The Planning Commission may reduce the amount of required open space based upon the characteristics of the parcel to be subdivided if they determine that the subdivision design and amount of protected open space otherwise meets the stated purposes of a conservation development.	N/A	N/A

Impervious Area Management

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Unconnected Impervious Areas	Section 4.5 (A)(9)(c)(2), Low Impact Stormwater Management	Minimize impervious surfaces to minimize stormwater volume… Reduced road lengths and widths as well as shorter/narrower driveways and minimizing lawns can meet this objective.	Unclear why minimizing lawns would be a positive aspect for minimizing stormwater volume	New green infrastructure opportunities, including vegetative buffers, living shorelines, and catch basins may be useful

Onsite Wastewater Management

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
	Section 4.3 (A) Development Density	Yield plans shall… [include] the location of the well and onsite wastewater disposal system shall be shown on each lot.	Excellent starting point for yield plans to include well and onsite wastewater location information.	N/A

Pet Waste Management

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
N/A	N/A	N/A	N/A	N/A

Fertilizer Application

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Best Practices for Use	N/A	N/A	Most design guidelines are located in the subdivision and land development regulations, rather than the zoning ordinance, but best practices for limiting nutrient runoff/leakage from fertilizers is minimal within both regulations.	Add a section in the subdivision and land development regulations that specify guidelines for fertilizer usage in each zoning district with specific requirements for any lots south of Route 1 or along salt marshes.

Agriculture

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Farming	Section 4.5(A)(11)(d), Limits on Site Disturbance	Clearing and excavation of open space areas may be permitted only for the installation of stormwater management facilities, other necessary utilities, or for permitted park, recreational, agricultural or forest management uses in accordance with a plan approved by the Planning Commission. Such uses shall not degrade the soil or make use of noxious chemicals.	Language does not specify mechanisms necessary for reducing nutrient loading.	Consider adding restrictions on fertilizer applications.
			Restrictions on agricultural uses and requirements for best practices should not be limited to conservation developments.	Expand provisions for agricultural uses, fertilization best practices, and implementation of green infrastructure to apply to all subdivisions.
			The only reference to irrigation in the land development and subdivision regulations is found in this section, which limits its usefulness from a regulatory perspective.	Creating irrigation standards or at least guidance for homeowners and agricultural businessowners might be useful.

2021 Comprehensive Plan

Vegetation and Landscaping

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Preservation of Natural Areas	Natural Resources, Page 2-25	Although the salt ponds watershed comprises only 28% of Charlestown's land area, it contains over 63% of all developed parcels, and includes the Town's most densely developed areas. There are 3.7 square miles of lands classified as Developed Beyond Carrying Capacity in Charlestown, most of which are south of Route 1. The largest such area is the Charlestown Beach area along the border with South Kingstown and adjoining Green Hill Pond and the easterly portion of Ninigret Pond.	Improper management of natural resources can result in development encroaching on wetlands and protected areas.	Consider regulating management of protected areas.
Tree Protection	Energy, Page 6-9	Forested buffers keep streams and rivers cool, necessary for fish habitat, and prevent nutrient and sediment runoff from harming water quality.	Stormwater runoff may contain pollutants that can harm waterways and wetlands.	Development of an urban forestry plan that follows the Rhode Island Department of Environmental Management "Urban and Community Forestry Program" that focuses on stormwater management and nutrient pollution uptake.
Landscaping Islands for stormwater management	N/A	N/A	N/A	N/A
Riparian Buffers	Natural Resources, Page 2-25	Development also has an impact on habitats. Within the pond buffer zones, succession from open field habitat to shrub habitat, or conversion of open fields to other land uses, reduces the available nesting, migratory resting and refueling habitat for some bird species, threatening these species' populations	Lack of protection for wetlands and local waterways from encroaching development	Require wetland and buffer areas to be within protected open space areas to the extent possible.

		In 2016, the Rhode Island Legislature approved a bill, signed by the governor, which required that municipalities include wetland buffers (the perimeter wetland) in the calculation of minimum lot area and in the area of a parcel when calculating the maximum number of lots (overall density) for the parcel. This means that municipalities which require that new lots have an area of suitable land, or land free from constraints, equivalent to the minimum lot area under zoning, can no longer require that wetland buffers be excluded from that minimum lot area. This bill was strongly opposed by Charlestown and a number of other towns that consider wetland buffers to be constrained land which should not be counted towards minimum lot area and density. The practical effect of the legislation is to allow additional development on certain parcels of land, specifically those parcels that have large areas of wetland. It also removed an aspect of local autonomy in determining residential density.	Stormwater runoff may contain pollutants that can harm waterways and wetlands.	Develop a robust plan on vegetative buffers and living shorelines that reduce runoff velocity, restrict pollutants from reaching local waterways, and filter pollutants prior to harming the local ecosystem.

Minimizing Land Disturbance

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Limits of Disturbance	N/A	N/A	N/A	N/A
Open Space and Cluster Development	Services and Facilities, Page 5-13	Charlestown has embraced the principals of Low Impact Development (LID) in its Subdivision and Land Development Regulations, which require that all new subdivisions be developed as cluster subdivisions (individual house lots with commonly held open space areas) unless there is a compelling reason why a conventional subdivision is more appropriate. The regulations require the use of LID site planning and design elements to mitigate pollution, reduce sedimentation, provide visual amenities and wildlife habitat, and utilize structural and nonstructural best management practices (BMPs) as per the 2010 RI Stormwater Design and Installation Standards Manual, and the RI Soil Erosion and Sediment Control Handbook (revised 2014).	Development is growing rapidly around the salt ponds creating significant threats from runoff and OWTS.	Restrict development around salt ponds, particularly south of Route 1 around Quonnie and the eastern portions of Charlestown or offer financial incentives, including TDR and conservation easement and mixed-use development in commercial districts. Adopt a cluster development plan that embraces low-impact development and promotes development away from the coastal ponds.

Minimizing Land Disturbance

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Streets and Driveways	Transportation, Pages 8-14 & 8-15	Design standards for new roads are contained in the Subdivision Regulations. New public streets proposed as part of a subdivision or land development require a 24-foot pavement width within a 50-foot-wide right-of-way. Reductions in pavement width are often permitted by the Planning Commission for small subdivisions, or when the developer agrees to create a more compact subdivision with smaller lots and shorter roads in order to protect trees and preserve rural quality and reduce both traffic speeds and road run-off.	N/A	N/A
		Flexibility in road design is as important in the design of new subdivisions and compounds as is lot configuration; flexible roadway standards can include… Requiring roadside swales, and other low impact drainage systems as opposed to pipes and structural drainage systems. Low impact stormwater control is addressed in the 2010 Rhode Island Stormwater Design and Installation Standards Manual	N/A	N/A

Parking Areas and Sidewalks	Services and Facilities, Page 5-13	the Town owns and operates a number of small-scale systems that drain localized parts of municipal roads and public parking areas. The DPW works to replace failed catch basins with new pre-cast concrete basins with sumps and maintains retention ponds within the Town owned rights of way.	Replacing failed catch basins with pre-cast concrete basins with sumps often fail to address the long-term problems of runoff.	A combination of structural soil procedures with natural plantings in addition to the concrete basins may provide a greener, higher quality
	Transportation, Page 8-20	Sidewalks that are constructed of concrete or other impervious surfaces increase stormwater run-off.	Lack of permeable surfaces and significant runoff concerns.	Installation of permeable pavement that does not infiltrate the groundwater across more locations in Town.
Unconnected Impervious Areas	Natural Resources, Page 2-25	Stormwater runoff from large areas of impervious cover, including roadways, parking lots, driveways, rooftops and similar surfaces within the densely developed areas surrounding the salt ponds and, in the watershed, discharges to the salt ponds either by direct runoff (nonpoint source) or storm drains (point sources). This runoff can be the source of a variety of contaminants including nutrients, pathogens, organic matter, road salt, oil and even heavy metals. Excess nutrients promote algae and plant growth, which in turn depletes the water of oxygen when they decay, a condition known as eutrophication, and which can eventually lead to fish kills	Discharge of highly contaminated stormwater runoff into salt ponds is extremely dangerous to local ecosystems, which impacts natural resources, and in turn, economic development.	Installation of green infrastructure specifically located in areas with particularly high amounts of impervious surfaces, including catch basins, bioswales, and permeable pavement.

Onsite Wastewater Management

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
	Natural Resources, Pages 2-23 & 2-24	In Charlestown, OWTS are the largest contributor of nitrate to the groundwater, particularly in the salt ponds watershed, which is the limiting nutrient in coastal environments and which has significant water quality and health implications. Models developed by the University of Rhode Island (URI) indicate that in the densely developed areas of Charlestown, approximately 80% of groundwater nitrate is attributable to OWTS discharge. As a result, RI DEM mandates the use of nitrate (N)-reducing septic systems in the salt ponds watershed for all new OWTS installations Charlestown Comprehensive Plan or for systems that require an upgrade. N-reducing OWTS are designed to lower the wastewater effluent total nitrate concentration by 50%.	Potential sources of contaminants such as leaking heating oil tanks, the handling of hazardous materials, etc., also pose localized risks to groundwater quality.	Adoption of an updated oil spill contingency plan to coordinate Town, state and federal response in this area as it affects the salt ponds.
			OWTS are largely responsible for nitrate groundwater issues	Educate homeowners on the importance of getting regularly scheduled maintenance of their septic systems.
	Services and Facilities, Page 5-15	The Town obtained a grant in late 2017 to monitor the efficiency of installed systems that employ nitrate- reducing technology. Under the grant, recommended landscaping process policies will be implemented, and six demonstration rain gardens will be installed on Town properties to improve stormwater infiltration.	Six demonstration rain gardens is a strong pilot program, but more green infrastructure is needed to combat the significant nitrate loading concerns in Town.	Significant investments in green infrastructure should be made across Town, particularly south of Route 1; constructed wetlands could be one such option for some areas.

Pet Waste Management

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
	Natural Resources, Page 2-25	Development within the salt ponds watershed can have a long-term impact on the ponds' water quality and habitat value. Water quality is impacted by nutrients and other pollutants entering the salt ponds through both groundwater and surface water runoff; these pollutants originate from a variety of sources associated with development and use of land around the ponds, including on-site wastewater treatment systems, fertilizer use, stormwater runoff and animal waste	Improper pet waste management practices and poor pet-owner education leads to contaminated runoff.	Educate pet-owners on best practices for properly disposing of waste and the environmental problems associated with improper pet waste management.

Fertilizer Application

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Best Practices for Use	Natural Resources, Page 2-25	Water quality is impacted by nutrients and other pollutants entering the salt ponds through both groundwater and surface water runoff; these pollutants originate from a variety of sources associated with development and use of land around the ponds, including on-site wastewater treatment systems, fertilizer use, stormwater runoff and animal waste.	Education on fertilizer use is not substantial enough when in such close proximity to the salt marshes, as was noted in the 2021 Comprehensive Plan.	Potential restrictions on fertilizer applications or reuse of manure.
	Natural Resources, Page 2-24	Similar to the nitrate from septic systems, nitrate and other nutrients from fertilizers and other chemicals enter the groundwater, surface water bodies and the salt ponds. This can occur by both stormwater runoff directly into surface water bodies, and by infiltration into the groundwater.	Fertilizer runoff and groundwater infiltration can be difficult to combat without limiting its use entirely or using natural fertilizers like compost/manure.	Incorporation of compost and manure instead of nitrate fertilizer has been proven, in tandem with moisture via recharge, to result in long-term denitrification in soils.

Agriculture

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Farming	N/A	N/A	N/A	N/A
Irrigation	N/A	N/A	Lacking information on irrigation	Many municipalities offer fact sheets that indicate basic irrigation tips and tricks as well as best practices for reducing fertilizer runoff/groundwater infiltration, which might be useful for Charlestown.
Manure Deposition	N/A	N/A	N/A	N/A

Charlestown Recommend Landscaper Process

Fertilizer Application

Topic	Source - Regulation	Language of Concern	Potential Issues	Recommendations
Best Practices for Use	Rev #2-17-16	No fertilizer application in buffer zones of ponds, roadways and driveways so runoff will not end up on our salt ponds. No fertilizing prior to rain or in rain.	N/A	N/A
		Charlestown strongly recommends you utilize a soil test for nutrients (UConn and UMass), but the application of nitrate not to exceed 2 #'s / 1,000 sq. ft… Measure and document the lawn so that measurement can be used to only spread less than 2 pounds of nitrate / 1,000 sq. feet annually. Use a non-water soluble or slow-release nitrate fertilizer.	Non-water soluble or slow-release nitrate fertilizer are good as a starting point for reducing nitrate contamination and runoff, but additional steps might be necessary, especially south of Route 1.	Incorporation of compost and manure instead of nitrate fertilizer has been proven, in tandem with moisture via recharge, to result in long-term denitrification in soils.
				Significant investments in green infrastructure should be made across Town, particularly south of Route 1; constructed wetlands could be one such option for some areas.
		The Town will work with local wholesalers and retailers to make slow-release nitrate fertilizers available.	It is also unclear how the Town works with local wholesalers and retailers.	Outline strategy for ensuring retailers sell slow-release nitrate fertilizers or even give financial incentives (or other governmental incentives) to encourage sale of these items.

APPENDIX C

Approaches to Controlling Nitrate Levels

Technological Approaches

Permeable Reactive Barriers for Cleaning Groundwater

A permeable reactive barrier (PRB) is a technology installed in the saturated soil of the groundwater aquifer, which is used to treat contaminated groundwater. It can be described as a subsurface technology that uses a flow-through wall for treating contaminated groundwater. PRBs typically consist of a layer of sandy soils overlying a layer of mixed with finely ground wood that is dosed by a low-pressure distribution system. It involves placing a permeable treatment zone in the path of a contaminated groundwater plume. As the groundwater flows through this barrier, contaminants are removed or transformed into less harmful substances through physical, chemical, or biological processes. This technology offers an effective passive method for large-scale remedy using readily available materials (i.e., sawdust, mulch, etc.), reducing nitrate contamination in local areas of Charlestown. In tests, PRBs have shown an ability to achieve a high percentage of nitrogen removal (up to 90%), as well as significant attenuation within the nitrifying layer of pathogens, pharmaceuticals, and personal care products.[1] The removal of nitrogen in a PRB involves two steps:

(1) a nitrification step in which ammonia and reduced organic nitrogen is septic tank effluent is converted to nitrate in an unsaturated, oxygen (O_2) rich sand layer; and

(2) a denitrification step in which nitrate is converted to nitrogen gas in a semi saturated to saturated, O_2-limited sand plus lignocellulose (wood chips or sawdust) layer.

The PRB will be constructed as a horizontal later in a multi layered soil absorption field system. As shown in Figure C-1, a septic system releases nitrate-enriched groundwater into the surrounding soil and groundwater. The barrier is permeable, allowing groundwater to flow through it while interacting with the reactive materials. The installation process involves creating a continuous reactive zone within the groundwater flow path. Reactive media are delivered to the site using a truck and injected into the ground through an injection well. This media fills the designated reactive zone, forming the PRB. As nitrate-enriched groundwater flows through the PRB, chemical and/or biological reactions occur within the reactive zone. These reactions transform nitrate compounds into less harmful forms, such as nitrate gas or inert substances, thus significantly reducing nitrate levels in existing groundwater. The treated groundwater continues its natural flow towards the water body, now with a lower contaminant load.

Technologies like this could be deployed to treat contaminated groundwater immediately upstream of a sensitive receptor (e.g., a groundwater well or salt pond). The Town of Eastham, Massachusetts is currently piloting use of PRBs to remove nitrate from groundwater. Eastham's estuaries require nitrate reduction to achieve healthy ecosystem function. Initial results are promising and indicate PRBs could provide a solid base as an alternative technology for groundwater restoration (Town of Eastham Health Department, 2020).

[1] Domenica, M., Shreve, B., Winchell, P., AECOM, R., Donoghue, P., & Parece, T. (2016). Subject Town of Orleans, MA Water Quality and Wastewater Planning Task Number 8 -NT Demonstration Projects Deliverable 8.1.2.A -Draft Nitrogen Reducing Barriers Feasibility Project Number 60476644. In \ *AECOM Technical Services*. https://www.town.orleans.ma.us/DocumentCenter/View/786/Draft-Nitrogen-Reducing-Barriers-Feasibility-PDF?bidId=

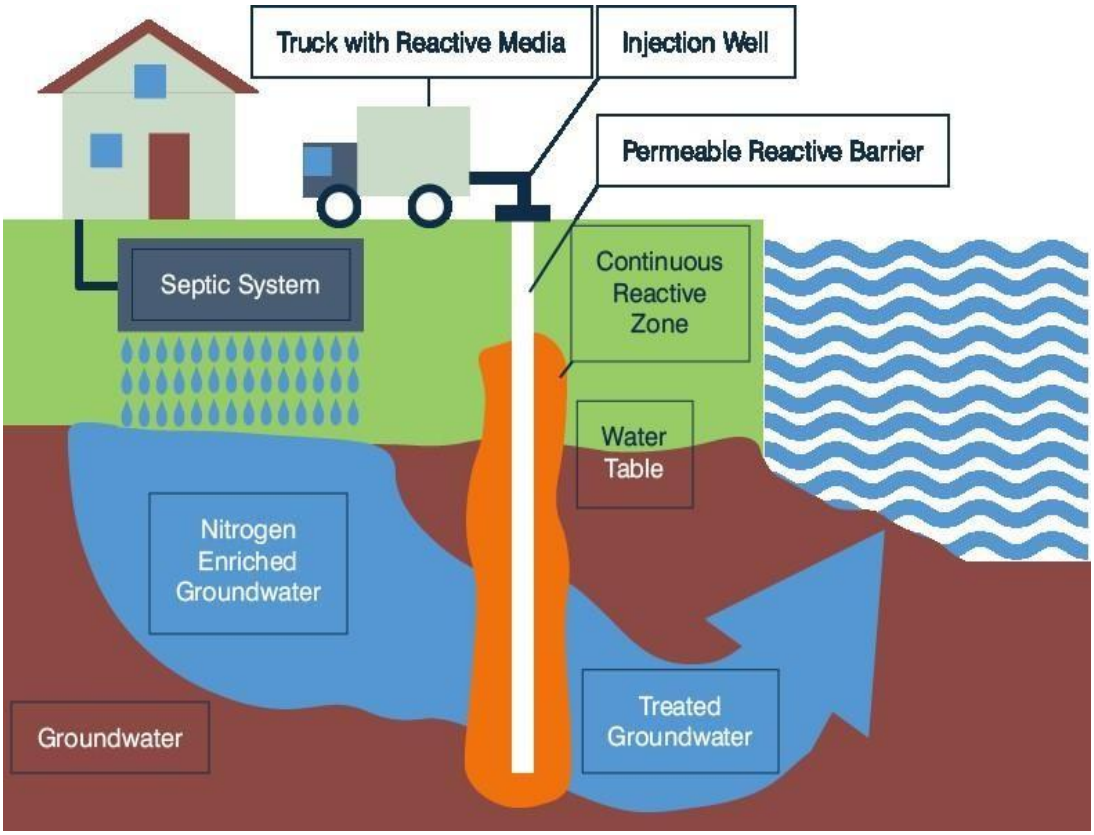


Figure C-1. Diagram of Permeable Reactive Barriers (PRB)

Vegetation and Landscaping Design

Vegetation and landscaping regulations and standards can be implemented by Charlestown to ensure that nitrate reduction practices are included in design considerations. Nitrogen fixing trees offer a multitude of benefits for property owners. These trees contain bacteria that take up nitrate and limit the amount that remains in the soil, thereby reducing nitrate pollution. Planting these trees around neighborhoods or on individual properties in the vicinity of septic system effluent plumes could help to reduce the concentration of nitrate in groundwater. Trees offer a natural filtration system for nitrate pollution, as depicted in Figure C-2 while simultaneously acting as an aesthetically pleasing landscaping option.

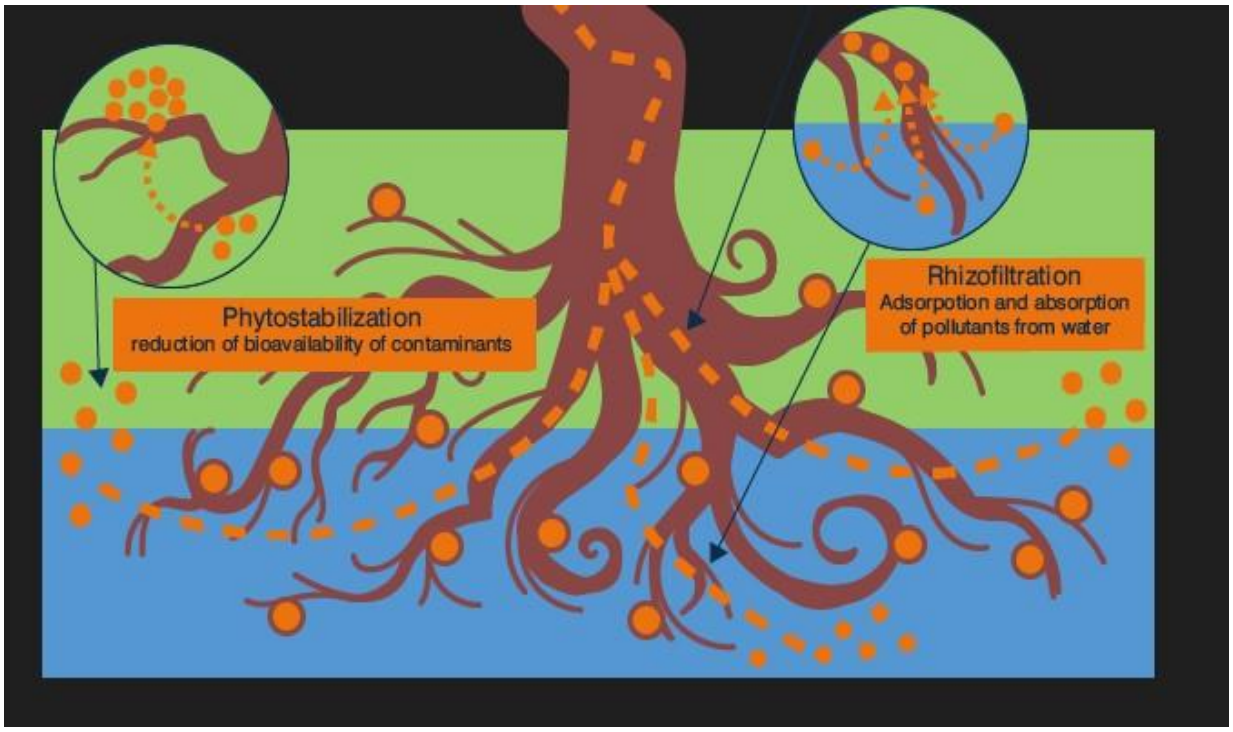


Figure C-2. Diagram of Nitrogen Fixing Trees' Denitrification Process

Nitrogen fixing trees can be planted as part of a variety of environmentally friendly landscaping methods. It is important to keep the species selection in mind while selecting nitrogen fixing trees. Selected trees should be native, and non-invasive species.

Phytoremediation and low-maintenance, sustainable lawns are two such options. Phytoremediation is the process of utilizing plants and microorganisms to cleanup a site. A detailed illustration of this cycle can be found in Figure C-3. Landscapers that want to minimize fertilizer may turn to low- maintenance, sustainable lawns. This involves selecting plants that can survive with little or no fertilizer to create a more sustainable ecosystem. Regardless of approach, each method can be implemented on small or large scales with varying levels of maintenance required. The incorporation of nitrate fixing trees can only enhance the effectiveness of these approaches.

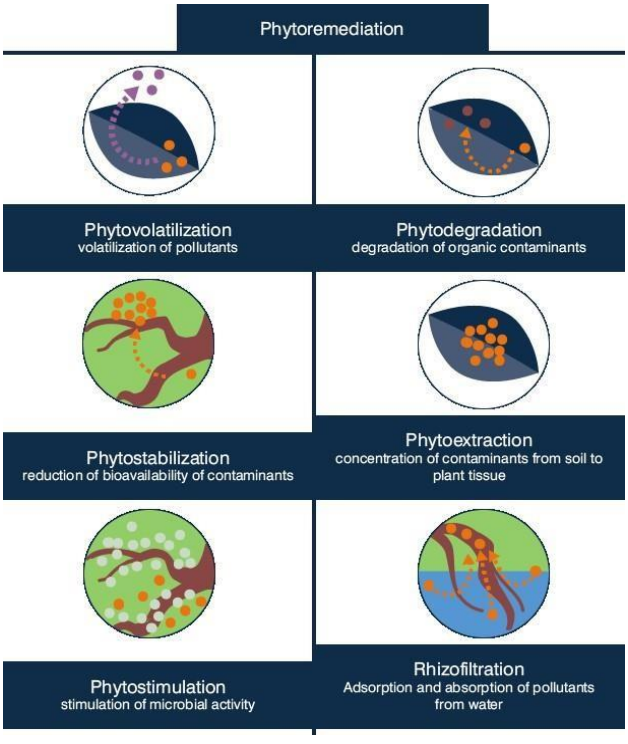


Figure C-3. Diagram of Phytoremediation

Composting Toilets & Holding Tanks

The nitrate in wastewater discharges is responsible for a majority of the nitrate found in groundwater and surface waterbodies in Charlestown. Wastewater can be characterized as being made up two parts—blackwater (human waste) and greywater (wash water). Waterless toilets and composting toilets significantly reduce nitrate by eliminating blackwater from wastewater. Composting and waterless toilets store human waste in a container placed under the toilet or somewhere further from the toilet itself. Human waste is divided into solid and liquid matter, and a decomposition process starts. Decomposition breaks down the waste into a residual similar to fertilizer. This type of technology has the potential to reduce the amount of nitrate that is released into the groundwater by nearly 90% (NEIWPCC, 2019).

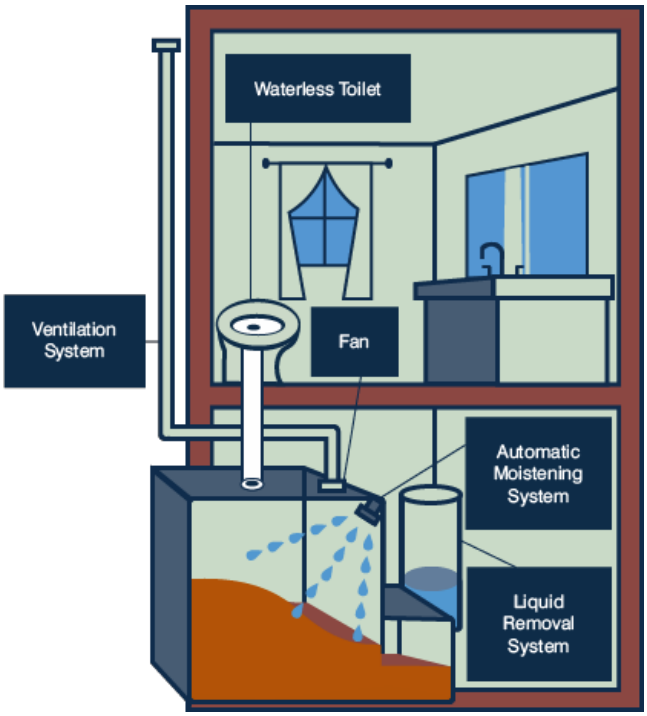


Figure C-4. Components of a Composting Toilet

Holding tanks are an alternative in which a buried tank—similar to a septic tank with no outlet—does not discharge any effluent. The tank stores the wastewater and is cleaned out on a routine basis. Wastewater from the holding tank is pumped to a septage hauling truck for disposal at a local wastewater facility. No effluent is released from the holding tank.

Composting toilets and holding tanks are considered effective methods for preventing nitrate pollution. According to RIDEM's Alternative or Experimental (A/E) Technology Permit Count, last published by the RIDEM Office of Water Resources in 2022, 161 holding tanks have been approved for use throughout the state with 150 of those being approved since 2002. Forty-three composting toilets have been approved by RIDEM. Although holding tanks are currently prohibited for new construction, per the Rhode Island Code of Regulations, they can be installed for existing development (Rhode Island Department of State, 2024). Composting toilets can be utilized regardless of the stage of development and offer an alternative option for new developments. These technologies are less well accepted by the general public than other wastewater technologies; however, they do present a means of radically reducing nitrate contribution from wastewater in areas that are experiencing very high nitrate levels (e.g., above 10 ppm).