A brief description of Sherborn's residents, land, water and regulations.
How did we get here and what does it mean?

1. A history of settlement, water and wastewater treatment in Sherborn & surrounding communities.

This year (2024) marks the 350th anniversary of Sherborn's incorporation as a unified town. Settled more than 100 years before the Revolutionary War, the poor, rocky soils and lack of significant waterways limited land use, with the town's major industries centered around apple orchards (which grow well in rocky soils) and cattle grazing. The paucity of tillable land also kept the population of Sherborn relatively low compared to nearby communities blessed with better soils for farming.

The first US Census (1790) reported Sherborn's population as 801 total persons[1]. Typical for the time, drinking water came from on-site wells and sewage was most commonly disposed of in cesspits[2] (early predecessors of the modern septic systems found throughout town today, although 54 cesspits are still active in Sherborn). Sherborn's population grew to 1,043 by 1850, and 1,558 by 1920[3]. A period of declining population due to the human toll of WWI and WWII was followed by rapid growth in the 1960s and 1970s. By 1980, the population of Sherborn leveled off near its approximate current population of 4,400.

Compared to the surrounding communities, Sherborn remains the least densely populated, with an average of one person per every 2.3 acres across its 16.2 square miles. Given the town's proximity to Boston, one can only imagine this low population density is not due to a lack of interest by developers, but one or more limiting characteristics. For Sherborn, poor soils for siting septic systems paired with a lack of town water and sewer infrastructure make development - particularly dense development - difficult if not impossible for currently undeveloped land. A brief history of development of the MetroWest region and its varying impacts on population growth between communities (Fig. 1) is helpful to put Sherborn's current population density and development trends in context.

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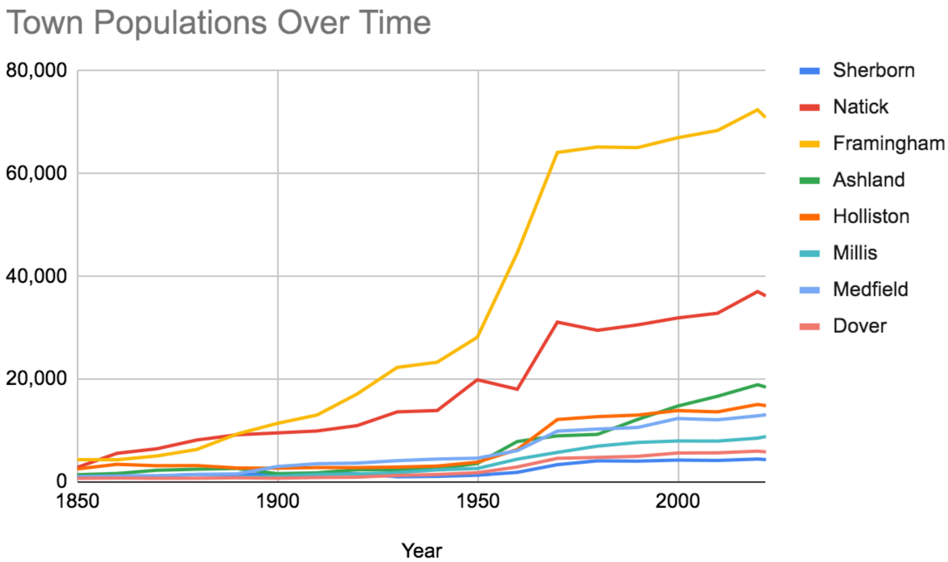
[1] p. 25 https://www2.census.gov/library/publications/decennial/1790/number-of-persons.pdf
[2] https://www.sciencemuseum.org.uk/objects-and-stories/everyday-wonders/flushed-away-sewers-through-history
[3] https://en.wikipedia.org/wiki/Sherborn,_Massachusetts

Figure 1: Sherborn and surrounding town populations over time based on the US Census.



Much like Sherborn, the towns of Framingham and Natick were sparsely populated in 1850, being largely farming communities dependent on on-site water resources (wells, streams, ponds) and cesspits or open water for disposal of waste. But 1848 saw the completion of an aqueduct connecting Framingham's plentiful water resources (particularly Lake Cochituate) with Boston to meet the needs of ***Boston's*** growing water demand[4], and ultimately leading to further development of Framingham and its neighbor to the east, Natick. Reflecting the particular importance of Framingham's water resources in supporting Boston's growing needs, opening day of the aqueduct (Oct. 25, 1848[5]) included a performance of the "Cochituate Grand Quick Step[6]" on Boston Common. However, the aqueduct came at a high cost for 71 Framingham families, many of whom were farmers, as 1,050 acres (1.5 sq. mi.) of land was effectively seized and repurposed for reservoirs & aqueduct. Individual families lost as many as 60 acres to the creation and expansion of the system, and litigation of land seizures went on for years. However, the aqueduct system also provided for new industries along its path as well as support for denser development.

[4] https://www.youtube.com/watch?v=d9JiIDYojXQ (used for many historical references here and to follow)
[5] https://newenglandhistoricalsociety.com/flashback-photo-boston-holds-a-water-celebration-in-1848/?noamp=mobile
[6] https://levysheetmusic.mse.jhu.edu/collection/163/001

An unintended consequence of plentiful water flowing east to Boston, coupled with an initial lack of sewage treatment along the aqueduct system, was rapid contamination of Boston Bay and several serious epidemics within the city (including 1849[7] and 1850[8]). Construction of sewers soon followed, again following the path of communities through which the aqueduct system flowed. Ironically, Framingham's initial development of a sewer system was brought about due to litigation from Boston, who wanted to stop the dumping of raw sewage into Lake Cochituate, which impacted the quality of water reaching Bostonians.

The 175 years since the grand opening of the aqueduct and subsequent sewer networks resulted in what is now known as the Metrowest Water Resources Authority,[9] which continues to serve the Boston metropolitan area and those communities along the path of water flow (Fig. 2). It cannot be over-emphasized that development of the water and sewer infrastructure now known as MWRA was initially and primarily created to serve Boston's water/sewer needs and not as a result of local demand. Framingham and Natick had, and still have, plentiful water resources for their own populations. But Boston's investments in the development of water and sewer infrastructure to its west, reaching farther out to tap into greater expanses of source waters, ultimately allowed for denser development within Framingham, Natick, and later Ashland.[10]

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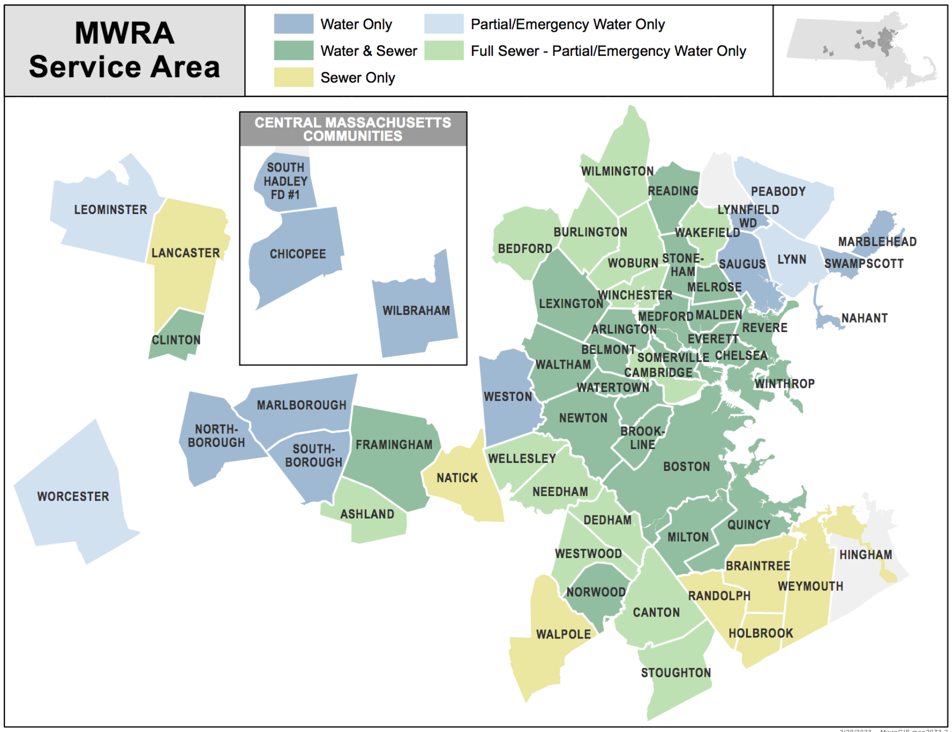
[7] https://globalboston.bc.edu/index.php/cholera-report/

[8] https://books.google.com/books?id=qbzSETdn9AsC&newbks=1&newbks_redir=0&printsec=frontcover&dq=inauthor:%22BOSTON,+Massachusetts.+City+Council.+Committee+on+the+Petition+of+David+Sears+and+others%22&hl=en#v=onepage&q&f=false

[9] https://www.mwra.com/

[10] It should be noted that the scale of the MWRA is difficult to fathom, with 2.5 million residential customers and 5,500 industries supported by a daily use of 200+/- million gallons of water per day. This equates to roughly 80 gpd of water use per person. Although certainly not all, much of this water comes from Framingham, which has sufficient surface waters and the largest aquifer in the state beneath it. Sherborn, however, does not have the same access to plentiful waters. See https://www.mwra.com/04water/html/wsupdate.htm, https://www.mwra.com/04water/html/wat.htm and https://www.youtube.com/watch?v=vmqBKxWp3-k 13:10 min.

Figure 2: Map of the Metrowest Water Resources Authority service area, which includes Sherborn's direct neighbors of Framingham, Natick and Ashland.



Being a distance from the aqueducts and sewers linked to Boston, and lacking the state support needed to fund a connection to it, Sherborn and other surrounding communities (Holliston, Millis, Medfield and Dover) remained dependent on local/on-site water sources and cesspits, and therefore also remained sparsely populated. By the early 1900s, the pros and cons of town water and sewer systems were understood by these communities and fierce debates occurred regarding the investments required to construct them. Some towns ultimately voted to fund and construct town water & sewer systems (Holliston, Millis and Medfield), while others voted down the bonds needed to pay for their creation. For Sherborn, the final votes that put to rest any notions of a broad town water supply occurred just over 100 years ago, in March of 1923[11]. Sherborn remains without public water/sewer infrastructure (similar for Dover), and therefore Sherborn's population density (see Figure 3) has remained quite low (0.44 people/acre) relative to communities connected to the MWRA (Framingham, Natick and Ashland, at 4.43, 3.52 and 2.24 people/acre, respectively) and those that developed more modest town water & sewer systems (Millis, Medfield and Holliston, at 1.12, 1.40, and 1.22 people/acre, respectively). In effect, residents of Sherborn "live off the land" with regard to well water & septic treatment, and the town's potential for development is therefore limited by federal, state & local regulations, and more fundamentally, the physical characteristics of the land & aquifers beneath it. Towns like Sherborn, although bucolic due to their naturalistic character, also lack tax revenue from commercial industries as a result of their lack of infrastructure. For Sherborn, that translates to residents footing property tax rates in the top 9% of the state to support schools and services.[12] It would be difficult to imagine a different future trajectory for Sherborn at this point, as any

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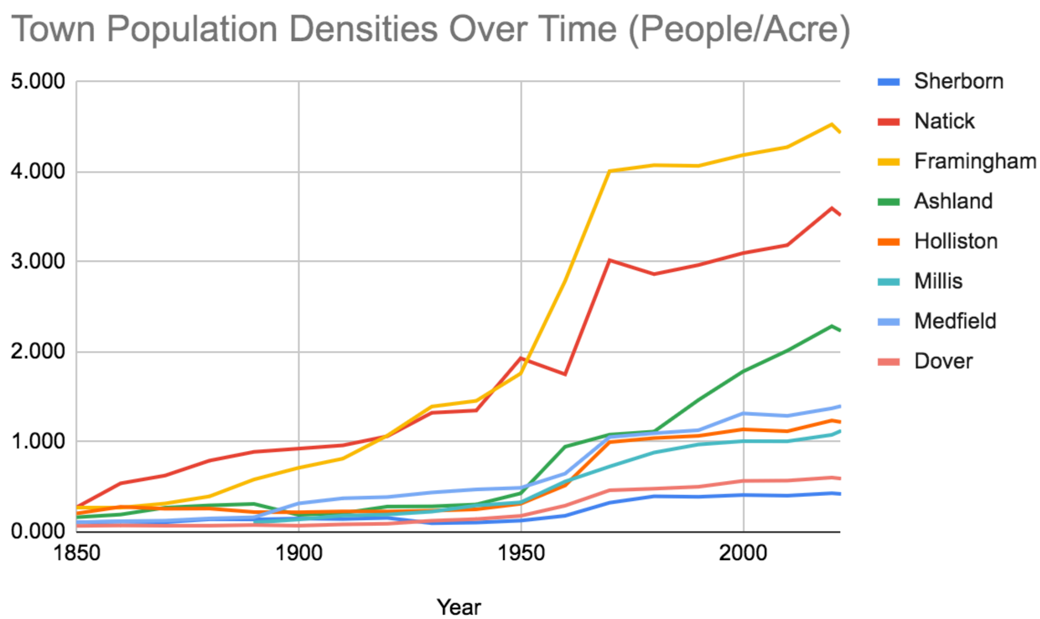
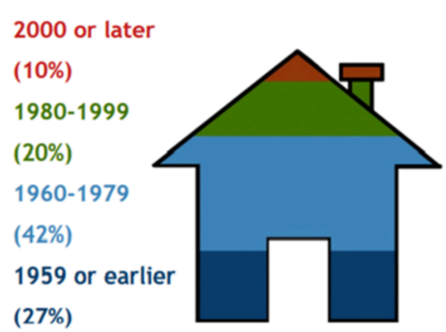
[11] https://archive.org/details/historyofsherbor00shau/page/60/mode/2up p. 59-60.
[12] https://dlsgateway.dor.state.ma.us/gateway/DLSPublic/ApprovedTaxRateReport/ApprovedTaxRate

attempt to fund a town-wide water and/or sewer system would exceed its residents' ability to afford their property tax bills. Knowing that groundwater must be maintained for its current and future residents, Sherborn is understandably vigilant and protective of land & water use within and near its borders.

Figure 3: (Top) Population densities, in people per acre, of Sherborn and surrounding communities. (Bottom) Percentage of Sherborn homes by year built.





The largest "bump" in Sherborn's population occurred between 1950 and 1970, which followed a post-war population boom in the US. Figure 3, bottom, shows the breakdown of existing homes in Sherborn by year built. Note that development in Sherborn has slowed in recent times, primarily due to the institution & tightening of environmental & water quality regulations since the 1970s (described below) paired with most remaining unbuilt land lacking characteristics favorable enough to meet those standards. Of the homes built since 2000, many have been built on "tear-down" sites.

2. Regulations related to well water and septic systems.

Introductory biology students often learn about London's cholera outbreak of 1854 and the Broad Street pump, as this historical episode ultimately led to the development of Germ Theory and creation of related public health & water quality measures both in the UK & abroad.[13] Given that 1854 was after the Framingham to Boston aqueduct was placed in use, it is no surprise that it took some time before legislation related to waste water & drinking water were placed on the books, with federal regulations taking over 100 years to materialize. The first attempts (1890) at understanding water quality in Massachusetts focused on mapping how areas of Boston varied via a sanitary survey.[14] No meaningful regulations were developed for many decades, but inlets were moved or filters added to improve water quality where needed. By 1900, "conventional" water treatment procedures of coagulation, sedimentation and filtration were common for public water supplies, and chlorination became common by 1930. For those using on-site water and waste disposal, soil filtration and adequate spacing between cesspits and wells ensured water quality (not unlike today).

Development of agriculture & industry post-WWII led to increasing quantities of environmental pollutants & increasing awareness of their harms. A number of limits were set at the federal level for drinking water contaminants (like hexavalent chromium in 1946, and cadmium, cyanide & nitrate in 1962). But a test of 969 public water sources in 1969 revealed 41%, serving millions of people, did not meet these guidelines. This and other public & governmental revelations & efforts ultimately resulted in the first broad, federal piece of water quality legislation: the 1974 Safe Drinking Water Act.[15] Other public health and environmentally-related bodies and regulations were similarly created around this time (Fig. 4). The passing of Massachusetts' Chapter 40B is added for reference due to its current significance with regard to currently proposed development in Sherborn.

Figure 4: Table of legislation and regulation related to water quality in Massachusetts.[16]

Year	Regulatory Change	Significance
1969[17]	Enacting of MA Chapter 40B	Allows override of local zoning and health by-laws for development of affordable housing
1970	Creation of the US Environmental Protection Agency	Established the agency that would become responsible for water and waste risks to public health
1972	US Clean Water Act (amended in 1977 & 1987)	Established goals for river water quality, regulated waste discharges and provided grant funds for upgrading community wastewater plants

[13] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7150208/
[14] https://www.mwra.com/04water/html/historypaper/ch3.pdf
[15] https://journalofethics.ama-assn.org/article/safe-drinking-water-act-1974-and-its-role-providing-access-safe-drinking-water-united-states/2017-10
[16] https://www.mwra.com/04water/html/historypaper/ch3.pdf
[17] https://en.wikipedia.org/wiki/Massachusetts_Comprehensive_Permit_Act:_Chapter_40B

1972	MA Wetlands Protection Act[18] (revised many times since, now enforced by MA DEP)	Protection of public & private surface & groundwater supply and aquatic & wildlife habitats.
1973	US Endangered Species Act	Established protections that would stop projects like reservoirs that impact critical habitat
1974	US Safe Drinking Water Act (amended many times since)	The first universal national drinking water standards
1975[19]	Formation of MA Executive Office of Energy and Environmental Affairs	Governing authority; includes the MA Department of Conservation and Recreation (DCR) & MA Department of Environmental Protection (DEP)
1975[20]	MA DEP adopted Title 5 regulation 310 CMR 15.00 (revised many times since)	Regulates on-site disposal systems to protect public health and the environment

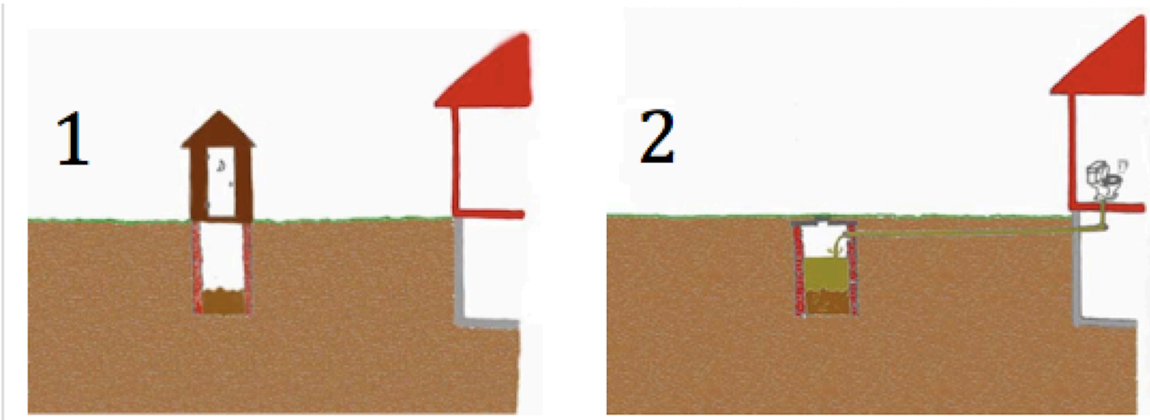
With water quality legislation on the books, there was a push within federal, state and local governments as well as the scientific community to understand how best to support or expand upon water quality regulations. Several reports or documents originating from this time and which relate to Sherborn's soils, hydrology, water quality and septic design include:

- MA Title 5[21] (310 CMR 15.00) - This regulation governs the construction and maintenance of septic systems and the transport of septic-system waste.
- US EPA Report To Congress (1977)[22]: *Waste Disposal Practices and Their Effects on Ground Water*
- Soil Interpretations for Waste Disposal (1979)[23] - A report prepared for the state of Connecticut, but many of the soil layers described within comprise the surface layers of Sherborn, as the same geological strata and glacial processes shaped much of New England.
- US Geological Survey & USDA soil and water maps.[24]

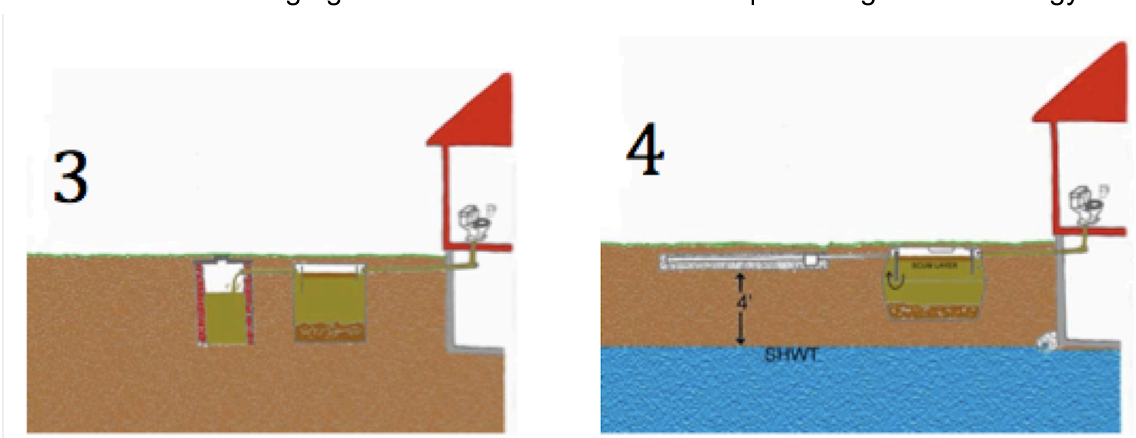
Sherborn remains dependent on on-site waste water treatment, and a brief history of septic system design follows.[25] Outhouses (1, below) were constructed above a hole lined with rocks or brick (with gaps to allow outward flow of liquid) and in which wastes were directly disposed. If the hole filled with waste, it was covered with earth and a new hole prepared. The invention of the flush toilet (2, below) allowed wastes to travel from within a building to an exterior rock- or brick-lined hole (cesspit) via water flow. The waste & water separated and liquid (effluent) portions were able to seep outward through gaps. If the cesspit became filled, it could be

[18] https://www.mass.gov/doc/310-cmr-1000-the-wetlands-protection-act/download
[19] https://www.mass.gov/info-details/brief-history-of-eea
[20] https://www.mass.gov/doc/re22rc20-title-5/download
[21] https://www.mass.gov/regulations/310-CMR-15000-septic-systems-title-5
[22] https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000J6YI.TXT
[23] https://portal.ct.gov/-/media/caes/documents/publications/bulletins/b776pdf.pdf
[24] https://www.usgs.gov/the-national-map-data-delivery
[25] https://ruralhometech.com/evolution-of-the-septic-system/

pumped or additional cesspits added in series. Flush toilets with cesspits started to become common in the 1850s, once public water supplies (like the Framingham to Boston aqueduct) and/or electricity for pressurized well water tanks became available. Sherborn still has 54 active cesspits across town.



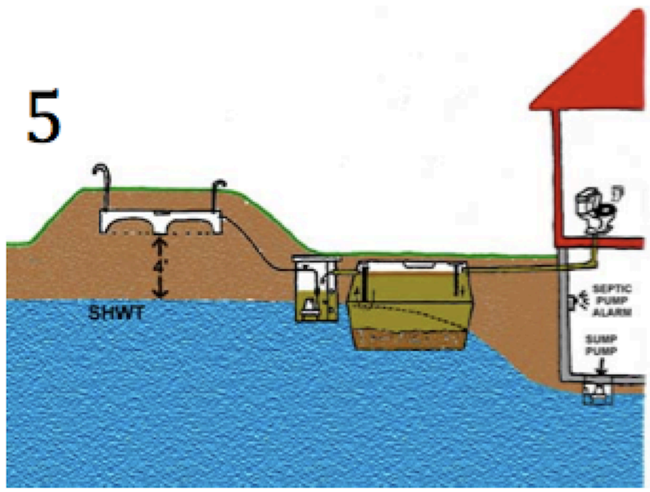
Problems with cesspit design, particularly when the pit depth allowed seepage of the substantial amounts of untreated, muck-laden liquid formed via indoor plumbing directly into groundwater, made addition of an intermediate septic tank (3, below) preferred (c. 1940s). The septic tank was water-tight, allowing retention of solid wastes for breakdown while allowing the liquid-only effluent to flow to a cesspit for leaching. Developments in Sherborn built into the 1960s, such as those along Old Orchard Rd, used this type of septic system (many still using the original systems). Areas that had high groundwater tables (4, below) were ill-suited for cesspits of even moderate depth, so modern septic fields with trench-style effluent distribution lines became the next innovation. This style of septic system (which uses a “conventional leaching field”) has been common since c. 1970, due to the overlap between demand for new construction and the institution of federal, state and local water quality regulations. In Sherborn, many lots unbuilt prior to the 1970 due to high ground water tables were developed using this technology.



The most modern septic systems (5, below, Innovative/Alternative or IA systems[26]) can be used in even shallower soils to ground water and with poorer soil types. Alterations like mounding of

[26] https://www.epa.gov/water-research/innovativealternative-septic-systems

additional soil increases the leach field's distance from the water table, but requires pumps to push the effluent against gravity. Nitrogen-reducing aeration tanks can be added to ensure sufficient treatment of waste water as it percolates through shallow, poor soil layers. And chambered trench pipes can increase efficiency of the leach field, reducing the land area required to meet septic system regulations. In Massachusetts, many IA systems have received general, remedial, secondary and provisional[27] approval for use.



For the town of Sherborn, much of the land that could accommodate conventional septic systems (4) had already been developed by the 2000s. Newer construction & septic upgrades/replacements for existing homes tend to include IA technologies (5) due to the poor physical characteristics or remaining lots, such as high ground water and shallow, poor soils[28], or to increase the efficiency of existing leaching fields. One can only surmise that with its long history of settlement and proximity to Boston, any Sherborn lands currently left undeveloped have been left untouched for a reason. IA technologies may put more of them into play for some types of development, but such endeavors should be evaluated with exacting detail and care[29].

Below is a table (Fig. 6) of select MA Title 5 minimum regulations for septic systems, as well as Sherborn's General By Laws, or Board of Health (BOH) & Conservation Commissions regulations for comparison. Fig. 7 illustrates how these would translate to a development plan. The number and distance of these setbacks further restricts development in town, keeping population density low.

[27] https://www.mass.gov/guides/approved-title-5-innovativealternative-technologies#-provisional-use-

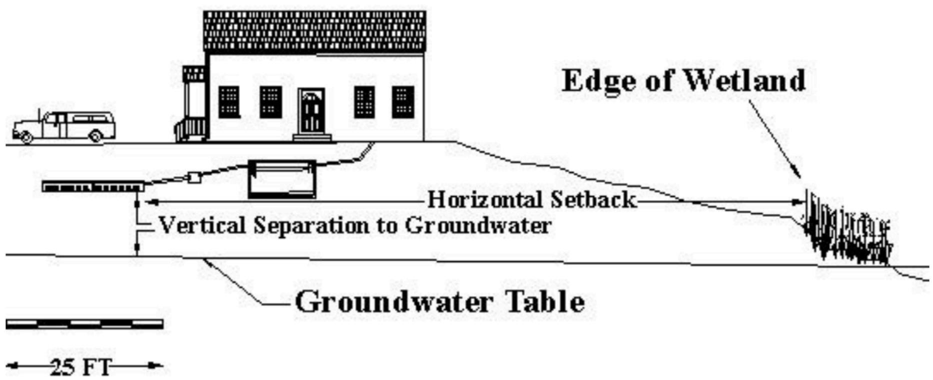
[28] These IA technologies require regular monitoring and more frequent maintenance due to their greater complexity and dependence on pumps, additional treatment chambers, and closer proximity to ground water.

[29] MASSTC https://www.masstc.org/ is an excellent resource for accessing real-world evaluations of IA technologies, and they regularly publish findings in reports such as https://www.masstc.org/publication/effectiveness-of-selected-onsite-wastewater-treatment-systems-in-removing-pharmaceutical-and-personal-care-products

Figure 6: Selected MA Title 5[30] and Sherborn General by-laws[31], BOH[32] or Conservation Commission regulations[33]

Setback (septic system's distance to)	MA Title 5 Min. Requirement	Sherborn Min. Requirement
Seasonal High Water Table (SHWT)	4 feet in soils with percolation rates >2 in./min.	5 feet
Private water supply well	100 feet	125 feet (150 feet if downhill of septic system)
Surface Waters (except wetlands)	50 feet	100 feet
Wetlands	100 feet	100 feet
Certified Vernal Pool	100 feet	150 feet

Figure 7: Development design plan showing how setbacks are applied.[34] Addition of a well would make this image most accurately reflect development within Sherborn.



Finally, the town of Sherborn is divided into several zoning districts that set minimum lot sizes per dwelling (Fig. 8). These zones are broadly linked to variations in geology across town (see Fig 8A inset and Fig. 8B), which in turn influence the septic density each region can reasonably support. The relationship between zoning/minimum lot sizes, soils, septic density, and public health in Sherborn has been upheld in court (Wilson v. Sherborn, 1974[35]), and is another reason for the continued low population density shown in Fig. 3. The next section expands upon why this is the case.

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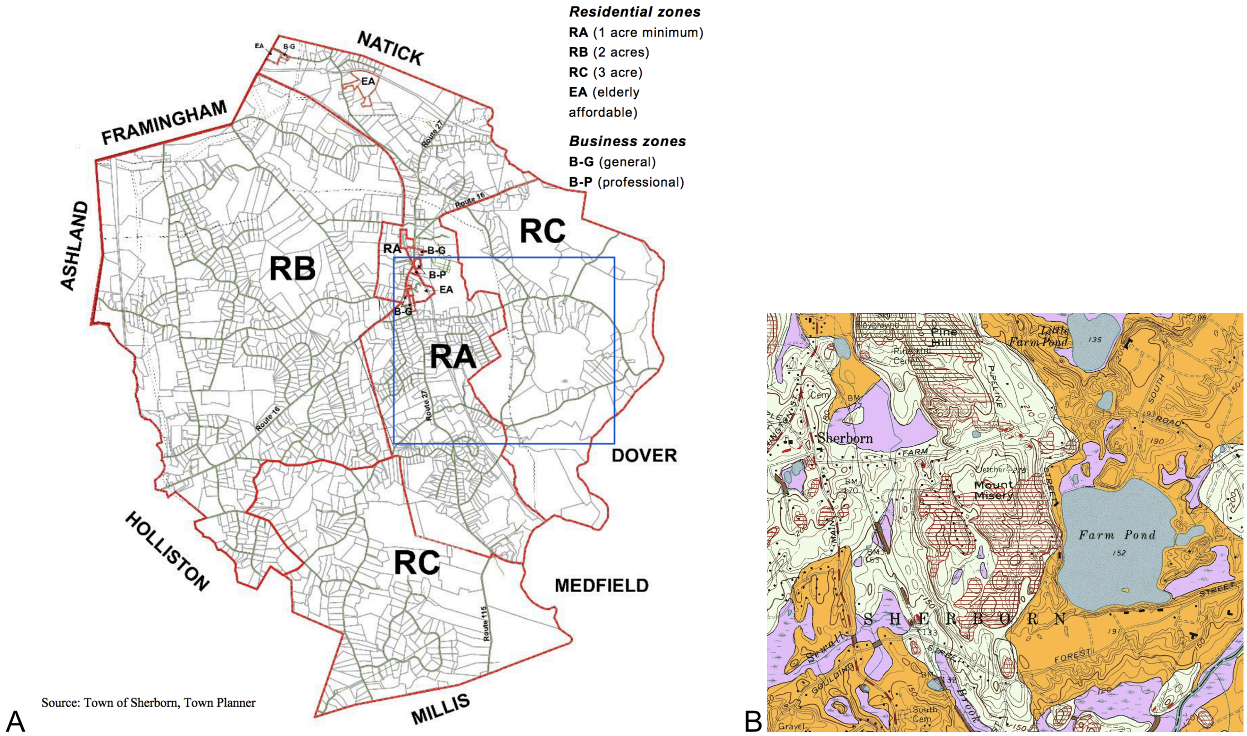
[30] https://www.learntitle5.org/Module3.PDF
[31] https://sherbornma.org/DocumentCenter/View/418/2023-General-By-laws-PDF
[32] For conventional or IA septic systems. https://www.sherbornma.org/DocumentCenter/View/337/2020-Board-of-Health-Regulations-PDF
[33] https://www.sherbornma.org/DocumentCenter/View/379/2017-Sherborn-Wetland-Regulations-PDF?bidId=
[34] https://www.learntitle5.org/Module2.PDF
[35] https://casetext.com/case/wilson-v-sherborn

Figure 8: A) Sherborn Zoning Districts.[36] B) Geological map of area outlined in blue[37]. The division between the RA and RC zoning districts roughly corresponds to different bedrock formations beneath them, as well as the smaller districts close to town center.



3. Interplay of soils, groundwater, septic design & density and water quality, with particular focus on Sherborn geology and subsurface hydrology.

A brief explanation of how soils influence the ability of septic systems to adequately treat waste water is provided below, beginning with a schematic of where within septic system design natural soils play their most important role (Fig. 9).

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36 https://sherbornma.org/DocumentCenter/View/889/33-Sherborn-Zoning-Districts-PDF
37 https://ngmdb.usgs.gov/Prodesc/proddesc_108424.htm

Figure 9: Side view of the components of a septic tank and conventional trench leaching field, with soil layers beneath the leaching field forming a zone of purification (treatment of effluent).[38]

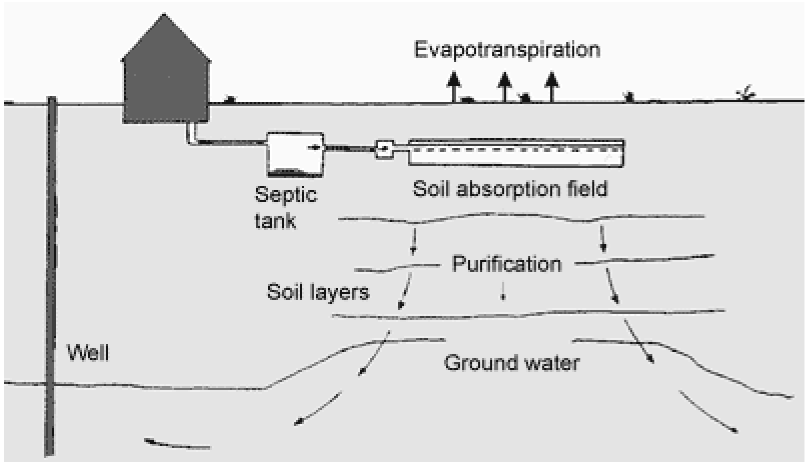


Fig. 9 labels the region of soil between the septic leaching field and ground water as the "purification" zone. The native soil, and the microbes living within it, are responsible for breaking down contaminants in septic effluent before it enters ground water. Subsurface soil, therefore, has a direct effect on water quality in areas dependent on wells, and poorly designed or failing septic systems are directly related to contamination of ground water. A few parameters largely determine the degree to which "purification" can occur: depth to groundwater, soil permeability/composition, and soil classification.

Depth to groundwater - Increasing depth between the septic system's leaching field to ground water increases the likelihood of that septic effluent will be sufficiently treated. The minimum depth to ground water set by Title 5 is 4 feet (Fig. 6), but due to the poor soils found in Sherborn, local regulations set minimum depth to ground water at 5 feet. This additional depth for purification ensures sufficient time/interactions between the effluent and the "cleansing" microbes that break down potential contaminants.

Soil permeability/composition - The permeability of the soil is another central characteristic, as the rate of downward flow of effluent cannot be too fast (as insufficient treatment would lead to groundwater contamination), nor can it be too slow (as the home would produce effluent faster than the septic system could process it, causing back-ups); this is why the type of natural soil found on-site fundamentally influences the septic system's overall design and function. Some soils have better permeabilities, some worse. Some soils are so impermeable or naturally water-logged that they simply cannot reasonably support septic systems (such as clay soils or wetlands).

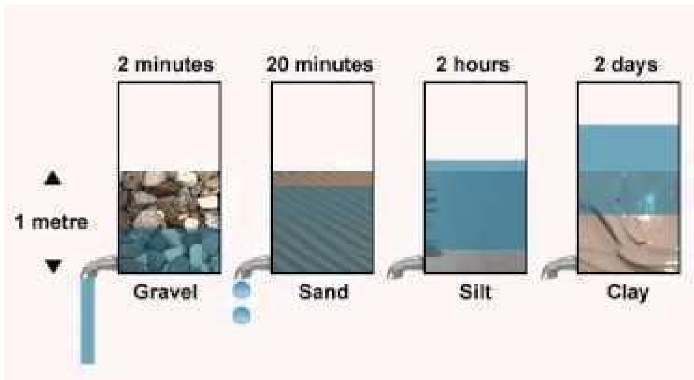
When evaluating natural soils for use under leaching fields, the relative amounts of gravel, sand, silt and clay directly impacts the soil's permeability (gravel having the highest rate of flow/permeability and clay the lowest, see Fig. 10). The permeability of a soil can be expressed relatively precisely with a "k" value, or "percolation rates" or "perc rates" (in minutes/inch, the

[38] https://www.agry.purdue.edu/soils_judging/new_manual/ch4-homesite-Onsite.html

number of minutes it takes an inch-deep layer of water to drain through the soil) which are used for quick determinations & comparisons.[39] Sherborn BOH regulations require perc rates for septic subsoils to be 40 min/inch or less.[40]

Figure 10: A) Example permeability rates for various soil components (visual). Water percolates through gravel in the least amount of time, so it has the fastest perc rate (smallest # of minutes/inch) and highest k value.[41] B) Example permeability rate, k, ranges for various soil types.[42]

A)



B)

Soil type	Permeability k (m/sec)	Reducing permeability
Gravel	>0.1	↓
Sand	0.1 – 10^{-4}	
Silt	10^{-4} – 10^{-8}	
Clay	<10^{-8}	

A soil sample can be analyzed to determine its percentage of sand, silt and clay (gravel is excluded as it is considered stone rather than "soil"). These three values (% sand, % silt and % clay) give the soil its texture (Fig. 11), which in turn influences its permeability. Fig. 11 also reflects where terms like "silty loam" or "sandy clay" are derived from. Sandy loams, loams and silt loams are soil textures best suited for septic leaching fields (Figs. 11 & 12).[43]

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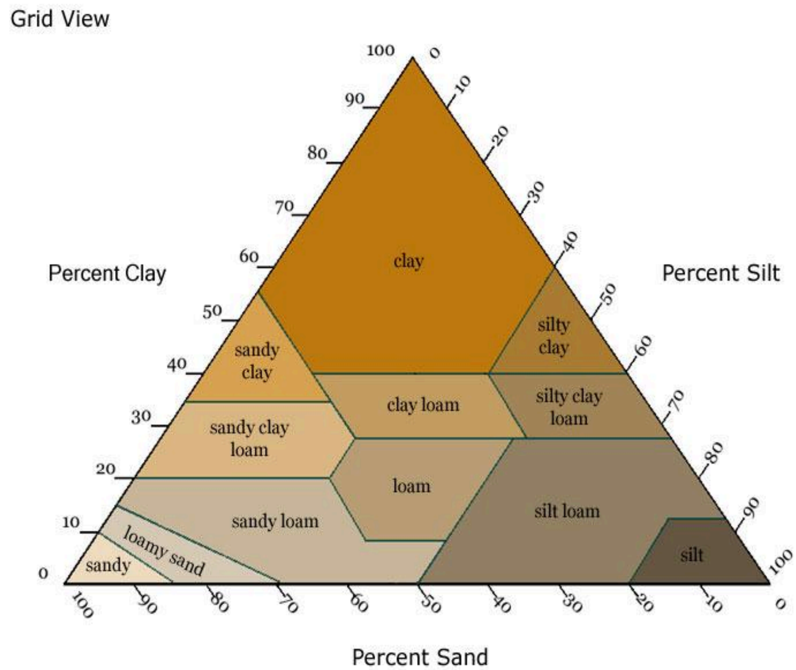
[39] https://extensionpubs.unl.edu/publication/g1472/html/view
[40] https://www.sherbornma.org/DocumentCenter/View/337/2020-Board-of-Health-Regulations-PDF
[41] http://www.kamloopspropertyforsale.com/blog/septic-system-design-all-you-need-to-know/print.html
[42] https://www.tensar.co.uk/resources/articles/the-permeability-of-soils-explained
[43] http://www.clean-water-for-laymen.com/soil-permeability.html

Figure 11: Detailed analyses of relative sand, silt and clay components in soil allow for more precise engineering of septic systems.[44] Soils with permeability characteristics best for septic systems have lower percentages of clay and higher percentages of sand, and therefore fall within the bottom regions of the soil texture triangle below.



<u>Soil Class</u> - One more classification of soils related to soil texture and commonly referenced in septic designs in Massachusetts is the Title 5 soil class (Fig. 12). This classification is designated by the state and is used in conjunction with percolation rates to determine the sizing of conventional septic fields (Fig. 13). Septic fields are sized to deal with expected amounts of effluent, but they can also be purposefully "over-sized" to distribute effluent over a larger area if the soils beneath are poor.

Figure 12: Soil classes for use in septic design in Massachusetts.[45]

Soil Class	Soil types	Suitability for Septic Use[46]
CLASS I	Sands, Loamy Sands	Suitable
CLASS II	Sandy Loams, Loams	Suitable
CLASS III	Silt Loams, Sandy Clay Loams with less than 27% clay, Silt	Suitable (if perc rate <40 min./inch)
CLASS IV	Clays, Silty Clay Loams, Sandy Clay Loams with 27% or more Clay, Clay Loams and Silty Clays	Not suitable

[44] http://kaddidle.com/soils/texture.htm
[45] From 310 CMR 15.243 - Types of Soil Textural Classes
[46] https://www.sherbornma.org/DocumentCenter/View/337/2020-Board-of-Health-Regulations-PDF

Figure 13: Table showing how percolation rates and soil classes are used to determine the sizing of leaching fields in the town of Sherborn (in gallons per day of effluent per square foot of leaching field).[47] Note that in cases where a soil might be on the edge of two classes, such as a Class I "loamy sand" or Class II "sandy loam", the recommendation is to go with the more conservative classification (Class II) for leach field sizing. In some cases, the difference in sizing can be substantial (such as a ~35% sizing difference for a Class II vs. Class III soil with a 15 min./inch percolation rate).

Percolation Rate (minutes per inch) Title 5 soil classes	Side wall & bottom area (gpd/square foot) Class I soils	Side wall & bottom area (gpd/square foot) Class II soils	Side wall & bottom area (gpd/square foot) Class III soils
Less than or equal to 5	.74	.60	--
6	.70	.60	--
7	.68	.60	--
8	.66	.60	--
9	--	.60	--
10	--	.60	--
15	--	.56	.37
20	--	.53	.34
25	--	.40	.33
30	--	.33	.29
40	--	--	.25
Greater than 40	Not Permitted	Not Permitted	Not Permitted

What kinds of soils are found in Sherborn?

Sherborn's soils were deposited by glaciers at the end of the last ice age and then further transformed via erosion from weathering and/or water flow (rivers, streams, etc.). The two basic soils found in Sherborn that can support septic systems are:

- **glacial tills** (the direct deposits of melting glaciers that include gravel, rocks and boulders) - see the soil beneath the green house in Fig. 14. These are typically Class II and Class III soils (Fig. 12) and require larger septic leaching fields (Fig. 13). These soils comprise the majority of Sherborn's land area & vary in depth to ground water/bedrock but are typically thin.
- **sand, gravel, and alluvium** (smaller particles from glacial deposits that traveled downhill mainly due to water flow and were deposited in lowlands) - see the soil beneath the red house in Fig. 14. These are typically Class I and Class II soils (Fig. 12) and can be developed with smaller septic leaching fields (Fig. 13) as long as ground water is found far enough below the surface (Fig. 9). These soils are primarily found in the eastern portions of Sherborn, surrounding Farm Pond, Little Farm Pond, and the Charles River & its tributaries.

Other kinds of soils exist in Sherborn, but A) are considered Class IV soils (Fig. 12), B) surround wetlands & therefore are unsuitable for septic systems due to high ground water, C) are prone to seasonal flooding, or D) are extremely shallow to bedrock (i.e. contain "ledge"). Also, septic fields require large, flat areas of land to function properly, so areas within town with significant slopes cannot support them. Figure 14 illustrates the kinds of geological environments found

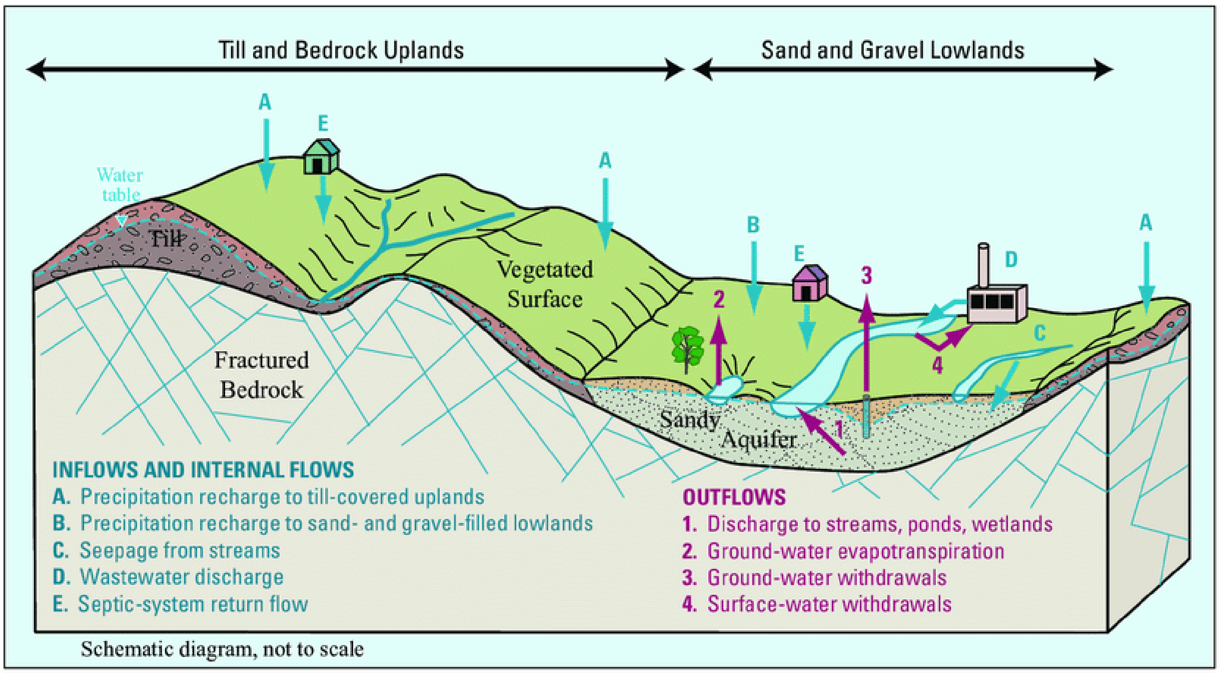
[47] https://www.sherbornma.org/DocumentCenter/View/337/2020-Board-of-Health-Regulations-PDF

within areas surrounding the Upper Middle Charles River, including Sherborn. As reflected in Fig. 14, the physical constraints of the land and subsurface render large areas of Sherborn unbuildable in the absence of town water & sewer systems as they contain one or more of the following, which interfere with septic system function:

- wetlands (covering 20% of Sherborn's land area)
- open bodies of water (over 150 acres)
- excessive slopes (including Bare Hill, Nason Hill, Pine Hill, Perry Hill, Peter's Hill, and Rocky Narrows)
- shallow soils
- high ground water tables

These constrained, unbuilable lands also contribute to the low population density in Sherborn.

Figure 14: Basic geology of the Upper Middle Charles River watershed, including Sherborn.[48]



Substantial research into soils and septic systems occurred in the 1970s and 1980s, and a particularly helpful report titled "Soil Interpretations for Waste Disposal"[49] (1979) provided direct links between specific soils and their potentials & limitations for septic design. Table 3 of this report (p. 14-28) characterizes nearly 200 soil types/variations found within southern New England in this manner, many of them also found in Sherborn. As 60 total soil types are found within Sherborn, we will focus on those found at select currently-built or proposed-for-development sites in Sherborn. Soil maps[50] for each site are provided for reference.

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48 https://www.researchgate.net/figure/Figure-The-water-cycle-of-the-upper-Charles-River-watershed-modified-from-DeSimone-and_fig1_242397139

49 https://portal.ct.gov/-/media/caes/documents/publications/bulletins/b776pdf.pdf

50 https://websoilsurvey.nrcs.usda.gov/app/

Sherborn Village, 59 N. Main St., Sherborn, MA 01770 (built)
This built development includes a septic system (approximate location outlined in pink on the map below) sized for 24 bedrooms located partially in soils 307B and 254B, as well as a reserve leaching field area (approximate location outlined in green) identified in soil 254B. As this development is located on 6.042 acres, its overall septic density is 437 gpd/acre (equivalent to a 4 bedroom home on a 1-acre lot). The most proximate neighboring properties have an average septic density of 402 gpd/acre (46-61 N. Main St.).

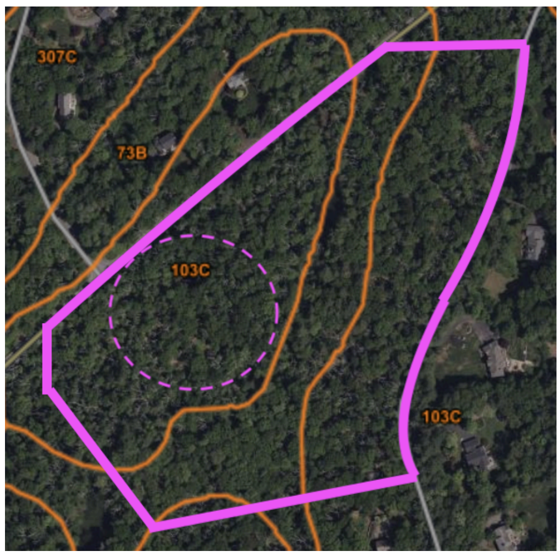
Map Unit Symbol	Map Unit Name	Septic Leaching Field Use
253B	Hinckley loamy sand, 3 to 8 percent slopes	● Severe limitations ● Low potential for septic use ● Poor filter capabilities suggest sewage collection and/or control of housing density ● Slope suggests serial tile distribution
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	● Severe limitations ● Low potential for septic use ● Poor filter capabilities suggest sewage collection and/or control of housing density
307B	Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony	● Severe limitations ● Medium potential for septic use ● Percs slowly - restrict percolation testing; use interceptor drains over hardpan; enlarge field, use sand filter and/or mound system ● Smears suggest avoiding construction when wet

Farm Road Homes, 55 and 65 Farm Rd., Sherborn, MA 01770 (proposed)
This proposed development's approximate proposed septic system location is outlined in pink on the map below and is located within soil layer 104D. No reserve area is provided in the proposed plan. The proposed lot is 14.0 acres and the proposed septic system is designed for 8,360 gpd, giving it an overall septic density is 597 gpd/acre (equivalent to a roughly 6 bedroom home on a 1-acre lot). The most proximate neighboring properties have an average septic density of 172 gpd/acre (48-70 Farm Rd.).

Map Unit Symbol	Map Unit Name	Septic Leaching Field Notes and Management Practices to Overcome Limitations
103C	Charlton-Hollis-Rock outcrop complex, 8 to 15 percent slopes	• Severe limitations • Medium potential for septic use • Depth to rock may require addition of fill • Poor filter capabilities suggest sewage collection and/or control of housing density • Smears suggest enlarging leaching area and avoiding construction when wet • Slope suggests serial tile distribution
104D	Hollis-Rock outcrop-Charlton complex, 15 to 25 percent slopes	• Severe limitations • Very Low potential for septic use • Depth to rock may suggest soil least suitable for use • Slope suggests soil least suitable for use
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	• Percs slowly - restrict percolation testing; enlarge field, use sand filter and/or mound system • Wetness - use interceptor drains over hardpan

422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony	• Moderate limitations • High potential for septic use • Smears suggest enlarging leaching area and avoiding construction when we • Slope suggests serial tile distribution

Washington Street Homes, 0 Washington St. , Sherborn, MA 01770 (proposed)
This proposed development's approximate proposed septic system location is outlined in pink (dashed) on the map and is located within soil layer 103C. No reserve area is provided in the proposed plan. The proposed lot is 14.86 acres and the proposed septic system is designed for 7,700 gpd, meaning it would have an overall septic density of 518 gpd/acre (equivalent to a roughly 5 bedroom home on a 1-acre lot). The most proximate neighboring properties have an average septic density of 208.5 gpd/acre.[51]



Map Unit Symbol	Map Unit Name	Septic Leaching Field Notes and Management Practices to Overcome Limitations
103C	Charlton-Hollis-Rock outcrop complex, 8 to 15 percent slopes	• Severe limitations • Medium potential for septic use • Depth to rock may require addition of fill • Poor filter capabilities suggest sewage collection and/or control of housing density • Smears suggest enlarging leaching area and avoiding construction when wet • Slope suggests serial tile distribution
73B	Whitman fine sandy loam, 0 to 3 percent slopes, ext. stony	• Not listed in report - wetlands/unbuildable

51 https://www.sherbornma.org/DocumentCenter/View/2385/Abutters-Wesolowski-Document-on-Septic-Density-and-Well-Water-Quality-April-18-2024 p.2.

Sherborn Cottage Court, 34 Brush Hill Rd., Sherborn, MA 01770[52] (proposed)
This proposed development's approximate proposed septic system location is outlined in pink (dashed) on the map and is located within soil layers 503B and 503C. Septic plans are not yet available on the Sherborn Land Development page[53], but there does not appear to be space provided for a septic reserve area based on the proposed site layout/architectural plans. The proposed lot is 5.096 acres and the proposed septic system is designed for approximately 28 bedrooms (assuming four 3-bedroom and four 4-bedroom cottages), or 3,080 gpd, meaning it would have an overall septic density of approximately 600 gpd/acre (equivalent to a roughly 6 bedroom home on a 1-acre lot). The most proximate neighboring single-family properties have an average septic density of 190 gpd/acre (27-44 Brush Hill Rd.).

Map Unit Symbol	Map Unit Name	Septic Leaching Field Notes and Management Practices to Overcome Limitations
305B	Paxton fine sandy loam, 3 to 8 percent slopes	• Severe limitations • Medium potential for septic use • Percs slowly - restrict percolation testing; use interceptor drains over hardpan; enlarge field, use sand filter and/or mound system • Smears suggest avoiding construction when wet
305C	Paxton fine sandy loam, 8 to 15 percent slopes	• Severe limitations • Medium potential for septic use • Percs slowly - restrict percolation testing; use interceptor drains over hardpan; enlarge field, use sand filter and/or mound system • Smears suggest avoiding construction when wet • Slope suggests serial tile distribution

[52] It should be noted that this site lacks sufficient emergency vehicle access.
[53] https://www.sherbornma.org/500/Land-Development-Projects

Well Water/Aquifer Considerations in Sherborn

Sherborn's residents rely almost entirely on well water for their water needs, including clean drinking water. As described above, most areas of town rest on glacial till (like the green house in Fig. 14) and get their water from wells drilled into bedrock fractures beneath them. As visually depicted in Fig. 14, the volume of water below any given lot could be plentiful (if a large fracture exists) or not-so-plentiful (if only small fractures are found). Homes sited on lowland sands and gravels do have additional water storage beneath them (like the red house in Fig. 14), but Sherborn aquifers of this type are relatively small and few in number. And open bodies of water in town do not serve as resevoirs.

Recharge for both the fractured bedrock aquifers and lowland sand/gravel aquifers comes from the roughly 4' of precipitation Sherborn receives annually. Much of this water exits town, however, as it flows into the numerous streams, brooks, rivers, ponds, etc., that ultimately feed into the Charles River.

The cycle of precipitations to ground water to bedrock/aquifer to drinking water to septic is a long one, and takes months to years to fulfill. Although current water resources are far less limiting than land with regard to development in Sherborn, keeping ground water as contaminant-free is an obvious imperative. It takes relatively tiny amounts of pollutants to contaminate the less-limiting, but still modest, bedrock aquifers in town (typical EPA drinking water standards - see Fig. 4 - limit pollutants to the part per million or 1.0E-06 range). This leads back to an emphasis on septic design and low septic density to ensure adequate purification of effluent.

4. Currently available, collected and analyzed Sherborn water quality data (incomplete and in process)

Below is a summary of an on-going water quality analysis being conducted by the author, with a larger report found here:
https://www.sherbornma.org/DocumentCenter/View/2385/Abutters-Wesolowski-Document-on-Septic-Density-and-Well-Water-Quality-April-18-2024

As an abutting neighbor to the Washington Street Homes project, I wanted to determine historic baseline nitrate levels for groundwater in the area surrounding this proposed developement. This proposed development is located in an area of Sherborn zoned for 2-acre lots for single family homes, which in effect sets the maximum septic density. A reasonable question can be asked: is this septic density low enough to maintain groundwater quality over time, given that all households rely on well water and large areas of protected wetlands are in the immediate vacinity? To help answer this question, data were collected from water testing reports found in property files at the Sherborn Board of Health (BoH) office. These reports are typically submitted to the BoH as part of the well completion approval process for new construction, well relocations for existing homes, and less frequently during septic system upgrades or home sales. Additionally, a smaller collection of reports were submitted to the author directly by homeowners who have had their water tested by Mass DEP-certified labs for reasons unrelated to BoH oversight. To date, 97 such reports dating from 1969 to the present (April 2024) for properties surrounding Map 7, parcel 49 have been collected and analyzed (more properties and reports will be added as time & availability permit). A map of properties with collected reports (Fig. 16) and a graph showing wellwater nitrate concentrations from these reports are below (Fig. 15). The average reported wellwater nitrate level for all properties was found to be 1.1 mg/L, with a range from “not detected” to 4.0 mg/L. A linear fit of collected nitrate levels over time suggest a small, but statistically insignificant, upward trend.

Figure 15

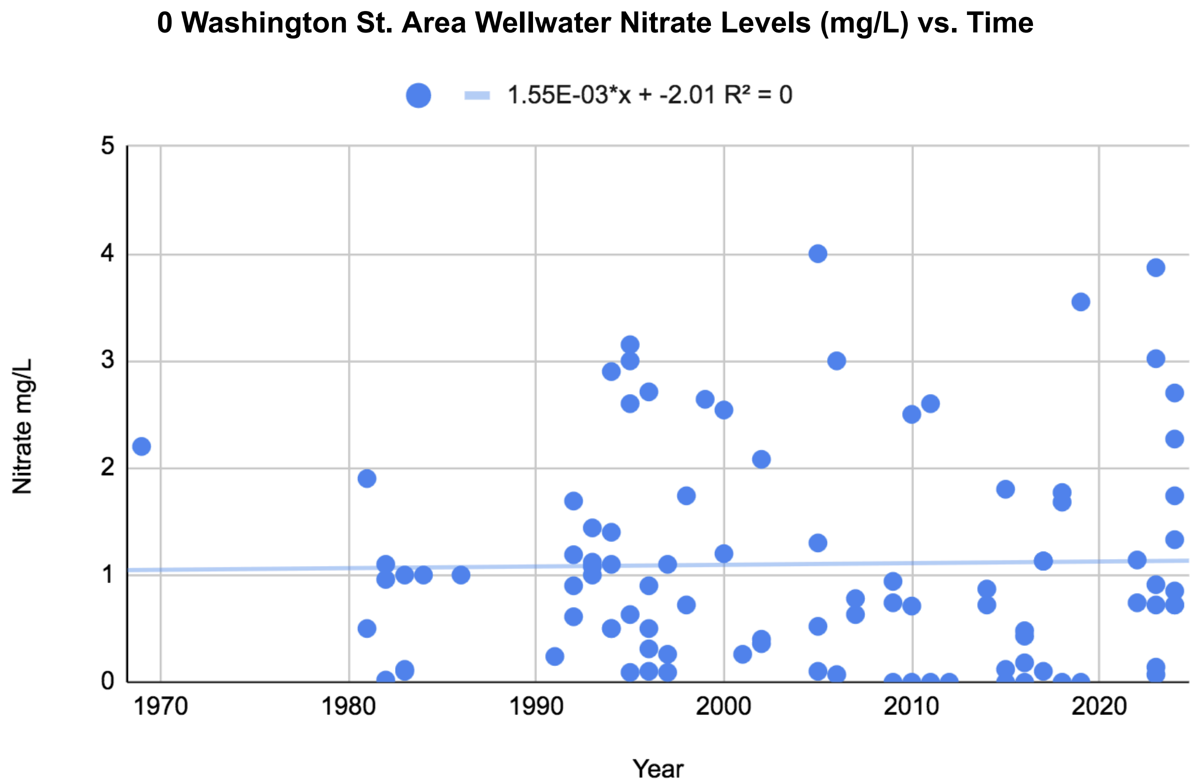
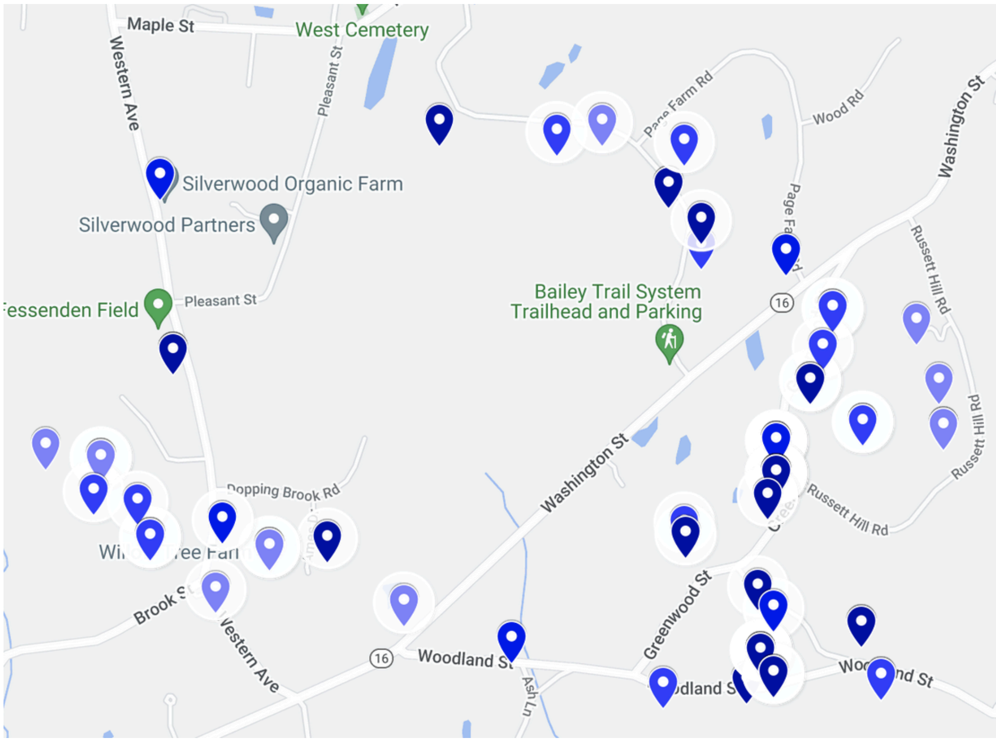


Figure 16

Google Maps-Generated Locations of Properties (blue markers) w/BoH Nitrate Data on File or Submitted by Homeowners



Note: *the area north of Washington St and central to the map includes MassDEP-designated wetlands as well as Sherborn Town Forest, which accounts for the lack of data directly abutting Washington Street between the Bailey Trailhead and Woodland St.*

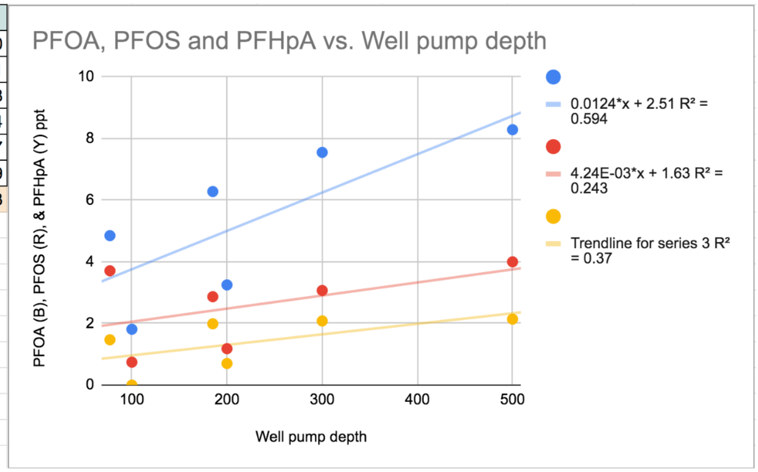
A review of EPA guidelines suggests that groundwater nitrate levels above 1 mg/L are indicative of human activity, and those over 3 mg/L indicative of contamination.[54] As some water quality data included in Fig. 15 were A) from well completion reports for new construction on previously undeveloped land and B) had results at or above 3 mg/L, it can be assume any EPA-designated nitrate contamination is due to a wider issue with the local groundwater supply than simply a point source such as a nearby failed septic system.

Although few in number, data related to PFAS have become available for a handful of properties surrounding 0 Washington St., with data provided below (Fig. 17).

[54] https://www.epa.gov/nutrientpollution/estimated-nitrate-concentrations-groundwater-used-drinking

Figure 17

Well pump depth	PFOA	PFOS	PFHpA
100	1.81	0.742	0
200	3.25	1.18	0.701
300	7.55	3.07	2.08
500	8.29	4	2.14
77	4.85	3.71	1.47
185	6.28	2.87	1.99
AVG	5.338333333	2.595333333	1.396833333



A scatter plot of PFAS values vs. well pump depth, shows a possible positive correlation. This would suggest that PFAS contamination of ground water may be occurring on a broad scale. One way to understand this is that shallow wells receive their water from relatively small regions of fractures within bedrock, while deeper wells can pull from larger areas and are more likely to access contaminated ground water from distant sources. These data, as well as the nitrate data, support the notion that current septic densities, and the zoning by-laws that help maintain them, may need to be considered caps for any future development in Sherborn.

5. What does this all mean?

I constructed this document with a few goals in mind:

1. To provide a resource by which others might *begin* to understand the "highlighted" data used to understand and evaluate land development projects in Sherborn, although the information provided within is far from exhaustive.
2. To explain to reviewers of Sherborn land development projects, both inside and outside of town, why our town is still dependent on well water and septic systems despite the passing of time, and will likely remain so indefinitely.
3. How Sherborn's physical characteristics, regulations, and our land- and ground water-dependence has resulted in a regionally low density of dwellings and population.
4. Suggest why this low density of dwellings and population needs to be maintained for any future developments using well water and septic to insure water quality for current and future residents.

The broader meaning of the information provided above, as well as how to address current and future land development projects, is ultimately for others to decide. I wish them the wisdom, patience, foresight and luck they will need to do so.

Respectfully submitted to the Sherborn ZBA on May 20, 2024
Meredith Wesolowski, 34 Greenwood St., Sherborn, MA 01770