FINAL REPORT

Recommendations for Individual Sewage Disposal Systems that Minimize the Release of Pathogenic Organisms to the Parsons Creek Watershed

Rye, New Hampshire

December 20, 2017

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Town of Rye, New Hampshire

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Introduction

Motivation for this Study

Parsons Creek in Rye, NH has been identified as an impaired waterbody by the State of New Hampshire due to high levels of bacteria. Multiple studies have been conducted to identify the causes of this impairment and likely sources have been identified as individual sewage disposal systems (ISDS), stormwater runoff, and wildlife (NHDES, 2011). The Town of Rye has worked to mitigate these sources through the implementation of multiple phases of a NHDES 319 Water Quality Grant that included actions such as the installation of stormwater Best Management Practices (BMPs), a wide-reaching public education program, and the development of an ISDS tracking and management program. Other town-funded actions include targeted annual water quality sampling and bacteria source tracking and the development of a pump-out ordinance for ISDS in the watershed.

To further address potential issues with ISDS in the Parsons Creek watershed, this report presents a review and analysis of alternative ISDS systems that would provide more complete treatment of bacteria. This analysis included a literature review of the limits of ISDS in conditions similar to those found in the Parsons Creek watershed, current state and local regulations for (ISDS), and the best available ISDS technology to treat bacteria.

The Parsons Creek Watershed

Parsons Creek is located in Rye, New Hampshire in Rockingham County. Its watershed is 2.28 square miles and drains to the Atlantic Ocean just east of Ocean Boulevard near Concord Point (Figure 1). Parsons Creek consists of two main branches that converge just west of Ocean Boulevard. The west branch flows from Wallis Road due east through Massacre Marsh to the outlet. The north branch begins east of Brackett Road above Marsh Road Pond and flows south through Wallis Marsh before crossing Wallis Road and meeting the west branch (NHDES, 2011).

The mouth of the Parsons Creek River in Rye, NH

Land use in the Parsons Creek watershed is predominantly woods and wetlands (49% and 22% respectively). Tidal wetlands dominate the coastal areas and account for 9% of the total 22% of wetlands in the watershed. The remaining 29% of watershed area is comprised of other land-cover types, such as developed area, disturbed area, and hay/pasture (NHDES, 2011).

Soils in the watershed are predominately classified as well drained to excessively–drained soils (Table 1, Figure 2). These soils include fine sandy loam and muck. In the wetlands, soils are predominately a poorly drained salt-grass habitat rich in organic matter and salt. Closer to the mouth of Parsons Creek and the coast, soils are predominately rapidly draining sandy loam.

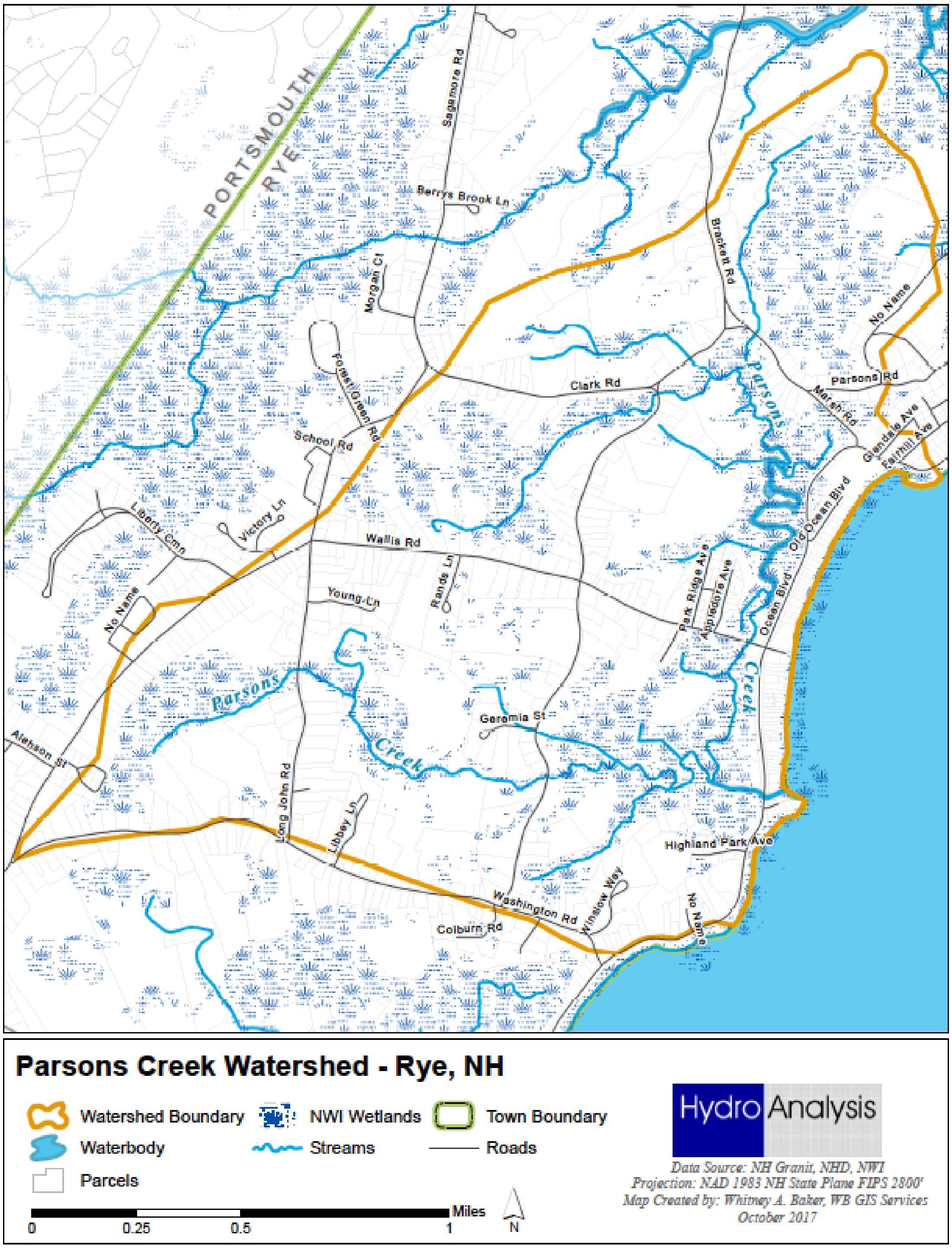

Figure 1 – The Parsons Creek Watershed in Rye, NH

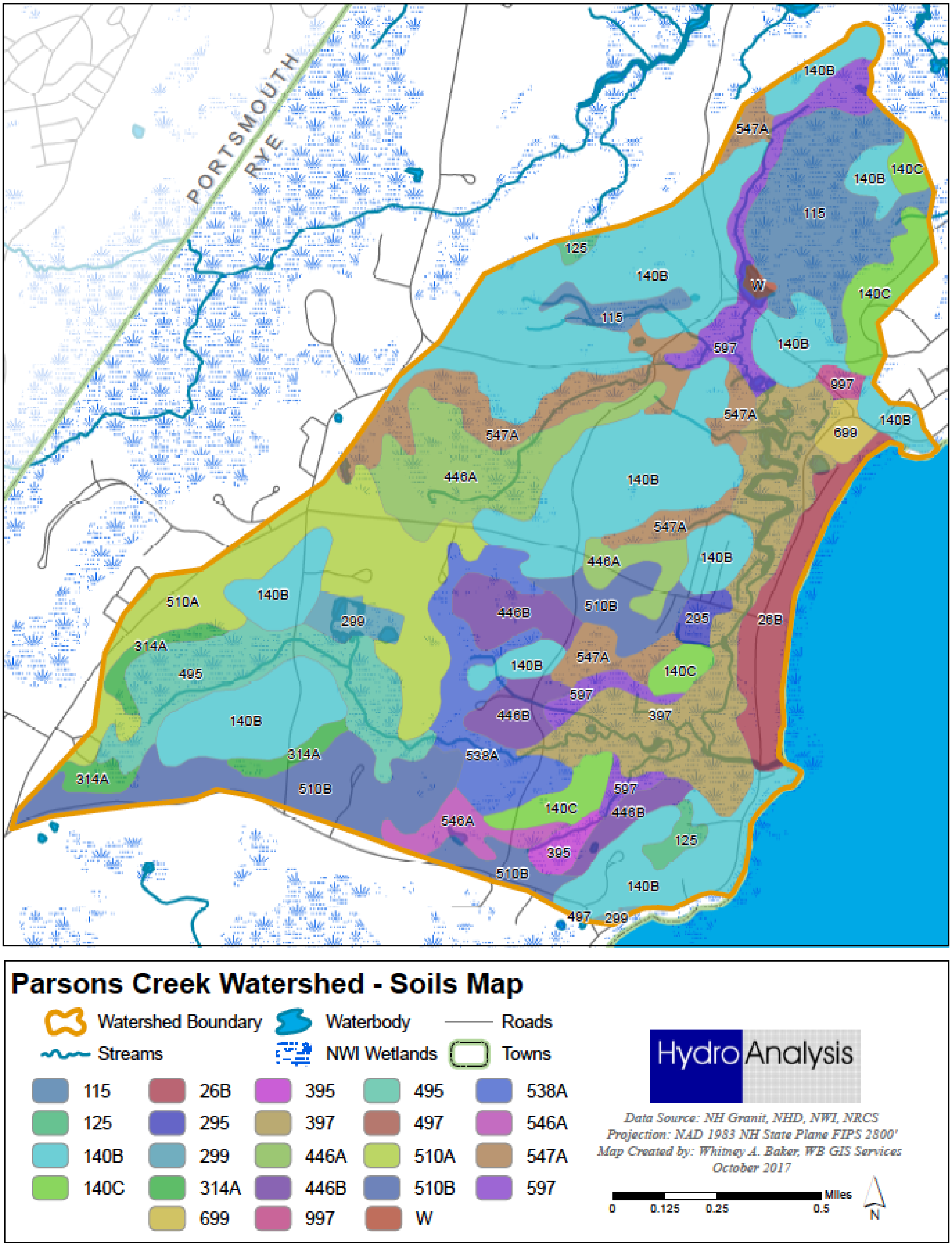

Figure 2 – Soils in the Parsons Creek Watershed, Rye, NH
(See Table 1 for key to soil types)

Table 1 – Soils in the Parsons Creek Watershed, Rye, NH (SCS, 1994)

Map Unit Symbol	Map Unit Name	Square Miles	Percent of Watershed	Depth (feet) to SHWT[1]	Rating for EDA[2]
140B	Chatfield-Hollis-Canton complex, 0 to 8 percent slopes, rocky	0.67	29.3%	> 6	Severe (depth to rock)
510A	Hoosic gravelly fine sandy loam, 0 to 3 percent slopes	0.18	8.0%	> 6	Severe (poor filter)
397	Ipswich mucky peat, 0 to 2 percent slopes, very frequently flooded	0.18	7.9%	-1 to 0	Severe (flooding, ponding)
510B	Hoosic gravelly fine sandy loam, 3 to 8 percent slopes	0.17	7.6%	> 6	Severe (poor filter)
115	Scarboro muck, coastal lowland, 0 to 3 percent slopes	0.14	6.4%	-1 to 1	Severe (ponding, poor filter)
547A	Walpole very fine sandy loam, 0 to 3 percent slopes, very stony	0.14	6.1%	0 to 1	Severe (wetness, poor filter)
446A	Scituate-Newfields complex, 0 to 3 percent slopes	0.13	5.7%	1.5 to 4	Severe (wetness)
495	Natchaug mucky peat, 0 to 2 percent slopes	0.11	4.9%	-1 to 0.5	Severe (ponding, percs slowly)
140C	Chatfield-Hollis-Canton complex, 8 to 15 percent slopes, rocky	0.09	3.8%	> 6	Severe (depth to rock)
446B	Scituate-Newfields complex, 3 to 8 percent slopes	0.08	3.6%	1.5 to 4	Severe (wetness, percs slowly)
538A	Squamscott fine sandy loam, 0 to 5 percent slopes	0.08	3.6%	0 to 1	Severe (wetness, percs slowly)
597	Westbrook mucky peat, 0 to 2 percent slopes, very frequently flooded	0.08	3.5%	-1 to 0	Severe (flooding, ponding)
26B	Windsor loamy sand, 3 to 8 percent slopes	0.07	3.0%	> 6	Severe (poor filter)
314A	Pipestone sand, 0 to 5 percent slopes	0.04	1.7%	0.5 to 1.5	Severe (wetness, poor filter)
546A	Walpole very fine sandy loam, 0 to 5 percent slopes	0.03	1.2%	0 to 1	Severe (wetness, poor filter)
299	Udorthents, smoothed	0.02	0.9%	–	–
125	Scarboro muck, very stony	0.02	0.7%	-1 to 1	Severe (ponding, poor filter)
395	Swansea mucky peat, 0 to 2 percent slopes	0.01	0.6%	-1 to 0.5	Severe (ponding, poor filter)
699	Urban land	0.01	0.6%	–	–
295	Freetown mucky peat, 0 to 2 percent slopes	0.01	0.5%	-1 to 0.5	Severe (subsides, ponding)
997	Ipswich mucky peat, low salt	0.01	0.3%	-1 to 0	Severe (ponding, flooding)
W	Water	0.00	0.2%	–	–
497	Pawcatuck mucky peat, 0 to 2 percent slopes, very frequently flooded	0.00	0.0%	-1 to 0	Severe (flooding, ponding)
	Total	**2.28**	**100%**		

[1] Based on SCS (1994, Table 16). Negative values indicate water above the land surface.

[2] Based on SCS (1994, Table 11). Entries indicate "restrictive soil features" given by SCS as well overall rating of restriction.

Applicable ISDS Regulations

The construction and operation of ISDS are primarily governed by a comprehensive set of state regulations. As well, local municipalities are free to enforce local by-laws with stricter, but never more lenient, requirements.

Current State Regulations

Currently, ISDS are regulated by the State of New Hampshire under Chapter Env-Wq 1000 Subdivision; Individual Sewage Disposal Systems in the New Hampshire Code of Administrative Rules (New Hampshire Code of Administrative Rules, 2017) and promulgated under the authority of Statute Title 50, Water Management and Protection, Chapter 485A, Water Pollution and Waste Disposal (NH State Statute, 2017).

These regulations outline all aspects of ISDS installation and maintenance. For the purposes of this analysis, state regulations regarding setbacks, receiving layer, failure, and distance above the seasonal high water table (SHWT) were reviewed in detail.

Setbacks

Chapter Env-Wq 1008 addresses setbacks for septic tanks and Effluent Disposal Areas (EDAs). These regulations require a setback of 75 feet from all surface waters (for both tank and EDA) and a setback of 50 to 75 feet from all wetlands depending on the type of wetland soils.

Effluent Disposal Area

Chapter Env-Wq 1014 addresses the requirements for the EDA including the requirements for the receiving soil layer. Chapter 1014.07 requires at least two feet of permeable soil above any impermeable sub-soil and four feet of soil above bedrock. The regulations do not specify the nature of the "permeable" soil although "impermeable" soil is defined as having a percolation rate of greater than 60 minutes per inch. Chapter 1014.08 addresses the distance above the seasonal high water table (SHWT) which is defined under Env-Wq 1002.61 as the level at which the uppermost soil horizon contains 2% or more distinct or prominent redoximorphic features that increase in percentage with increasing depth. The state requires the bottom of the EDA to be at least four feet above the SHWT and in no case less than two feet above the SHWT if a conventional ISDS is used.

ISDS Maintenance and Failure

NH State Statute RSA-A:37 Maintenance and Operation of Subsurface Septic Systems requires that all subsurface septic systems must be operated and maintained to prevent a nuisance or potential health hazard due to a failing system. Further, the state and its agents may enter properties for the purpose of inspecting and evaluating the maintenance and operating conditions of all ISDS, and where appropriate, issue compliance orders.

Chapter Env-Wq 1004.20: Replacement of Systems in Failure cites NH State Statute RSA 485-A:2,IV. Failure is defined as "the condition produced when a subsurface sewage or waste disposal system does not properly contain or treat sewage or causes the discharge of sewage on the ground surface or directly into surface waters, or the effluent disposal area is located in the seasonal high groundwater table" (NH State Statute, 2017). If a system is identified as failing, the use of the current ISDS and EDA must be stopped, and efforts to pump out and install a replacement system must be made.

Current Town Regulations

ISDS are regulated by the Town of Rye under the Section 7.9 of the Building Code most recently revised in March 2017. Many town regulations regarding ISDS follow the state regulations. However, in an effort to protect water quality, some town regulations impose stricter requirements on some aspects of the ISDS than the state regulations. For instance, the town requires the bottom of the EDA to be a minimum of six feet above an impermeable layer and a minimum of four feet about the SHWT.

Currently, ISDS are prohibited in areas with the following conditions (Section 7.9.4):

- All lands within 100 feet of protected wetlands (as indicated in Section 301.7 of the Zoning Ordinance)
- Soils with a SHWT at or within 24 inches of the surface.
- Soils with bedrock or impervious substratum within 36 inches of the surface.
- Any land having a natural slope of 15% or greater.
- Soils with a percolation rate greater than 60 minutes per inch.

ISDS can be installed in areas meeting these prohibited conditions with a town-approved waiver.

Conventional Stone and Pipe ISDS

The most common type of ISDS is the conventional stone and pipe system, which includes a septic tank and effluent disposal area (EDA). As discussed in this section of the report, systems of this design are generally reliable and effective, but fail to give adequate treatment under certain adverse conditions. Such underperforming systems are believed to be largely responsible for the bacterial contamination problems documented in Parsons Creek.

Description of Conventional Stone and Pipe ISDS

When properly designed, sited, constructed, and maintained, a conventional stone and pipe ISDS (conventional ISDS) effectively reduces and often eliminates most human health and environmental threats by pollutants in wastewater. The conventional ISDS consists of a septic tank and an effluent disposal area (EDA) (Figure 3). The septic tank provides primary treatment of the wastewater, removing most of the solids as well as greases, oils, and other floatable matter. Soil bacteria flourish in the nutrient-rich effluent and grow to form a so-called biomat at the interface between the EDA and underlying soil. The biomat provides physical, chemical, and biological treatment of the effluent as it migrates toward the ground water. The unsaturated or vadose zone is located in the soil below the initial zone of infiltration at the EDA. Effluent flow occurs over the surfaces of soil particles and through finer pores of the soil while larger pores usually remain air-filled. This unsaturated soil allows air to diffuse into the open soil pores to supply oxygen to the microbes that grow on the surface of the soil particles allowing for further treatment of the wastewater.

Untreated wastewater has fecal coliform bacteria concentrations ranging from 10^6 to 10^8 CFU/100mL (US EPA, 2002). A properly functioning conventional ISDS relies on the physical, biological, and chemical processes in both the septic tank itself and in the vadose zone below the EDA. In a properly installed and maintained septic tank and EDA, bacteria has been shown to be reduced by 99 to 99.99% within two to three feet of the EDA (Pfluger et al., 2009; Mallin, 2004; US EPA, 2002).

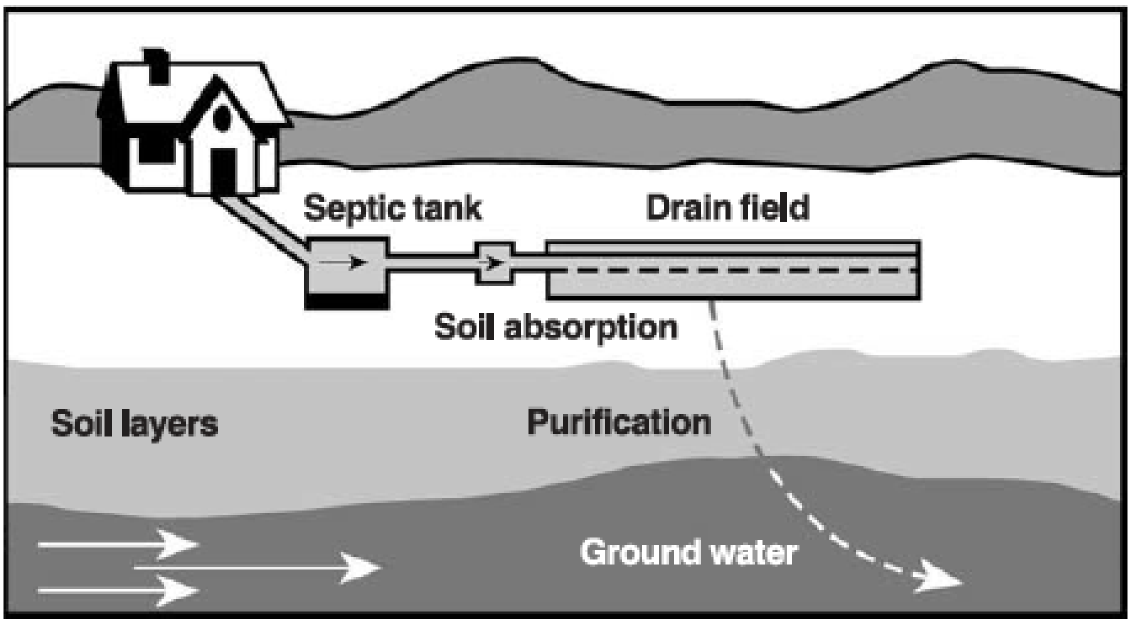

Figure 3 – Typical conventional stone and pipe ISDS (US EPA, 2002)

Limitations of Conventional ISDS

Multiple literature sources were reviewed to establish a set of hydrological and geographical requirements for optimal treatment of sewage by conventional ISDS. In general, commonly identified impediments to full treatment by ISDS included the following:

1. Depth to water table/impermeable layer
2. Soil percolation rates
3. Proximity to surface waters and wetlands
4. Number of ISDS in the watershed

Depth to Water Table/Impermeable Layer

Multiple literature sources show a clear link between the vertical separation of the ISDS from the water table or impermeable layer and bacteria removal (Humphrey et al., 2011; Humphrey et al., 2015; Pfluger et al., 2009; Meeroff, 2008; Mallin et al, 2004; Van Cuyk et al., 2004; Scandura and Sobsey, 1997). This soil layer, sometimes called the aerated layer, is within the vadose zone and provides treatment of pollutants. Temporary reduction of vertical separation (seasonally, during rain storms, or during periods of high tide) appears to be sufficient to reduce treatment effectiveness of soil adsorption (Iverson et al., 2017; Meeroff et al., 2008) (Figure 4).

The US EPA recommends that the layer of aerated soil be at least two feet thick but ideally up to five feet thick (Mallin, 2004). Other recommendations from the literature for the minimum vertical separation needed for bacterial treatment vary between one and two feet provided an alternative ISDS is used to achieve more effective initial treatment than a septic tank. In the most recent of the studies reviewed, Humphrey et al. (2015) recommend 18 inches after recommending 24 inches in an earlier study (Humphrey et al., 2011).

Depth to the water table in Parsons Creek watershed is a function of the topography and the soils as well as the time of year. SCS (1994) indicates that many soil types in the watershed are characterized by seasonally very shallow water tables (1 foot or less), including all of the muck soils as well as Walpole very fine sandy loam (soil type 547A) (Table 1). These soils are all potentially problematic with respect to the depth to the water table.

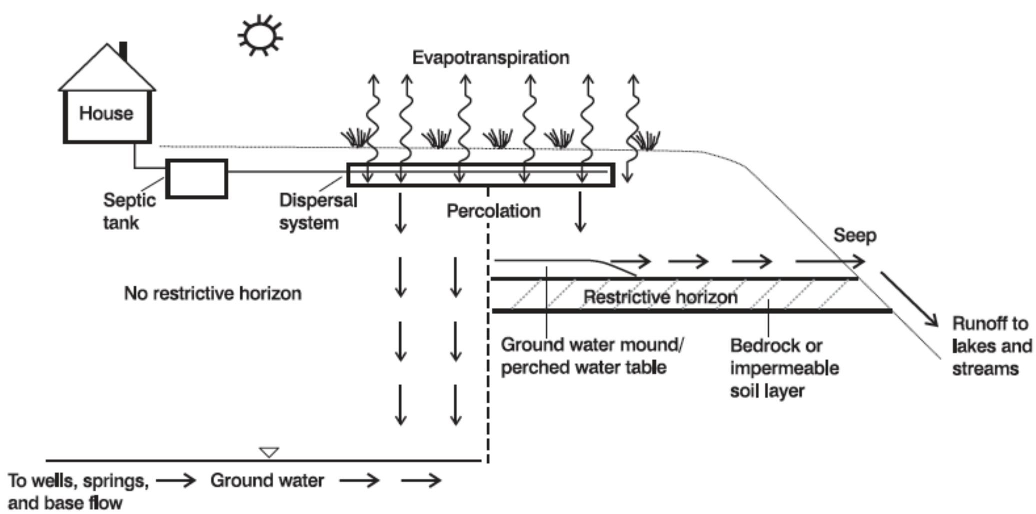

Figure 4 – Fate of water discharged to ISDS (US EPA, 2002)

Soil Percolation Rates

The soil percolation rate, or the rate at which water can be absorbed into the soil, is an indicator of how well a specific soil type will be able to treat pollutants. Coastal sands or other rapidly draining soils generally allow water to pass too rapidly to attenuate pollutants completely. At the other extreme, poorly draining soils such as clay soils result in surface ponding (Mallin, 2004). Ideal soils lie between these extremes, delaying effluent from the ISDS long enough to provide good treatment, but not so long as to not accept all of the effluent.

Soils in the Parsons Creek watershed are generally poorly suitable for on-site wastewater disposal. SCS (1994) rates essentially all of the soils in Table 1 as "severe" indicating "soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required." Only soil type 140, Chatfield-Hollis-Canton soils, is rated by SCS as potentially suitable, and then only if the depth to bedrock is sufficiently large. In the Parsons Creek watershed, very sandy coastal soils (soil types 26B, 125) and marsh soils (soil types 397, 115, 495, 597, 295, 997, and 497) are likely to be the most problematic.

A particular problem in the Parsons Creek watershed arises from systems constructed in very sandy dune soils. Traditionally, sanitary codes have been concerned only with soils that percolate too slowly. However soils that percolate too quickly, such as coarse sand and gravel, can also create water quality problems by allowing effluent to pass through the soil without enough time to achieve adequate treatment. Harrison et al. (2000) describe a region in western Washington State in which the naturally coarse soils provide inadequate treatment leading to groundwater quality degradation. New Hampshire state regulations fail to recognize this issue and nowhere preclude the use of soils that percolate too quickly. A preferable recommendation is available from the widely-used septic system design manual by the U.S. Environmental Protection Agency (Otis et al., 1980, pg. 214), which indicates that soils with percolation rates faster than one minute per inch (i.e., <1 min./in.) are unsuitable for EDAs.

Proximity to Surface Waters and Wetlands

Proximity to the shoreline increases the risk of bacterial contamination. Schneeberger et al. (2015) found *E. coli* concentrations dropped roughly an order of magnitude for every 65 feet of lateral distance from the EDA and Scandura and Sobsey (1997) found viruses dropped an order of magnitude in 100 feet. Septic tank effluent contains on the order of 10^6 coliform per 100 mL, implying a completely failed system would need to be at least 300 feet from the shoreline to prevent contamination.

Other studies have sought to characterize the size of the effluent plume below an ISDS to determine the appropriate distance between the EDA and nearby surface water and wetlands. The studies showed the average plume length was approximately 80 feet, with a range from 30 to over 300 feet (Schneeberger et al., 2015; MPCA, 1999).

Of the 843 parcels in the Parsons Creek watershed, 383 fall within 100 feet of a stream, wetland, or other waterbody. 367 parcels fall within 75 feet and 331 parcels fall within 50 feet (Figure 5). Not all of these properties would have ISDS within 50, 75, or 100 feet of a waterbody or wetland as, in some cases, only a small portion of the parcel intersects the buffer. However, the proximity to surface waters and wetlands is likely a concern for multiple properties in the watershed.

The Number of ISDS in the Watershed

Too many ISDS in an area may overwhelm the area's carrying capacity for treatment because individual septic plumes may intermingle and pollute large areas of groundwater. Yates (1985) has shown that areas with a density of more than 0.06 septic tanks per acre are potentially problematic for surface water quality. Mallin (2004) has shown that a density of more than 0.26 septic tanks per acre can lead to fecal contamination.

In the 1,459 acre (2.26 square mile) Parsons Creek watershed, the number of "built" parcels in the watershed was used as a proxy for the number of ISDS as the exact number of systems is not knows. Of the 843 parcels in the watershed, 664 are considered "built," indicating there are approximately 0.45 ISDS per acre in the watershed, which is almost twice the density shown to be problematic in other studies.

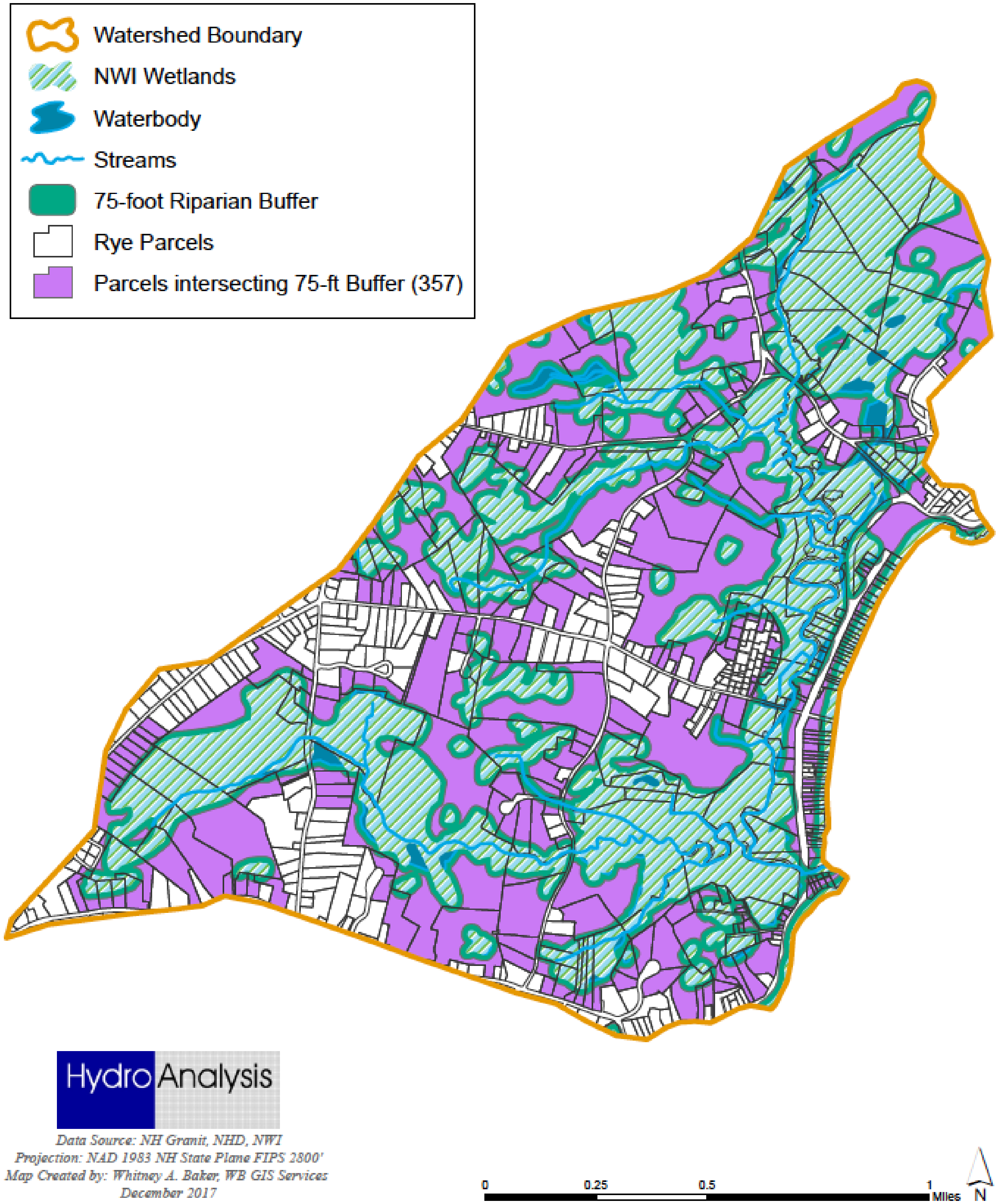

Figure 5 – Parcels in the Parsons Creek Watershed that lie within 75 feet of surface water or wetlands

Treatment Standards and Alternatives to Conventional ISDS

If properly sited, designed, installed, and maintained, conventional ISDS are effective at treating domestic wastewater. Malfunction or failure of a conventional system is likely due to improper maintenance, age of the system, or installation in geographic and hydrologic conditions that are not conducive to treatment. For these conditions, alternatives to conventional ISDS must be considered. Establishing performance standards or criteria for the treatment of bacteria by a system under different conditions will ensure that the correct type of ISDS is installed in the proper setting. Multiple alternatives to the conventional ISDS are available to treat domestic wastewater before discharge to the environment.

Performance Standards for ISDS

As described in the sections above, many sources have established a link between vertical separation of the septic system from the water table and bacterial removal (Humphrey et al., 2011; Humphrey et al., 2015; Meeroff, 2008; Van Cuyk et al., 2004; Scandura and Sobsey, 1997). In settings with a reduced vadose zone due to a high seasonal water table or shallow depth to bedrock or other impermeable soils, there is not enough soil for treatment of wastewater. The US EPA (2002) provides a management scheme that considers the setting and depth to the water table to recommend a set of treatment standards. For a setting in which primary recreation or shellfish harvesting occur and in which adverse impact is moderately or highly probable (as would be indicated, for example, by proximity to the shore or in areas adjacent to an impaired waterbody), they recommend the treatment standards listed in Table 2.

Table 2 – Recommended Vertical Separation of the ISDS from the Water Table (adapted from US EPA, 2002)

Vertical Separation of Bottom of EDA from SHWT (feet)	Treatment Performance Standard for Fecal Coliform Bacteria (CFU/100mL)
>4	10 million
3 to 4	50,000
1 to 3	10,000
<1	200

Other treatment standards for septic systems tend to specify management approaches more than specific standards—see for example US EPA (1997, 2001, 2003). NSF/ANSI Standard 40, Residential Wastewater Treatment Systems, provides standards for wastewater treatment, but does not include bacteria in the parameters specified (NSF, 2012). NSF/ANSI Standard 350-1, On-site Residential and Commercial Graywater Treatment Systems for Subsurface Discharge, specifies maximum single-sample *E. coli* concentrations of 240 and 200 MPN/100 mL for residential and commercial settings, respectively, and average concentrations of 14 and 2.2 MPN/100 mL (Bruursema, 2011). These standards apply to certification of treatment system technologies rather than monitoring of an in-place system.

Both the NSF single-sample standards and EPA performance standards are comparable in magnitude to US EPA (2012) water-quality criteria for *E. coli* in recreational waters (geometric mean of 100 or 126 CFU/100 mL depending on level of risk of illness).

Alternative ISDS Designs

As noted previously, the Parsons Creek watershed is 2.28 square miles and drains to the Atlantic Ocean. The watershed has rapidly draining soils and a large portion of the watershed is considered wetland. Parsons Creek is tidal and is considered impaired for bacteria. As such, many areas in the watershed are likely unsuitable for conventional ISDS as the depth to the SHWT or impermeable layer is not large enough to provide adequate bacteria treatment (Table 2).

Public sewers are not currently considerable a viable option for the watershed. Therefore, achieving adequate treatment of bacteria in wastewater necessarily requires alternative ISDS technologies where conventional ISDS would be inadequate. The type of alternative system to use in a given setting depends on multiple factors including soil type, depth to SHWT, depth to impermeable soil or bedrock, proximity to wetlands and surface water bodies, and desired water quality treatment standards. The following describes a number of alternative technologies.

Holding Tanks

Holding tanks are watertight tanks that store wastewater until it can be pumped and treated at another location. There is no actual treatment that occurs in the holding tank. The wastewater in the tank must be removed before the tank fills and wastewater overflows the system. Tanks are typically 1,000 gallons and fill quickly, requiring frequent pump-outs. A single pumping of a holding tank generally ranges from $200-$300. This alternative to a conventional ISDS is expensive because, depending on use, pumping may have to occur as often as every three to four days (PA DEP, 2016). This alternative is only recommended as an interim solution while a more sustainable alternative is considered and installed.

Mounded Systems

Increasing the vertical separation between the bottom of the EDA and the SHWT or impermeable soil layer, as would be achieved by constructing a mounded system, is a potentially effective remedy for septic systems achieving inadequate treatment. A study by Harrison et al. (2000) shows considerable improvement in treatment by adding a 30-centimeter-thick layer of sand beneath the leaching system. A before-and-after study by Conn et al. (2011) showed the effectiveness of reconstructing a failed system as a mounded system.

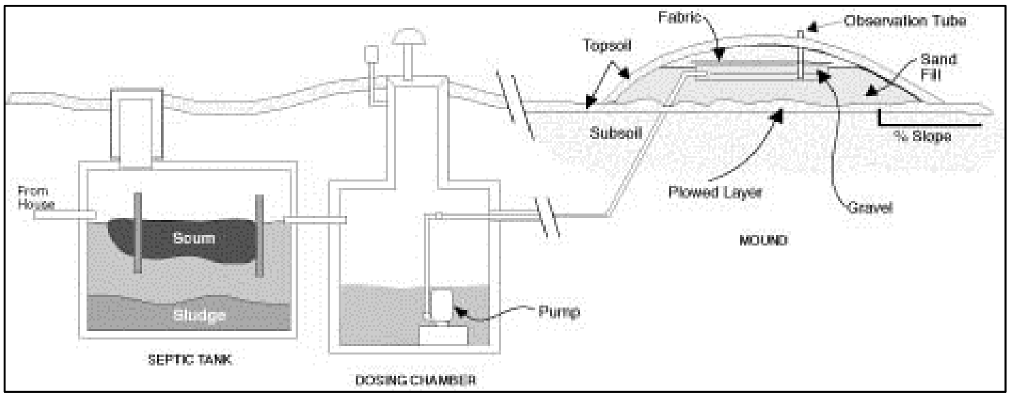

Figure 6 - Diagram of a Mounded ISDS (Building Advisor, 2017)

The installation of a mounded system is similar to that for a conventional system with the addition of a pump chamber and the soil to form the mounded treatment area (Figure 6). Soil should be carefully selected to provide adequate treatment (i.e., the soil should not be too coarse). Maintenance costs and monitoring of the system are typically higher than a conventional system. Treatment standards are the same as for a conventional system provided the additional soil increases the vertical separation to an appropriate distance.

Aerobic Treatment Units

In areas where increasing the vertical separation between the EDA and SHWT or impermeable layer is not possible or desirable, alternative treatment technologies such as Aerobic Treatment Units (ATUs) may be used to improve the quality of the effluent discharged to the EDA. Unlike conventional systems that rely solely on anaerobic processes for treatment, ATUs inject and circulate air inside the treatment tank. Bacteria that thrive in oxygen-rich environments break down and digest the wastewater inside the ATU. Generally, ATUs include a pretreatment chamber to encourage the settling of solids through anaerobic processes and an aeration treatment area to provide secondary treatment (Figure 7). As the ATUs are buried underground, electricity is required to pump oxygen into the tank. In some cases, a disinfectant such as chlorine is added before discharge (Lesiker et al., 2010; Pfluger et al., 2009; National Environmental Services Center, 2005).

ATUs included suspended-growth systems and fixed-growth systems. Suspended-growth systems keep the microorganisms and bacteria treating the wastes in suspension while the fixed-growth systems require a media, such as a synthetic fabric, to be suspended in the tank, allowing for bacteria to attach to its surfaces. These microorganisms convert the organic matter into gases and cell tissue, removing many pollutants from the influent (Lesiker et al., 2010; Pfluger et al., 2009; National Environmental Services Center, 2005; Obropta, 2005).

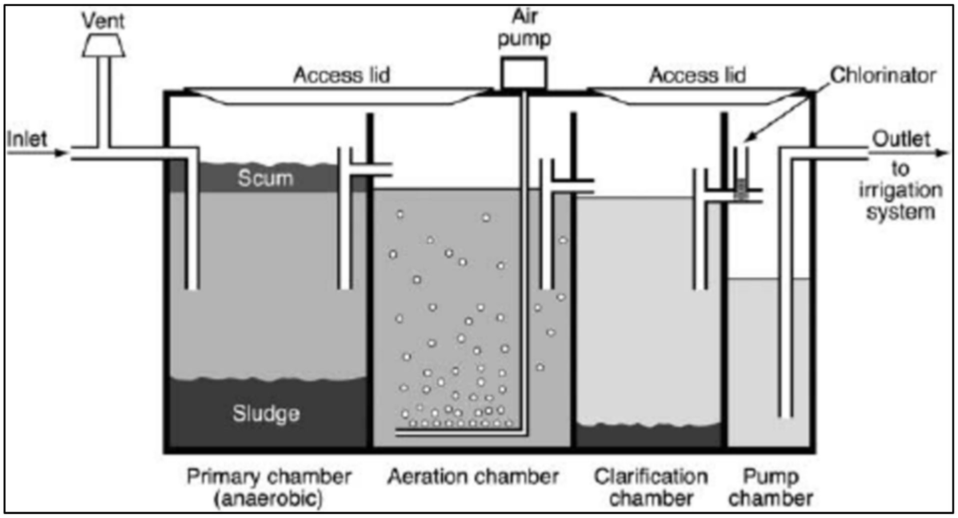

Figure 7 - Cross-section of a typical Aerobic Treatment Unit (Levett et al., 2010)

ATUs are often used in areas where there is not enough room for an appropriately sized EDA, and in some cases, effluent is discharged without one or with a smaller EDA. ATUs have been shown to reduce bacteria in the effluent by up to 98%, resulting in tank effluent with bacteria ranging from 10,000 to 20,000 CFU/100mL (Pfluger et al., 2009; National Environmental Services Center, 2005; Potts et al., 2004).

Recirculating Media Filters

Recirculating media filters can be used in areas where secondary treatment is required or there is not adequate space for a properly sized EDA. Recirculating media filters range in scope from a multi-unit system with pretreatment in a settling basin and secondary treatment in a sand or other media filter to a single unit (Figure 8). Wastewater is generally circulated through the filters five times to ensure maximum treatment. As these systems use a pump, electricity is required. These types of ISDS have been shown to reduce bacteria in the effluent by up to 98%, resulting in tank effluent with bacteria ranging from 10,000 to 20,000 CFU/100mL (Gustafson et al., 2000).

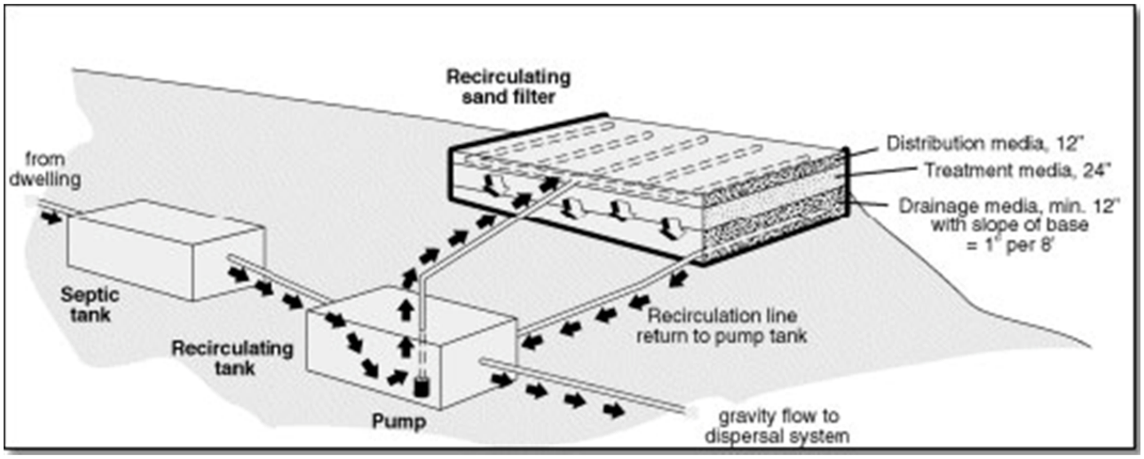

Figure 8 – Example of a Recirculating Media Filter (Gustafson et al., 2000)

Constructed Wetlands

A constructed wetland is an alternative treatment system that recreates the treatment processes of a natural wetland. The constructed wetland contains microorganisms, media, and plants that provide the treatment of incoming effluent (Figure 9). Most constructed wetlands are used in tandem with a septic tank for pretreatment. Effluent from the constructed wetland has been shown to be similar to that of an ATU (Pfluger et al., 2009).

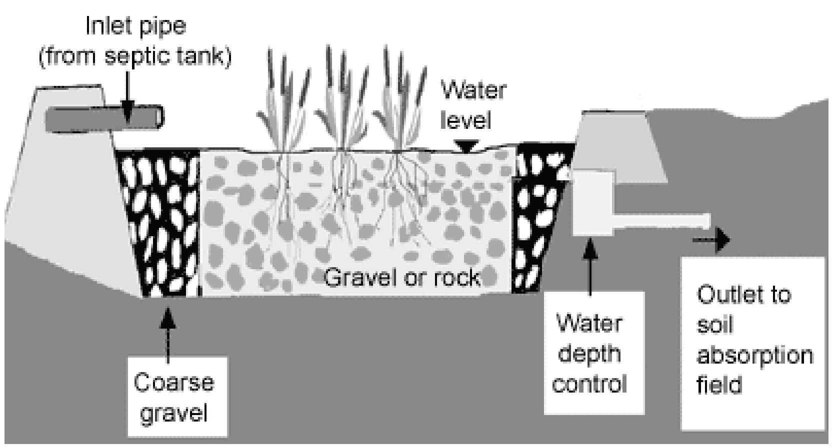

Figure 9 - Example of a Constructed Wetland (Pfluger et al., 2009)

Trickling Filters

A trickling filter is a type of wastewater treatment system that allows influent to flow downward over fixed media. This downward movement encourages a layer of biofilm to grow on the media and aerobic conditions encourage degradation of the wastewater to occur before dispersal. Often a trickling filter is followed by a clarifier or a sedimentation tank for the separation of sludge (Figure 10). As an example, trickling filters have been used in clustered wastewater systems in Piperton, Tennessee and have produced effluent with very low fecal coliform counts (<100 CFU/100mL) when paired with UV disinfection (WERF, 2016).

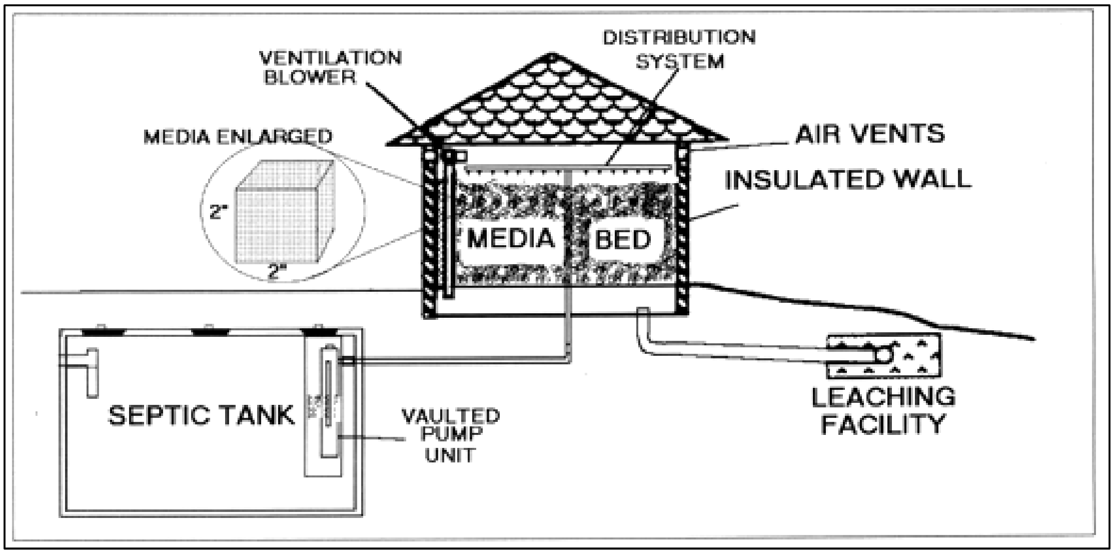

Figure 10 – Example of a Trickling Filter (WERF, 2016)

Disinfection Systems

Many alternative ISDS use a disinfection unit as part of their treatment systems. The main disinfecting agents used are chlorine and ultraviolet (UV) light. Chlorination is the most common form of disinfection. Chlorine is added to the wastewater in tablet or liquid form to reduce the number of pathogens immediately before the effluent is discharged. UV light disinfection uses a lamp that bathes wastewater in ultraviolet light as the wastewater passes through a chamber. The UV light alters the genetic material of the microorganisms in the effluent. Both types of disinfection are effective when used under the appropriate conditions. Use of disinfection with a conventional ISDS is not effective as the solids level of the effluent is too high to render these types of disinfection effective. However, when paired with alternative ISDS, bacteria can be reduced by close to 100% (Lesiker et al, 2010).

Membrane Bioreactors

Membrane bioreactors (MBRs) can be broadly defined as systems that integrate the biological degradation of waste with membrane filtration. MBRs have been typically used on larger scale properties to treat wastewater from municipal or commercial sources. However, smaller scale versions of this technology have been developed over the past few years. The system first pretreats the wastewater by dissolving the coarse degradable material and separating all non-degradable material. The separated wastewater is then pumped to an aeration section where it is passed through microfiltration membranes with a 0.3-0.13-µm pore size (Figure 10). The membrane filters eliminate suspended material and bacteria and produce relatively clear water that can be discharged directly to the surrounding environment. Some of these systems can be installed in the basement of a house and do not require any type of specialized EDA as the water that is released is considered safe for release into the environment. Many of these systems are now certified by the NSF/ANSI Standard 350 and have been shown to produce effluent with fecal coliform concentrations below 200 CFU/100mL (Liu et al., 2005; Cicek, 2003).

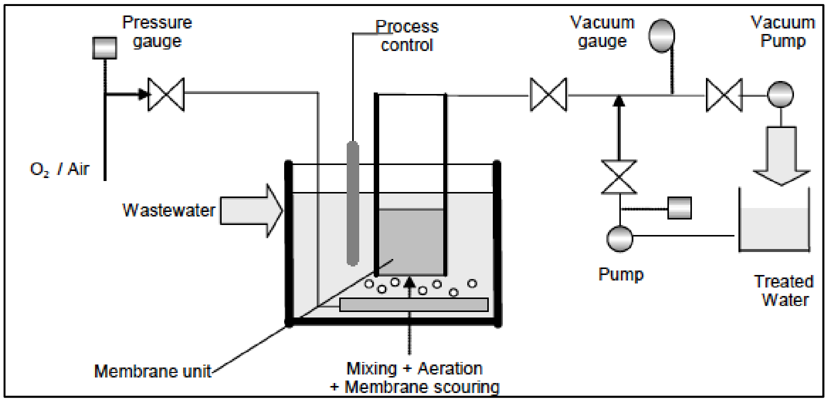

Figure 11 – Schematic of a Membrane Bioreactor (Cicek, 2003)

Cost Comparison for ISDS

Capital costs for treating domestic wastewater onsite include the cost of materials, design, and installation. Operation and maintenance costs include electricity for systems with a pump or aeration system, pumping, and maintenance. Actual installation costs for ISDS were estimated based on a review of the literature and specific product websites (Table 3). All installation costs are expected to vary based on site as designs must adhere to each specific property and its restrictions.

Table 3 – Cost Estimates for ISDS

Type of ISDS	Capital Cost Range	Other Cost Considerations
Conventional ISDS [1,2,3,4,5]	$3,000-$8,000	Pumping, inspection
Holding Tank [1,2,3,4,5]	$2,000-$3,000	Pumping, inspection
Mounded EDA with Tank [1,2,3,4,5]	$10,000-$20,000	Electricity, pumping, inspection
Aerobic Treatment Unit [1,2,3,4,5]	$10,000-$20,000	Electricity, pumping, inspection
Constructed Wetlands [1,2,3,4,5]	$10,000-$20,000	Electricity, pumping, inspection, plant maintenance
Recirculating Media Filter [1,2,3,4,5]	$10,000-$15,000	Electricity, pumping, inspection
UV Disinfection [4]	$1,000	Add-on to other system
Trickling Filter [1,2,3,4,5]	$10,000-$15,000	Electricity, pumping, inspection
Membrane Bioreactors [4,5,6]	$10,000-$25,000	Electricity, pumping, inspection
1 – Gustafson et al., 2000; 2 – Wardell, 2005; 3 – Obropta, 2005; 4 – Pfluger et al., 2009; 5 – Product websites; 6 – Fletcher et al., 2007.		

Case Study – Old Saybrook, Connecticut

Other coastal communities have faced problems similar to those at Parsons Creek. The literature provides useful case studies though many of these result in the installation of a sewer system or cluster system for problem neighborhoods. The following describes one particularly pertinent case study, Old Saybrook, Connecticut.

Old Saybrook, Connecticut is located on Long Island Sound and has many densely developed neighborhoods, many of which were built as vacation homes along the coast. These homes were often built with inadequate onsite wastewater disposal due to small lot size, shallow depth to the SHWT, and close distance to the shore. Though for this type of situation, centralized sewers are recommended as the best waste management option, the town did not want to consider sewers and opted to investigate other avenues of domestic wastewater management (Old Saybrook WPCA, 2017; Grose et al., 2010).

Through their Water Pollution Control Authority (WPCA), established by a town ordinance in 1980 to "create a sewer avoidance program and seek compliance with the Connecticut Department of Environmental Protection," the town developed a Decentralized Wastewater

Management Program (DWMP) with a focus on upgrading existing ISDS within identified focus areas. The DWMP also identified properties that required alternative ISDS with the focus of reducing nitrogen loading to the groundwater and Long Island Sound. The DWMP involved a series of workshops with the WPCA, Connecticut Department of Energy & Environmental Protection, the local Department of Health, and other partners to determine a set of parameters to be considered in the upgrade of existing ISDS. The upgrade process was regulated by the Town's Decentralized Wastewater Management District Ordinance and included the following requirements:

- Properties were required to have a minimum two-foot separation from the bottom of the EDA and the SHWT.
- Properties adjacent to LIS or other open water bodies were required have an advanced treatment system installed.
- All onsite systems, whether conventional or advanced treatment, required permits, which were issued for five-year terms. Service contracts were required for all advanced systems.

The pollutant of concern for Long Island Sound is nitrogen and thus advanced systems were defined as systems that reduce nitrogen by at least 50 percent. Connecticut does not have an established list of accepted advanced treatment systems, and thus the program selected specific manufacturers and models of treatment systems to meet the advanced treatment system requirements through bids from manufacturers of nitrogen removal treatment systems.

The DWMP included an investigation of all properties in each focus area and an assignment of the type of upgrade required for each property. The investigation allowed the WPCA to collect information on current ISDS including digging test pits and conducting soil testing to determine the function and age of existing ISDS. If it was deemed necessary to upgrade the current ISDS due to issues such as inadequate depth to the SHWT or proximity to a water body, the WPCA hired contractors through the Clean Water Fund grant and loan program (25% from the CWF, 25% from the Town, and 50% from the homeowner as a 20-year loan at 2%) to design and install appropriate systems.

Beyond the efforts of the DWMP to upgrade ISDS, the program also established a 10-year groundwater monitoring project to assess the level of nitrogen pollution and identify areas of concern. The program also established a town-wide public education program. As of 2016, the program had installed over 500 new ISDS and has identified over 800 systems as compliant (Old Saybrook WPCA, 2017; Grose et al., 2010).

Recommendations

As noted above, many areas in the Parsons Creek watershed are unsuitable for conventional individual sewage disposal systems (ISDS) as the depth to the seasonal high water table (SHWT) or impermeable layer is not large enough to provide adequate bacteria treatment (Table 2), the systems are too close to surface water bodies, or the soils are deficient in some way. RSA 485-A:2,IV accounts for the separation between the effluent disposal area (EDA) and the SHWT in its definition of a failing ISDS, indicating that currently multiple ISDS in the Parsons Creek watershed may be failing.

This review of the domestic wastewater treatment literature and available alternative treatment technologies, as well as meetings with the Town Planner and Building Inspector, changes to the current building code for the Town of Rye are recommended. These changes are intended to apply to only those properties located in the Parsons Creek Watershed Overlay District.

Recommended Changes to the Building Code

Effluent Disposal Systems for Homes in the Parsons Creek Watershed Overlay District

All requirements of the current Building Code Section 7.9: Effluent apply. If a property fails any of the conditions listed in the current building code, an alternative ISDS must be installed. Failing conditions include:

- All lands within 100 feet of protected wetlands (as indicated in Section 301.7 of the Zoning Ordinance), or 75 feet of other wetlands and surface water bodies.

- Soils with a percolation rate greater than 60 minutes per inch.

Additional requirements are necessary for properties in the following areas:

- Vertical separation of the effluent disposal area (EDA)
    - Soils with a seasonal high water table (SHWT) of less than **four feet** from the bottom of the existing or proposed EDA. The SHWT must be determined under high tide conditions.
    - Soils with an impermeable layer (bedrock or ledge) less than **four feet** from the bottom of the existing or proposed EDA.
    - Soils with a percolation rate less than 1 minute per inch.

  - If a property meets the conditions noted above, the installation of an alternative ISDS must be installed.

- Alternative ISDS Requirements

  - The type of alternative ISDS will depend on the depth of the vertical separation from the bottom of the EDA and the SHWT (during high tide) and the impermeable layer (bedrock or ledge).
  - The type of ISDS must meet the treatment performance requirements as indicated in Table 4.
    - The technologies listed in Table 4 are examples of those that potentially meet the recommended treatment standards.
    - Note the vertical separation ranges in Table 4 differ slightly from those listed in Table 2. Vertical separation distances were modified in Table 4 to conform better with the treatment levels achieved by the various technologies.
  - All designs and specifications for alternative systems must be submitted to the Building Inspector.

- Conditions must be verified by the Building Inspector before installation of any ISDS, upon signs of ISDS failure, and upon transfer of property.

- Maintenance of alternative ISDS must adhere to the manufacturers' recommendations. These recommendations must be submitted to the Building Inspector with the ISDS design. Verification of maintenance must be submitted to the Building Inspector annually.

Table 4 – Recommended Performance Requirements and ISDS Alternatives based on Vertical Separation

Vertical Separation of EDA from SHWT and Impermeable Layer (feet)	Treatment Performance Standard for Fecal Coliform Bacteria (CFU/100mL)	Examples of ISDS meeting Treatment Standards
4	10 million	Conventional ISDS
3 to 4	50,000	Mounded System (to raise separation to >4 feet)
2 to 3	10,000 – 20,000	Mounded System (to raise separation to >4 feet) Aerobic Treatment Unit Recirculating Sand Filter Constructed Wetland Trickling Filter
1-2	200	Membrane Bioreactor Alternative ISDS with Disinfection
< 1	--	ISDS are prohibited

Other Recommended Actions for the Town of Rye

The Town of Rye has been working for several years to address bacteria pollution in Parsons Creek. As a coastal community reliant on ISDS, this issue is complex as it intersects private property, environmental pollution, and public health rights. In the case of Old Saybrook described above, Connecticut General Statutes allow for the line between public and private rights to be blurred:

- Sec.22a-427. No person or municipality shall cause pollution of any of the waters of the state.
- Sec. 22a-428. If the commissioner finds a municipality is causing pollution of the waters of the state or that a community pollution problem exists, or that pollution by a municipality can reasonably be anticipated in the future, he may issue to the municipality an order to abate pollution. A community pollution problem is defined as the existence of pollution which, in the sole discretion of the commissioner, can best be abated by the action of a municipality.

For the Parsons Creek watershed, conventional ISDS are likely not providing enough treatment for bacteria in many areas. It is currently difficult to assess the performance of individual systems, as provisions are not in place to ensure homeowners are accountable for the proper maintenance of their current system or that existing systems have been installed in a manner to ensure adequate treatment. Changes to the building code as described above are an important step in trying to mitigate bacteria from ISDS. Other actions that could assist with this goal include the following:

- Develop a groundwater-monitoring program to determine the range in depth to the SHWT and groundwater quality.
- Form a Water Pollution Control Agency at the town level. This agency would be responsible for managing all aspects of an ISDS program including the existing pump-out ordinance.
- Build upon the existing Septic System Database to document the location and type of all ISDS in the watershed. The database can be used to track maintenance and pumping of systems.
- Develop a comprehensive Onsite Wastewater Management Program with partners from the town, state, and Department of Public Health to work with local property owners to ensure all ISDS in the watershed are working. This program would build upon work already completed in the watershed as well as develop a system for inspection and replacement based on similar programs in other communities.
- Expand the public outreach program developed through the NHDES 319 grant program to include information presented in this report. Homeowners should be presented with this information when deciding how to proceed with a replacement system.

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