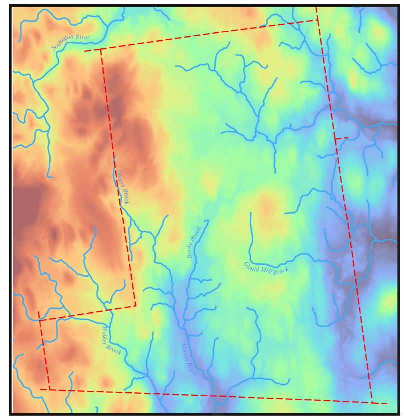
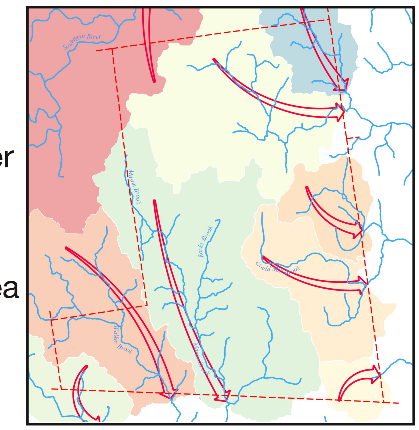
Mason's Terrain and its Implications for Water & Sewage Options



The goal of this assessment is to investigate Mason's terrain - its topography, hydrology, soils and other features - as it affects our water supply and sewage disposal options.

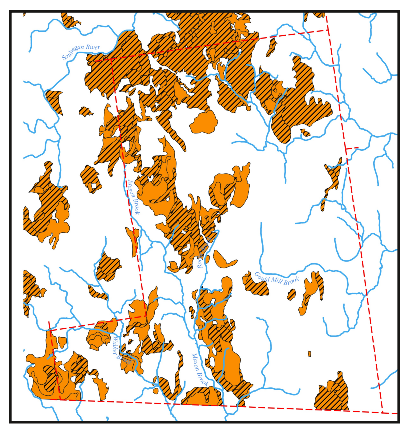
Mason is a "ridge town" with a fairly rugged topography which generally slopes downward towards the Southeast. Its elevations, shown at the right, vary from a low of 340 feet (blue) where Gould Mill Brook leaves to a high of almost 1,100 feet (dark orange) along Batchelder Rd, a difference of about 750 feet. The paths of the mapped brooks, shown as blue lines, result from that topography.



The second map shows the various watersheds along with red arrows showing the general direction of drainage flow.

The Eastern parts of Mason drain Eastward into Brookline, NH, via Mitchell, Spaulding, Lancy and Gould Mill brooks, into the Nissitissit River basin.

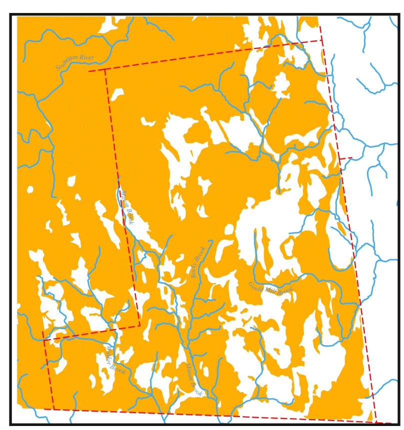
The Western parts of Mason drain Southward into Massachusetts via Walker and Mason brooks into the Squannacook River basin. A small area in Mason's NW corner drains Northward into the Soughegan River in Wilton. The flow in Mason's brooks is far too small to merit government gauging stations, so we do not have any precise flow data.



Mason's soils fall into 54 types, most of which have depths to bedrock of 60" (5 feet) or more. This map shows only the "shallow to bedrock" soils.

The plain orange areas show areas of types 160B, 160C and 160D types which are a mixture of 20", 40" and >60" deep soils - in other words, they include shallow to bedrock areas along with patches of deeper soils.

The cross-hatched orange areas show areas of types 161C and 161D which include only a mix of rock outcrops, 20" and 40" deep soils, along with type 399 rock outcrops - other words, no deep soils.



The USDA Soil Survey rates the soil type suitability for septic system use on a scale of "Slight", "Moderate" or "Severe" restrictions. This last map shows Mason's soils with a "Severe Restrictions" rating for septic system uses.

Soils with a Severe rating suffer from poor or excessive drainage, shallowness, steeper slopes, impervious layers, high water tables, or other issues. Designing a septic system on such soils requires special engineering such as terrain modification, adding restrictive layers, large amounts of fill, or expanded leach fields. While usually feasible, special care is required in the design and construction costs tend to be higher.

Implications for community water systems:

Mason's 750 foot elevation range has severe implications for any community water systems. Just pumping water up 750' requires 326 PSI, plus another 50 PSI for household pressure, plus some more to overcome friction, totaling around 400 PSI. This is more than 5X the maximum waterline pressure and thus requires pressure regulators or pumps in each elevation zone.

San Francisco, California, notorious for its steep hills, has an elevation range is slightly ***smaller*** than Mason's. San Francisco's public water system requires 7 independent distribution networks, each with its own pumping or regulating stations, in order to distribute water at safe pressures to all locations in the city.

Creating a public water distribution system in Mason's terrain would be prohibitively expensive.

Worse, in our cold Northeast climate, water supply pipes must be buried below the "frost line", usually at least 5' deep, to avoid freezing and bursting.

The above "shallow to bedrock" soils map shows that large portions of Mason, especially in its Western and Northern sectors, would require extensive blasting of trenches into the bedrock to support any community water piping (or sewage) system. Such requirements dramatically increases construction costs.

Implications for community sewage systems:

A community sewage system encounters the same problems as a water supply system: extreme elevation ranges and shallow to bedrock issues.

In addition, most sewage treatment plants depend on an adequate size river to accept their treated effluent; Mason does not contain any such river and the flow of its own brooks is far too slight, as are the Squannacook and Nissitissit Rivers into which our brooks flow.

The nearest real river is the Souhegan River to the West and North of Mason's NW high elevation corner. The Souhegan is already used by Greenville's sewage treatment plant. That plant is already operating at a design dilution ratio of less than 6:1 (flow:effluent) and is already at full capacity. Even if the pumping and pipe laying problems discussed above could somehow be overcome, it is unlikely that either the Greenville plant, or the Souhegan River itself, could accept Mason's sewage.

Consequently, community wide solutions to either water supply or sewage disposal problems are infeasible for Mason. Instead, for the long term, we must depend on individual wells and individual septic systems.

All our drinking water comes from our "ground water", and all our sewage fluids return to it.

Ground water protection must be a critical priority in Mason; there is no feasible "Plan B".

Our underground environment:

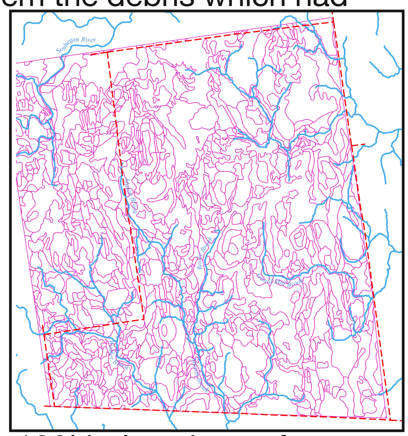
Beneath our feet we find "dirt" of varying thickness laying on top of the granite bedrock. Due to our terrain and glaciation history, Mason's soils are much more complicated than, say, Iowa's.

Our last glacial period began around 80,000 years ago when a global cooling cycle caused ice sheets in Canada to thicken. As their weight increased they spread Southward - like a ladleful of pancake batter spreads out in a pan. At its peak, around 22,000 years ago, that ice sheet had spread well South of New York City, was ~1 mile thick over Mason, and pressing down at ~1 ton per square inch.

In fact, "ice sheet" is a rather misleading description, suggesting something smooth and slippery.

As the ice sheet extruded over the landscape it picked up dirt, rocks and even large boulders, becoming a very abrasive mixture under very high pressure, pushed by irresistible forces. In some areas it cut distinctive "U" shaped valleys through mountain ranges, such as Franconia Notch; in the Northern Midwest it excavated what became the Great Lakes. As it encountered a North facing slope it would thicken until it over-topped it, then would flow over the South facing slope more easily, carrying away most of the loose materials. Mason largely slopes downwards towards the Southeast, so it is not surprising that our soils are often rather thin - our earlier soils are now in Townsend.

Then the global cooling cycle ended and the ice sheet began to melt, finally disappearing from Mason around 15,000 years ago. As it melted vast amounts of water flowed away - some flowing over the ice, some under, some smoothly and some in turbulent bursts as meltwater lakes on the sheet surface opened an exit and drained suddenly. These flows carried with them the debris which had been picked up. Depending on the flow pattern, some deposits were "sorted" - larger rocks would drop out soon, lighter sands would be carried farther, resulting in sand or clay deposits. In other places an unsorted mix of debris was deposited. Large boulders, likely including our Wolf Rock, were deposited wherever the ice sheet carried them. On the surface these are called "glacial erratics", often carried from far away.



Thereafter, over 15,000 years, the deposits were weathered and eroded by rain, freezing, and further modified by plants and other organisms.

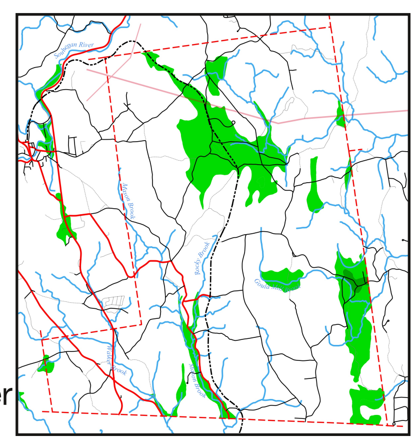
Our "top soil", the upper 5' of interest for agriculture, is classified into 54 different types. The result was a very varied and jumbled set of soils, as mapped at right. Subsoil fills the depth to bedrock, ranging from 0' to over 100' below the surface.

Ground water:

Rain water soaks into the ground; while upper layers may just get damp, at some depth water fills all the pores and cracks in the bedrock and becomes the "ground water". The *water table* is defined as the top of this ground water; its depth below the surface varies depending on the terrain, and varies somewhat during the seasons, being lowest in Fall.

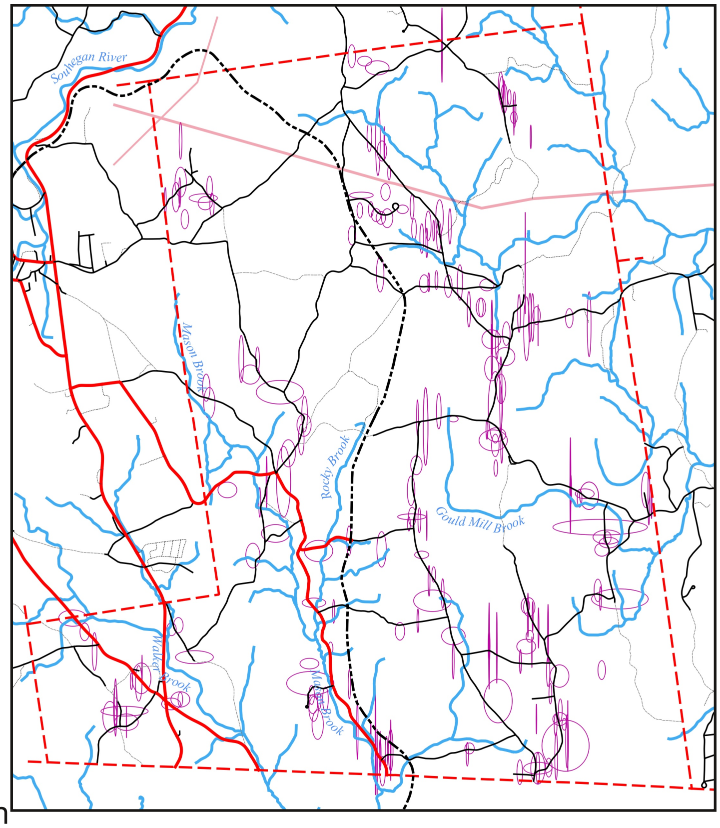
Where the water table reaches the surface we have ponds and streams. Where it is near the surface we have wetlands. The highest seasonal levels, the High Water Table (HWT), is important to farming and septic systems - too high makes an area unusably wet. Lowest water table is also important - if it falls too low then shallow wells run dry and some plants may wilt.

Below the water table everything is flooded by water. This is called the "*saturated zone*" and it is from this zone that we draw our water, and it is to this zone that our sewage liquids eventually return.



Depending on the location, the saturated zone may include include deep gravel deposits in which large amounts of water are stored and from which water is easy to withdraw. Such areas are called "aquifers". This map shows the Mason aquifers identified by the USGS. In those areas wells may be relatively shallow and may produce large amounts of water.

In other areas, indeed in much of Mason where soils are shallow, the water table may fall to within the bedrock where it fills cracks in the granite. Wells in such areas are generally deep and may produce limited flows. Drilling can be an expensive gamble - one is drilling through solid granite in the hopes of finding a crack with good connections to the water table. Indeed, I know of one case in which two wells were drilled to a depth of 1,000 feet without producing any water. Finally, a third well, drilled to 1,200 feet, produced a meager 1/4 gallon/minute!



This map shows the 314 known wells drilled since 1984 when NH began recording. The ellipse height is proportional to the depth drilled, the width is proportional to yield; well location is at centerpoint. Tall thin ellipses = deep wells with poor yields.

For the 314 known wells:

	Depth	Yield	BdRock	S.level
MIN	14	0	0	0
AVERAGE	435	11	24	39
MEDIAN	360	6	10	26
MAX	1,620	100	106	400

Depth in feet; *yield* in gallons/min; *BdRock* is depth to bedrock; *S.level* is static level, i.e., depth to standing water surface in the well.

Of these, 2/3 of wells are less than 400' deep and 90% are less than 800' deep. There are probably an equal unknown number drilled before 1984.

Benefits of drilling in an aquifer area can be lower depth, higher production and, to some extent, a more predictable result. A hazard is that contaminating the well can contaminate the aquifer and thus many other's wells.

Wells drilled into bedrock are much less predictable and more risky in terms of depth and yield, but possibly less of a hazard in terms of contaminating other wells. On the other hand, there is no way to know where the crack(s) that your well taps into connect - it could be a vertical crack leading up to under your, or a neighbor's, leach field (unlikely, but...).

The risk factors for wells include:
  Chemical pollution from spills or leaks
  Bacterial pollution from failed septic systems, livestock manure, etc.
  Failed well casing seals providing a direct path from contaminated surface waters into well
  Natural minerals from the bedrock itself: arsenic, radon (need to test drinking water periodically)

The State requires a 75' radius "well protection zone" from which septic systems, gasoline tanks, livestock pens, fertilizer storage, etc., are excluded. Current town regulations require the entire area to fall within the parcel; state law allows for overlap onto adjacent parcels if protected by easements.

An important concern is that the well casing has been correctly installed to prevent contaminated surface water from reaching the aquifer or bedrock. Recent wells are likely well sealed - standards have risen. *However, the 300 or so unrecorded wells predating 1984 remain a potential concern.*

With any well, the area around the well head should be protected; ideally the ground should slope away to avoid rainwater puddles, and the area is not a good place to park vehicles or store chemicals! Periodic testing of the water for bacteria, radon and arsenic is strongly recommended.

Generally speaking, at present Mason is in fairly good shape as regards its water supply. Most of Mason, with the exception of its Southwest "tail" and a limited Western portion of the adjacent Walker Brook watershed, does not receive waters from outside of town. In other words, any pollution we suffer in most areas will be of our own making and thus locally preventable.

Also, the great majority of wells are residential, thus not directly exposed to industrial chemicals.

Mason's abundant "home business" ecosystem consists primarily of small artisanal operations, or professional services, which are unlikely sources of large scale pollution. Further, the owners' on-site presence provides close supervision and strong motivation to prevent problems. However, a small machine shop or similar operation could, potentially, involve significant quantities of solvents which, if spilled, could reach the ground water.

There was a gas station tank leak which occurred many years ago at the intersection of Routes 124 and 31. Fortunately the tank was still owned by a large oil company that could afford the major remediation effort; the ground water plume has since been judged to be sufficiently diluted. Significant agricultural pollution from a CAFO near Churchill Rd and Rte 124 was eliminated many years ago. Other commercial operations include a couple restaurants and small vehicle repair shops.

We have been very fortunate that no industrial operations have settled here as these are the major potential sources for large spills of industrial chemicals with major ground water consequences. As in the gas tank leak, these can create pollution plumes which take years to remediate at very high cost.

Septic systems:

Private septic systems include tanks to delay the sewage for several days to allow bacteria to break down much of the waste and the pathogens it may contain, and also to allow remaining solids to either settle to the bottom or float on the surface scum. The clear liquids are then allow to flow to a leach field where they are allowed to flow downward to the ground water via sand filtering layers.

Provisions for, and the design of, septic systems is primarily regulated by the State. The fact that most Mason soils are rated as having "severe" limitations for septic systems mandates professional design and approval for new systems. Mason's subdivision regulations require that room for a second leach field be reserved as a back up.

So, it might seem we are in good shape. However, let me present a cautionary note about septic system design standards. Any public regulation embodies a trade-off between the cost of implementing the regulation versus the cost of failure. The costs being balanced are averages - the cost on average of upping the requirements versus the cost on average of failures. This is normal and reasonable practice.

If you are designed a Hubble telescope, then of course you build in multiple redundant systems with wide safety margins. You also expect to pay hundreds of millions, but that pays off when you can swap out systems remotely and get another decade of data.

On the other hand, if you designed a car that way no one could afford to buy it. So you lower your standards and expect failures every few years. Most failures result simply in a tow and repair bill, dismissed as the normal cost of owning a car.

Let me give a more relevant example. The 1968 Greenville Estates subdivision originally used private septic systems which met the standards of the era. By 1996, after almost 30 years of use, enough of the systems had failed that the pollution became severe. The solution was to extend Greenville's sewer system 5 miles to connect the Estates to the existing treatment plant. Of course the cost was quite high, but manageable when amortized across the 189 homes being served.

In short, the 1966 regulations weren't quite good enough, though they did get almost 30 years of use before failure, and, fortunately, there was a reasonable solution.

That it worked out well in Greenville is only because the homes were concentrated in a relatively small area with adequate soil depths and that there was a feasible and economical path along Rte 31 to connect the area to Greenville's existing sewage treatment plant.

Now imagine the cost in Mason of such a project! As discussed above, there would be no affordable "Plan B".

The point being that state wide regulations are intended to apply to an average case, not to outliers. They worked for Greenville but, as discussed earlier, Mason's terrain does make it an outlier.

While the State septic regulations have been tightened considerably since 1968, I believe we would be foolish to blindly assume that they provide solid guarantees of sustainability in our rugged terrain.

The risk factors for septic systems include:
  Poor design with inadequate safety margins
  Overloading - e.g., garbage disposal units, tank undersized for number of users
  Failure to periodically pump out settled solids & floating solids leads to leach field failure
  Improper disposal uses, e.g., flushing solvents, chlorine disinfectants, pharmaceuticals

Summary:

Mason does not have any practical "Plan B" alternative to its current parcel-based private water and sewage systems.

Its water supply depends solely on ground water and protecting its purity must be high priority.

This requires careful attention to proper well construction and maintenance, and to conservative septic system requirements, construction and maintenance. Article XXII "*Aquifer and Wellhead Protection Overlay District Ordinance*" of Mason's Planning (Zoning) Ordinance provides excellent tools for protecting our aquifers - if they are used consistently.

To protect its ground water resources, Mason should avoid permitting any industrial or commercial operations which involve significant quantities of toxic liquids. Remediation can take years and the costs can be extreme.

Mason's large minimum parcel size provides important protection by reducing the density of septic fields, thus reducing the concentration of effluent and providing more time for natural processes to cleanse any effluent that might escape private septic systems. It also spreads out the wells thus reducing the chances of a spill affecting multiple wells as well as increasing the dilution factor.

Educational outreach, especially to new residents, to inform them about proper well and septic system maintenance could be helpful. Many new residents arrive from urban areas where the sewer system is assumed to "take it away"; but there is no true "away" in Mason. Possible sponsors might include Health Officer, Building Inspector, Fire Department or Conservation Commission.

Such guidance should discuss at least the following topics:

Septic systems: avoiding overload (garbage disposals), keeping the septic tank bacteria healthy (don't flush disinfectants, toxic drain cleaners or medicines), periodic pumping to remove sludge and scum (before it breaks through and clogs the field), don't flush toxics, solvents or medicines (they will harm the tank bacteria and will pass through unchanged into ground water), etc.

Well head: importance of preventing contamination (keeping the area around it free of sources, redirecting drainage away), especially with older wells which may not have been as well sealed. Importance of periodic testing for bacteria, arsenic, radon, etc.

Ground water: the importance, where ground water appears on the surface as ponds and streams, of protecting it from contamination through unfiltered runoff from disturbed or fertilized areas.