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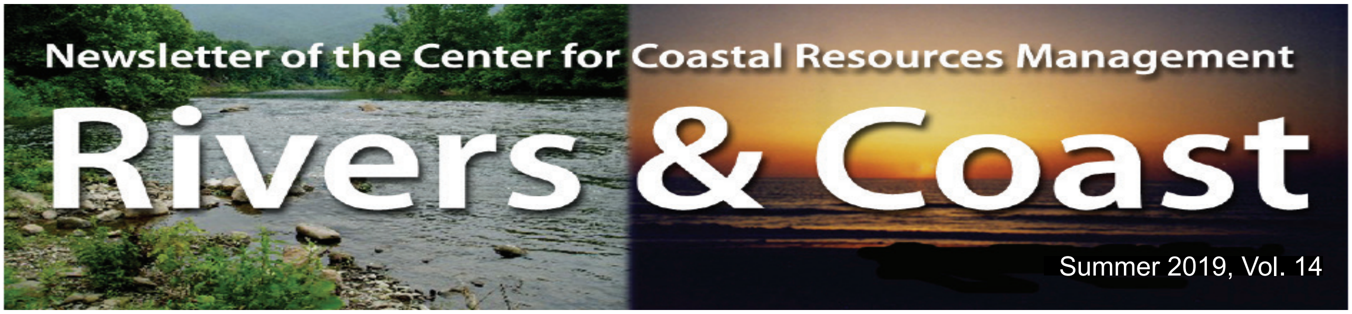
The Problem of Failing Septic Systems

Center for Coastal Resources Management, Virginia Institute of Marine Science.



The Problem of Failing Septic Systems

Efforts to improve water quality in the Chesapeake Bay began with an intense focus on upgrading wastewater treatment plants. These systems, which collect effluent from commercial and residential sites in urban areas, can be made very efficient at removing nutrients and pathogens. Virginia has had outstanding success at many of its largest urban centers, upgrading the treatment processes to significantly reduce the pollutant loads discharged back in to tidal waters. The impacts of these improvements can be seen in the water quality monitoring data routinely reported by the Chesapeake Bay Program (*https://www.chesapeakeprogress.com/?/clean-water/water-quality*).

More than half of Virginia's population is not connected to municipal wastewater treatment plants, especially in rural areas. Instead, many people rely on individual treatment systems, and the majority of these are septic tank and drain field installations. As we look for ways to further reduce pollutant loads to the Bay, attention has been focused on these private systems.

Problems with Septic Systems

1. A properly installed and correctly functioning septic system can still deliver a significant load of nitrogen to adjacent waters through the shallow groundwater (Reay, 2006, *https://doi.org/10.1111/j.1745-6584.2004.tb02645.x*).
2. Septic systems do not last forever, even when well-maintained. Over time septic tanks can fill with material that has not decomposed, the drain field can become saturated or clogged, and the system can begin to discharge directly onto the ground surface and/or into adjacent waters.
3. Recurrent tidal flooding over drain fields and higher groundwater elevations due to sea level rise are expected to aggravate this situation (Figure 1). A failing system due to increasing saturation can deliver even more nitrogen, phosphorus, organic matter, bacteria and pathogens.

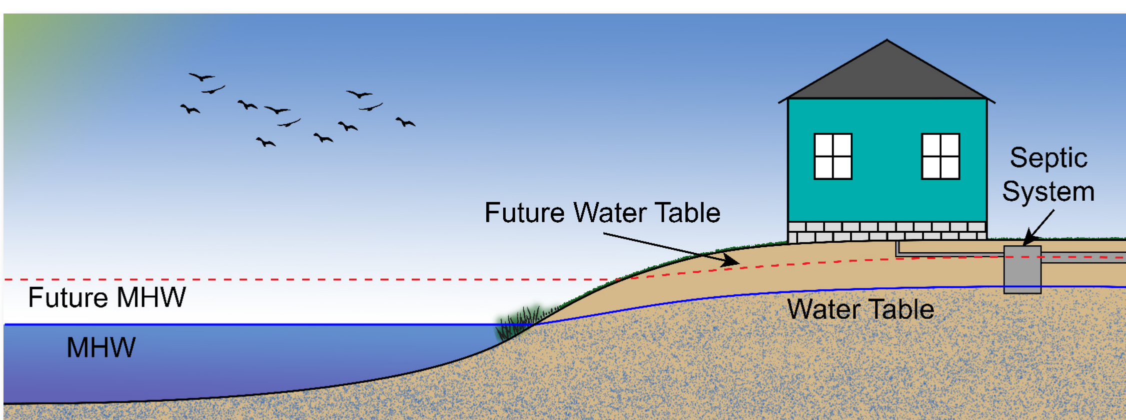


Figure 1. *Typical cross section of a shoreline property with an on-site septic system drain field positioned just above the water table; displaying current conditions, and the risk of future failure created by rising sea level and the resulting elevated groundwater.*

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Estimating the Scope of the Problem

The potential scope of the problem of failing septic systems was analyzed using available Geographic Information System (GIS) data. The GIS framework started with information on building locations, areas served by municipal sewers, and impaired surface waters as designated by the VA Department of Environmental Quality or DEQ (Figure 2). Combining these data layers provides an estimate for the number of buildings using on-site septic systems that are close to waters already impacted by pollutants.

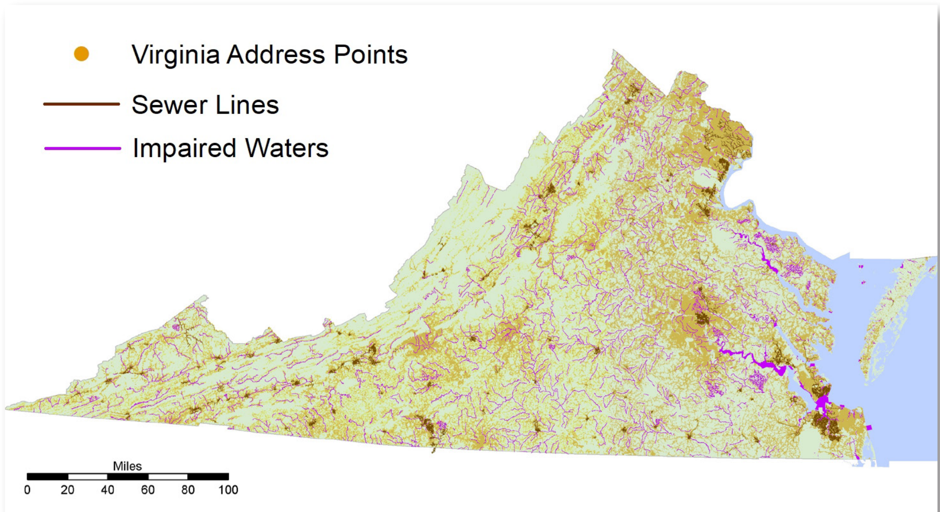

Figure 2. *Map of Virginia showing address points in orange, impaired waters in purple and municipal sewer systems in brown.*

Only an estimate is possible because there is no information currently available to indicate precisely which buildings have septic systems, nor exactly what type of system may be present. Most on-site systems are traditional tank and drain field installations, but there is a growing use of alternative on-site systems in some areas with less suitable soil characteristics. No attempt was made to distinguish between the two types of septic systems because the intent was to simply frame the issue.

This analysis used a database of all known address points in the state to identify the geographic location of buildings. Buildings relatively close to surface waters were assumed to be the most likely to increase pollutant loads from septic systems, and that septic systems near already impaired waters are the primary concern.

This mapping analysis found 780,831 address points within a 500 meter buffer (1,640 ft.) around all impaired waters in Virginia. Removing address points that also fell within a 500 meter buffer around municipal sewer systems left 506,675 address points where it was assumed there is some type of on-site septic system in proximity to impaired waters. The Virginia Department of Health (VDH) estimate of over 1 million on-site septic systems in use leads to the suggestion that about half of all the systems in Virginia have some potential for contributing pollutant loads to already impaired waters.

Finding and Predicting Septic System Failures

It is useful to know that the problem of failing septic systems in Virginia is potentially very large. Working to meet this challenge requires much more specific information about where current problems exist and where future problems are likely to arise.

The Challenges

Locating existing failing septic systems is not as simple as one might expect, largely because there is no effective way to ensure all failures are identified. Current requirements for septic system inspections only exist in Virginia's coastal zone as part of the Chesapeake Bay Preservation Act, and a lack of resources makes enforcement and data gathering a continuing challenge even in that restricted area. As a result, the Virginia Department of Health only has records for locations where someone has applied for a permit to repair a septic system. Those records are not specific about the problem needing repair nor do they document if the repair was actually completed.

A second challenge is that VDH records are a mix of old paper files, kept in Health District offices around the state, and newer electronic files that suffer from a lack of consistency. This results in significant difficulty accessing information and working with available data. VDH is actively working to remedy this situation with an on-going redesign of its databases, an upgrade in the information formatting, and an interest in moving older records into digital form. Unfortunately, this critical effort is resource limited and huge. Progress is being made, and so efforts like ours to inform management and policy will only get better over time.

This analysis worked with available information in a few selected localities to examine if it is possible to develop a predictive model of future failure risks. It was assumed that all repair permits represent failure locations. The next step was to determine if readily available information about the assumed failure locations is sufficient to model current and future risks (Figure 3).

MaxEnt Model

A computer program called MaxEnt was used to model where septic systems may have failed and where they might fail throughout several counties in coastal Virginia. MaxEnt is specially designed to work in situations when the only available information is where something happened – in this case where a septic system needed repair. This differs from other more common analytical programs that also require information about locations where something did not happen in order to predict possible future occurrences. Because we did not know with certainty that locations without septic system repair permits had not failed – failures may simply not have been reported – we could only work with locations of assumed failures.

Using information about the physical characteristics of sites with assumed septic system failures, MaxEnt identifies the strength of the relationship between selected characteristics and system failures. Basically, the program works to identify the suite of site characteristics most likely to identify other sites where failures may occur.

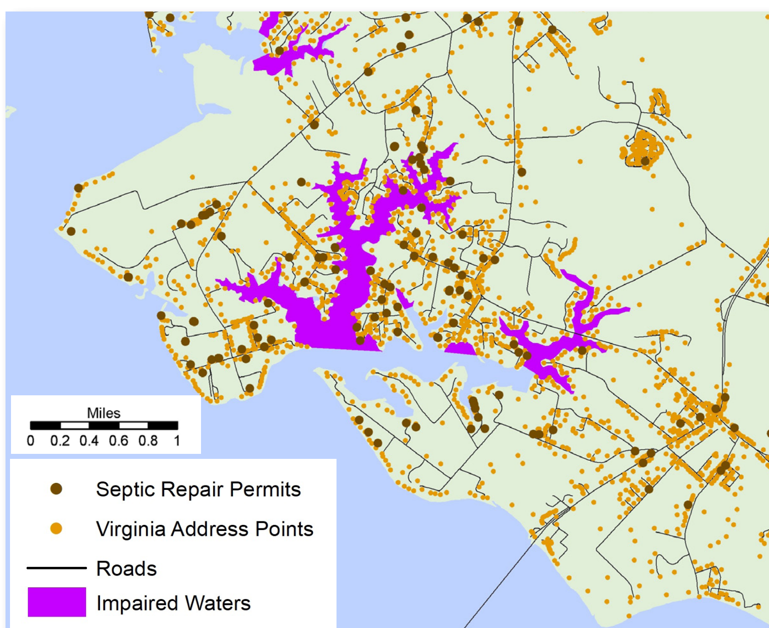

Figure 3. *Carter Creek in the area of southern Lancaster County showing the location of septic system repair permits (brown dots), with other address points (orange dots), and impaired waters (purple areas).*

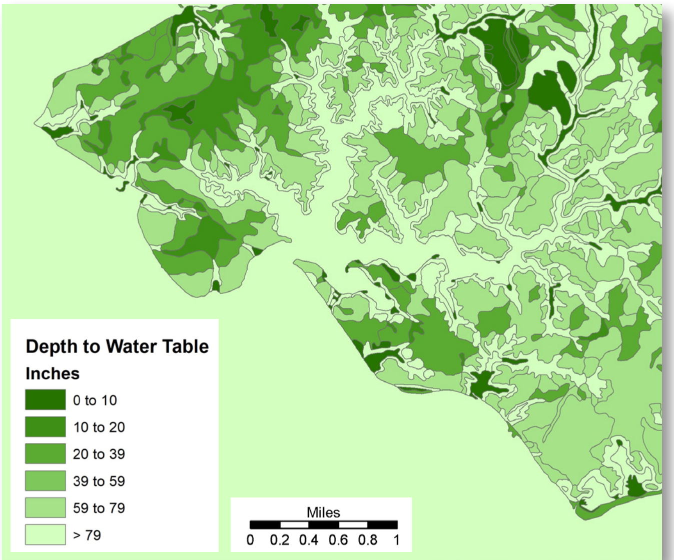

Figure 4. *Carter Creek area of southern Lancaster County showing the depth to water table as determined by soil maps for the area. Adequate separation of drainfields from saturated soils is required for effluent treatment.*

MaxEnt Analysis

Because septic systems are more likely to fail in waterlogged soils that do not drain well, the suite of site characteristics chosen to be examined by MaxEnt included elevation, slope of the land, soil composition, and depth to water table, plus others (see Figure 4 for an example of the data). By selecting characteristics most consistently associated with assumed failure sites, MaxEnt develops a model that can be used to assess an entire landscape and map where failures are most likely to occur.

Available information from Lancaster, Gloucester, Isle of Wight, Northampton, and Accomack counties was then used for MaxEnt to analyze.

Model Results

The results from this MaxEnt model indicate where there is a high probability for septic system failures among sites that do not have a repair permit. This does not mean those systems are currently failing. However, as they age, and based on the use and maintenance they receive, the site characteristics suggest they are at higher risk for failure.

The current model indicates one of the hot spots for potential septic system failures is in the Town of Chincoteague on Virginia's Eastern Shore. Figure 5 shows all the address points in the island community and the locations of septic repair permits. While the community is relatively dense, it is all served by on-site septic systems. The elevation is low and the depth to water table (groundwater) is shallow throughout the island, so all of the systems would logically be at risk now and in the future. The MaxEnt output suggests exactly that. As shown in Figure 6, almost all of the address points on the island share a high probability for failure. This is clearly an area where active monitoring and aggressive maintenance are warranted to minimize additional risks to human health and adjacent waters, many of which are already determined to be impaired.

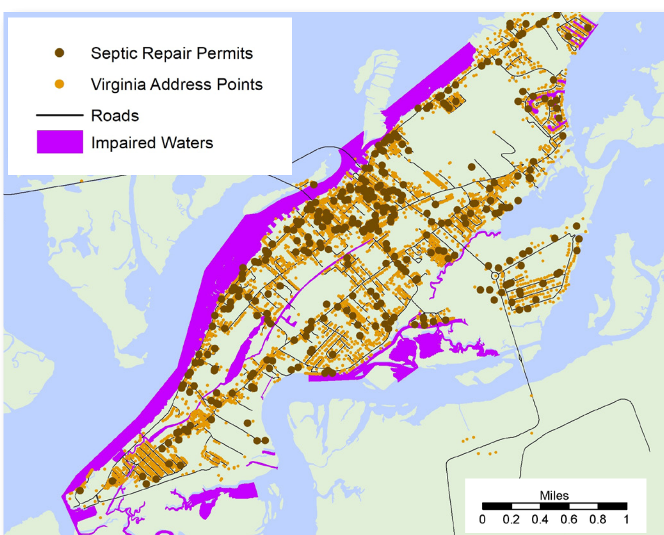

Figure 5. *Chincoteague Island on Virginia's Eastern Shore, showing address points for the community (orange dots), septic system repair permits (brown dots), and impaired waters (purple areas).*

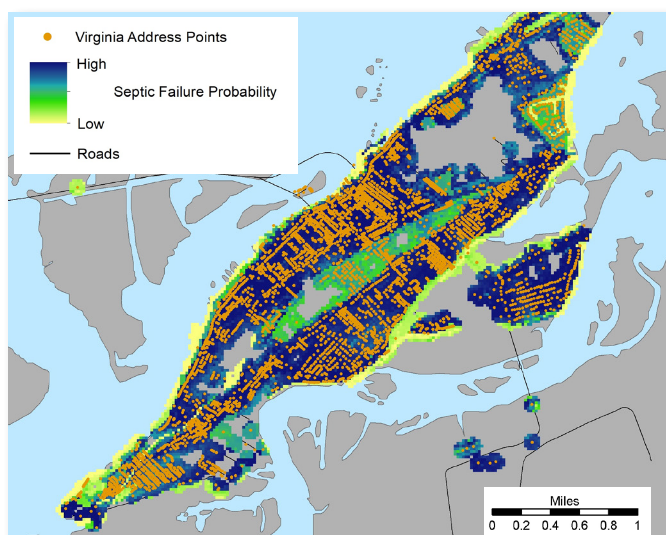

Figure 6. *Chincoteague Island probabilities of septic system failure determined by the current MaxEnt model. Address points for the community (orange dots) overlap with darker areas reflecting higher probabilities.*

Sea-Level Rise Compounds the Problem

While many areas already have characteristics which would appear to put them at risk for septic system failures, future conditions are expected to increase these risks. Sea level rise, in particular, will aggravate the problems of high and seasonally high groundwater tables in shoreline and other low-lying areas. As the height of tidal waters increases, groundwater is effectively held back at the water's edge, leading to increased saturation of surface soils. Most on-site septic system drain fields require adequate separation from saturated soils in order for effluents to be filtered through aerobic soils before encountering the shallow groundwater system. In most soils acceptable for septic system installation, the minimum distance above saturated soil horizons must be 18 inches or greater. There are many places in coastal Virginia where this condition is only marginally attained.

With sea level projected to rise 18 inches by 2050 (*http://adaptva.com/info/virginia_sea_level.html*) throughout much of coastal Virginia, the number of failing septic systems can be expected to increase significantly. For an example the MaxEnt model was applied to southeastern Gloucester County, in the area widely known as Guinea Neck. This low-lying region where the York River flows into the Chesapeake Bay, has been inhabited by people living in fishing communities since colonial times. Recent development has spread into the region, but municipal sewer lines stop before reaching much of the area, and connection to the sewer is not mandatory. As a result, almost all of the buildings in the area operate with on-site septic systems.

Figure 7 shows the Guinea Neck area of Gloucester County with an analysis of address points that are at high risk for failure under current conditions (red dots) and those that would be under high risk of failure following an 18-inch rise in sea level (yellow dots). To generate this analysis, an existing model developed at CCRM was used to estimate the groundwater elevation across a coastal landscape. This model uses elevations of all surface water bodies in the landscape along with tidal elevations along the shoreline to interpolate the location of the groundwater surface between those features. Combined with the latest Lidar data, which provides very accurate land surface elevations, the depth to saturated soils now and under future conditions can be estimated.

For the Guinea Neck area, this modeling analysis suggests that the number of sites with a high probability of septic system failures will approximately triple by 2050.

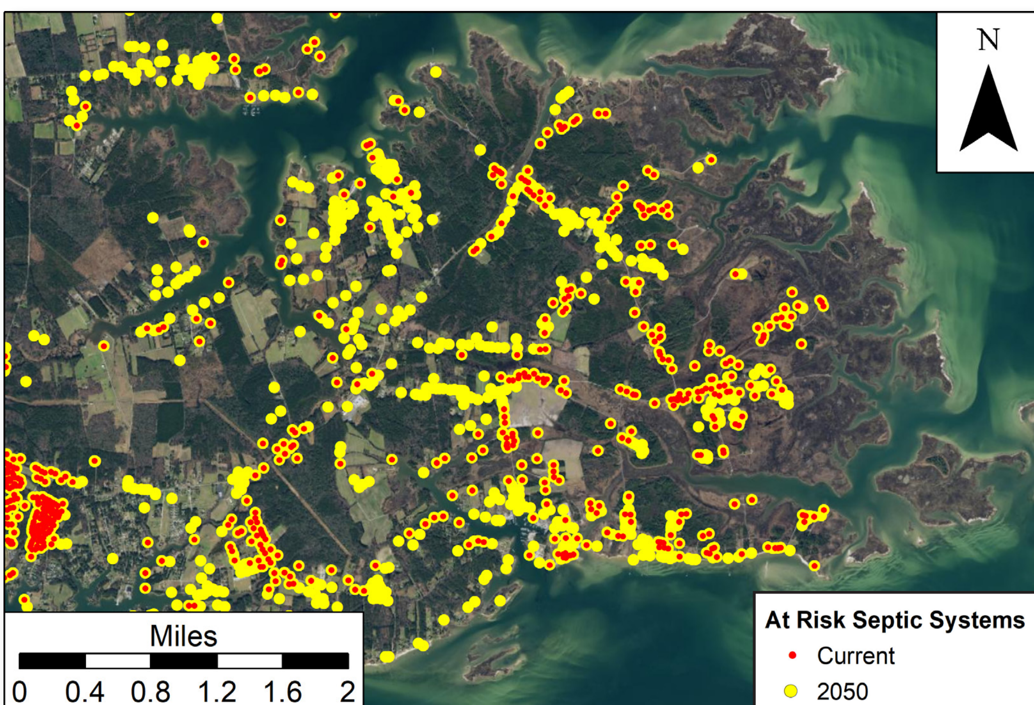

Figure 7. *Guinea Neck area of southern Gloucester County at the confluence of the York River and Chesapeake Bay. Address points with a high risk of septic system failure under current conditions are shown as red dots. Points that are estimated to have a high risk of failure under the sea level rise conditions forecast for 2050 are shown in yellow.*

The Emerging Issue with Aquaculture

One of the most concerning issues that arises from failing septic systems in the coastal zone is the fact that the pollutants they discharge, especially the bacteria and pathogens, can easily find their way into adjacent tidal waters. In many cases these are the same waters increasingly being used for shellfish aquaculture and successful shellfish aquaculture requires very clean water (Figure 8).

Because shellfish are filter feeders, they tend to catch and accumulate pollutants floating in the waters around them. This is unfortunately very true of disease organisms harmful to human health, and it is the reason that shellfish growing waters must have bacterial levels even lower than those required for safe swimming. The VDH Division of Shellfish Safety (DSS) routinely monitors all the waters available for growing and harvesting oysters and clams in the Commonwealth. Wherever bacterial loads in these waters are found to be above allowable limits, the DSS will impose closures, prohibiting direct marketing of animals from the area.

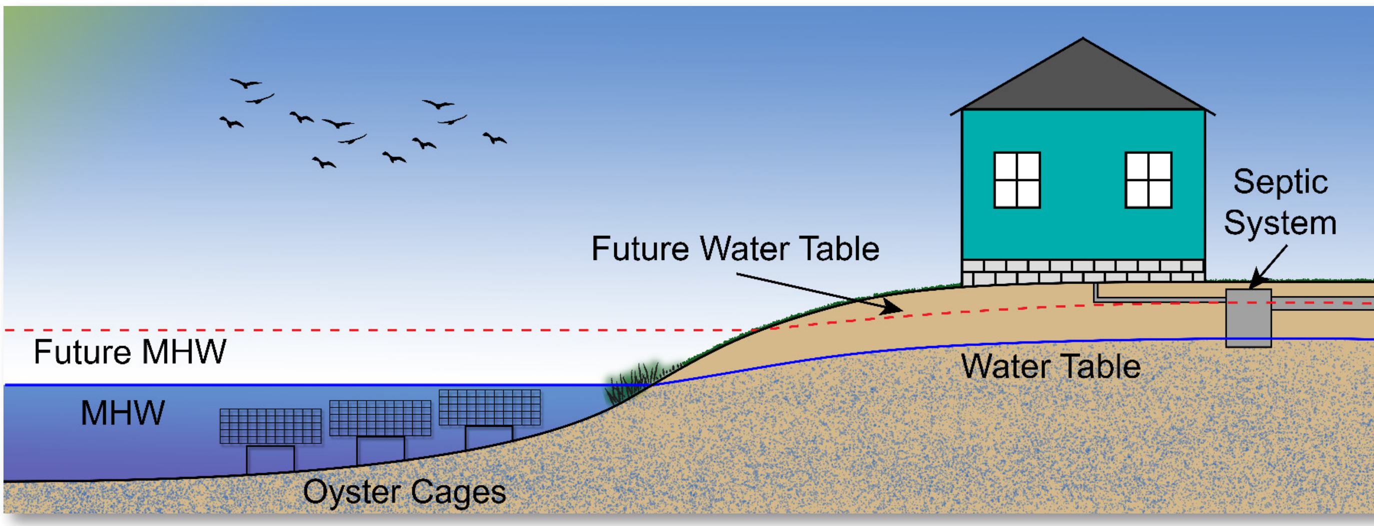

Figure 8. *Much of the current shellfish aquaculture activities in Virginia take place in shallow waters near the shoreline. Typically, clams are grown on the bottom under nets, and oysters are grown in cages either raised slightly off the bottom or suspended from floats. Most of these practices occur relatively close to the shoreline where they can be exposed to either shallow groundwater discharges or surface runoff from adjacent lands.*

Aquaculturists must make substantial investments in leasing growing areas, as well as acquiring and installing cages, nets and the other equipment necessary for a commercial venture. The risk that a product requiring a year or more to grow may not be marketable because the local water quality has declined is unacceptable.

Sustaining a profitable fisheries industry is a desire at all levels of government in Virginia, and recognizing emerging threats is critical to achieving that goal. Failing septic systems in the coastal plain is a threat that is already present and expected to increase.

One area where these problems have already been reported is in Lancaster County. The county has a lot of commercial and recreational shellfish growers, and the waters they use are among the ones the current MaxEnt model suggests may be at risk for increased contamination. Figure 9 (page 7) shows the same area of southern Lancaster County depicted in Figures 3 (page 3) and 4 (page 4). The current model analysis for this area suggests the risk of an increased number of septic system failures is high. Figure 9 shows where the failure probabilities are highest and also shows the water areas that have been designated by the Virginia Marine Resources Commission for shellfish growing leases (brown areas), public harvesting of wild oysters (light blue lined areas), and the locations of recreational oyster grower permits (pink dots).

As Figure 9 shows, aquaculture activities can be put at even greater risk with any increase in contamination from septic systems. As this analysis has demonstrated, the potential for that increase is significant.

Potential Application

Until improved septic system databases become available, this type of GIS analysis uses available information to assess the current problem of failing septic systems and to identify areas across entire landscapes where the risk for future potential problems appears to be high. This approach allows for different management and policy questions to be addressed using various outputs (Figure 10).

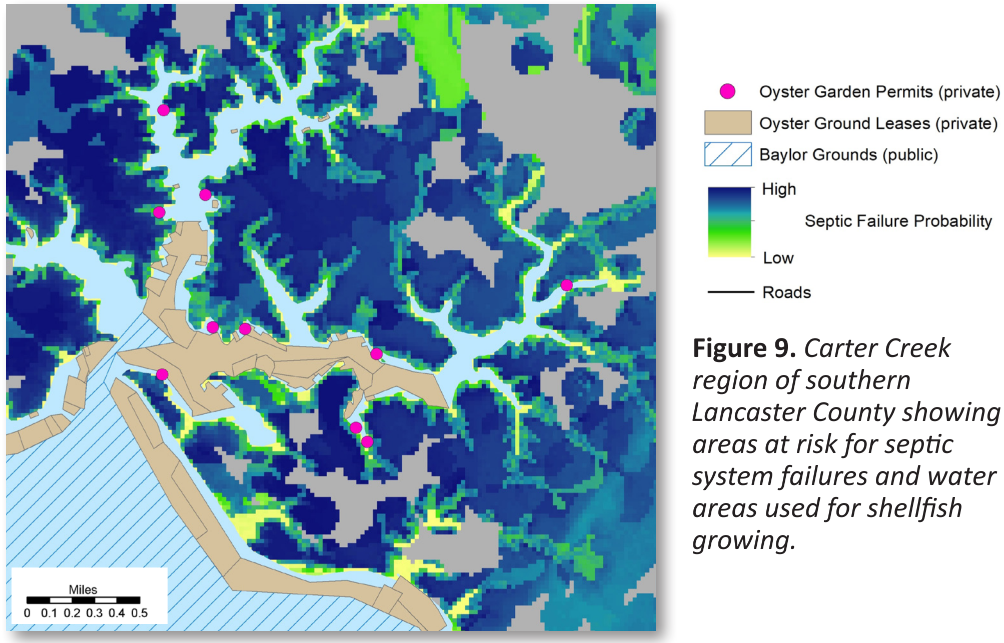

Figure 9. *Carter Creek region of southern Lancaster County showing areas at risk for septic system failures and water areas used for shellfish growing.*

Desired Information Output	Available Data Input
Address points assumed to have on-site septic systems <500 m from impaired waters	• Commonwealth of VA address points • Municipal sanitary sewer infrastructure • Impaired surface waters
Probabilities of septic system failure across an entire landscape	• Locations of septic system repair permits • Site characteristics at repair permit locations
Address points with on-site septic systems at risk of failure following 1.5 ft sea level rise	• Sea level rise • Ground water elevation model
Aquaculture activities at risk from septic system contamination	• Private shellfish leases • Public Baylor Grounds • Oyster Garden permits

Figure 10. *Examples of GIS data used in the MaxEnt model to generate desired information about failing septic systems.*

More information on these topics:

- Virginia Department of Health onsite sewage and water services program

http://www.vdh.virginia.gov/environmental-health/onsite-sewage-water-services-updated/

- Virginia Department of Health Division of Shellfish Safety

http://www.vdh.virginia.gov/environmental-health/environmental-health-services/shellfish-safety/

- Virginia Marine Resources Commission: shellfish aquaculture, farming and gardening

https://mrc.virginia.gov/shellfish_aquaculture.shtm

Management and Policy Options

Many of the challenges arising from failing septic systems throughout Virginia can be addressed by actions in the General Assembly and state agencies. The William & Mary Virginia Coastal Policy Center (VCPC) took a look at some of those challenges and developed a report entitled *Onsite Sewage Systems: Background, Framework, and Solutions.*

As the VCPC authors noted in their report, "Onsite system repairs are expensive and if the property owner is unable to afford the repair, VDH currently must either require the property owner to vacate the property, allow temporary corrections, or take criminal enforcement action." Solutions can be found in improved data collection, enhanced access to funding, and proactive mitigation strategies.

Specific recommendations from the VCPC report include:

Data

- Fund efforts to modernize collection and reporting of the location, type, and history of onsite systems.
- Support new efforts to gather and map this information.

Funding

- Inventory the many funding sources, and their relevant limitations, that exist to support mitigation of failing septic systems.
- To achieve a more coordinated approach to use available fund sources, create a grant administrator position in state government to handle this task.

Proactive Strategies

- Establish maintenance reporting requirements for conventional systems – similar in concept to the operation and maintenance requirements that are now in place for alternative on-site systems.
- Another option could be to expand the Chesapeake Bay Preservation Act pump-out or inspection requirement to the entire Bay watershed or, if the goal is water quality protection overall, expand this requirement statewide.

Additional Options

- VDH could offer a limited amnesty period that enables property owners to self-report failed or failing systems without the risk of enforcement action.
- In light of potential issues associated with sea level rise and recurrent flooding, the technical design criteria could be reviewed to determine if the current framework is the most protective of public and environmental health.
- Local government authority to require connection to municipal sewer systems could be expanded. Currently, only cities and certain counties have the authority to require such connection.

Onsite Sewage Systems: Background, Framework, and Solutions is available online:
https://law.wm.edu/academics/programs/jd/electives/clinics/vacoastal/reports/onsitesewage.final2.pdf