Isolation Distances

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Purpose of Isolation Distances

Prevention and Reduction of migration of contaminants

What we will cover

Why it matters
Historic overview of drinking water and human impacts

Science and Regulations
Groundwater, soils, geology, permits and regulation

Isolation distances
The core concept

Sources of contamination
And the pathways to drinking water sources

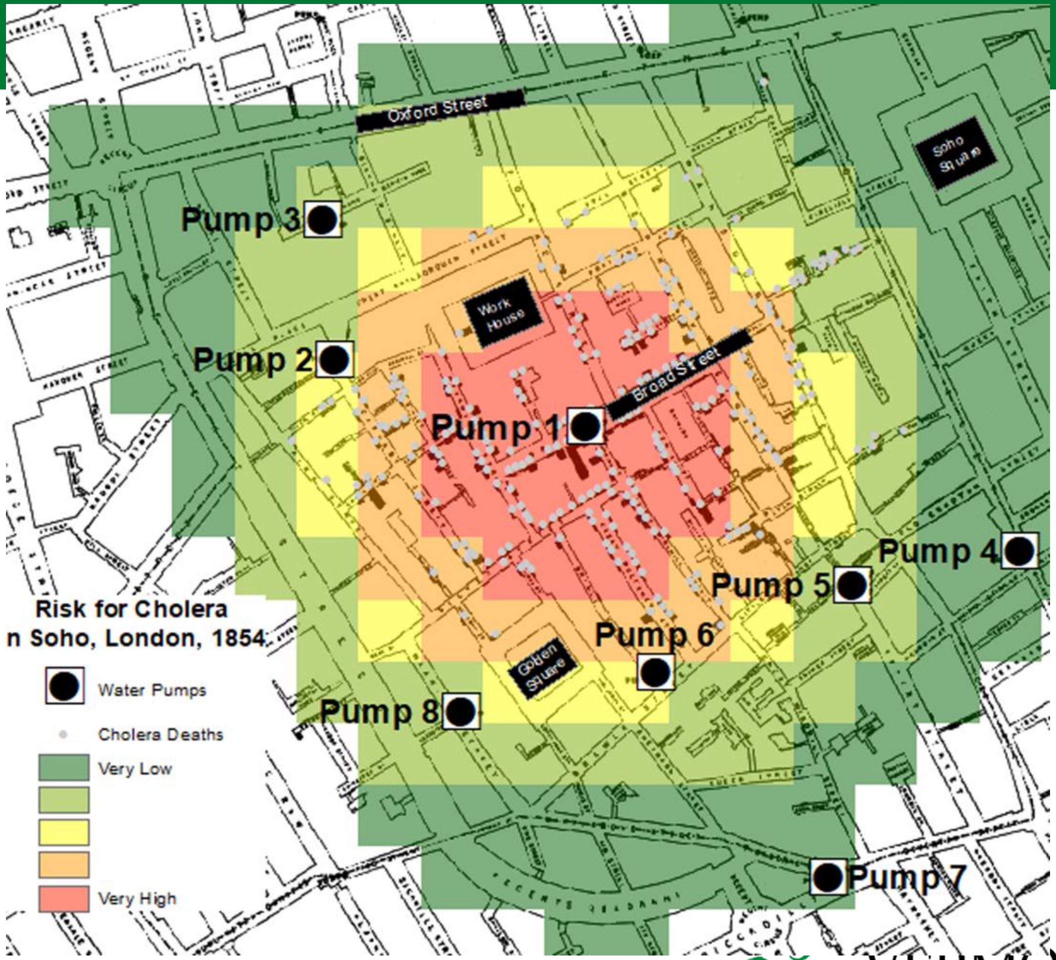
Source Protection Areas
Protection specific to public community water systems

Case Study and Key Takeaways
Key topics from today's session

Why it matters

- Historic perspective of drinking water and human impacts

Cholera 1854 - London



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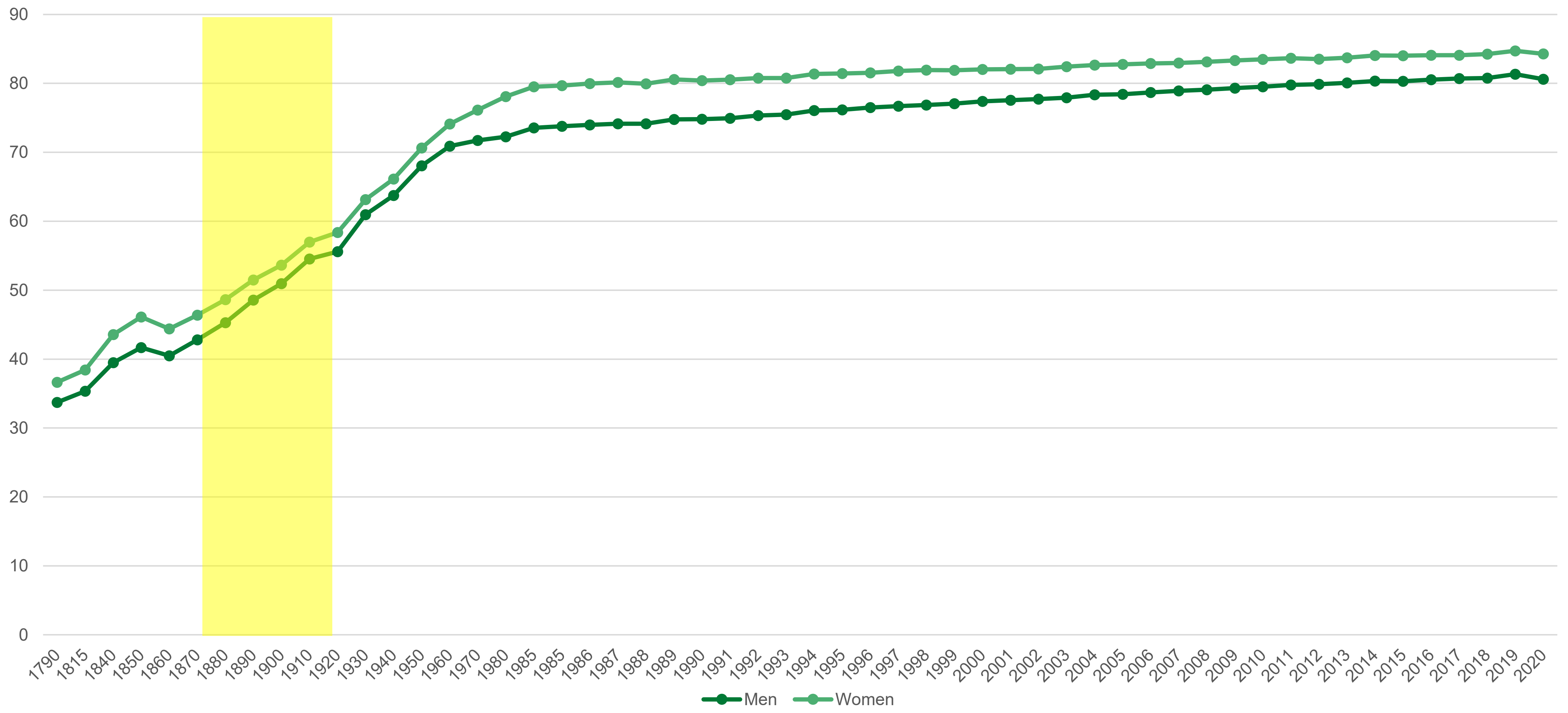
Life Expectancy Increase 1790 - 2020



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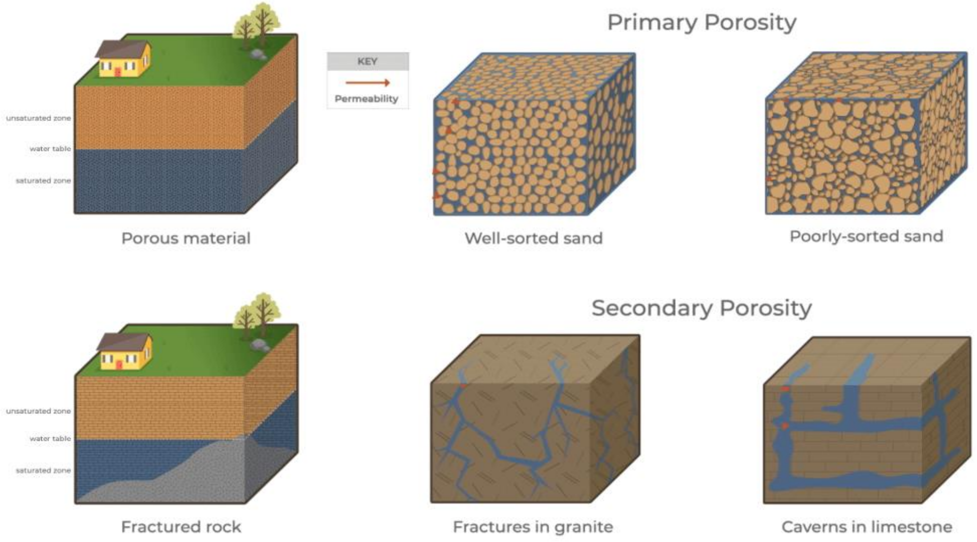
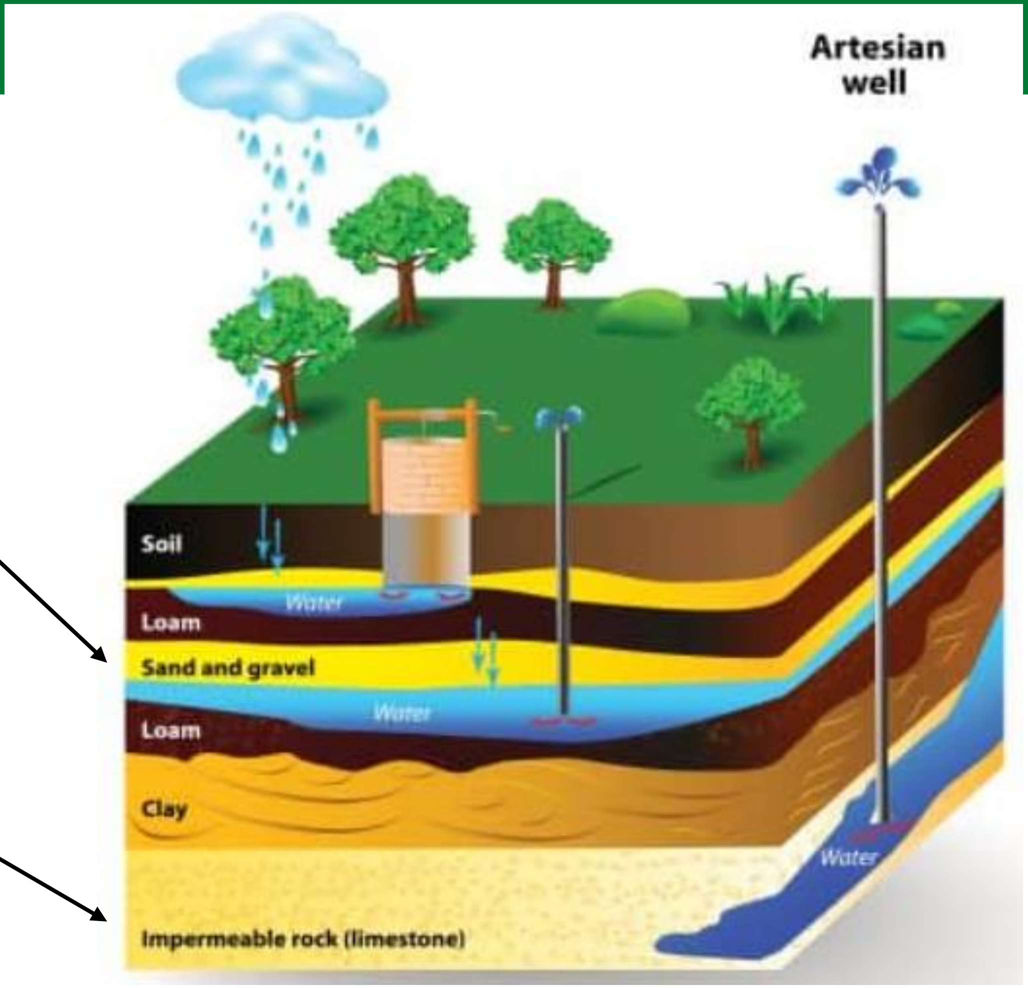
Science and regulation

- Groundwater, soils, geology, permits and regulation



https://geology.utah.gov/water/groundwater/groundwater-aquifers/



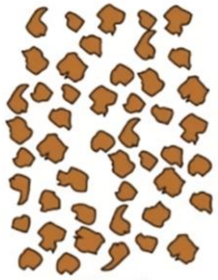
https://nobis-group.com/blog/sand-gravel-vs-bedrock-understanding-aquifer-solutions-for-your-water-supply/

Soil type is everything

The same contamination source can be low-risk in one location and a serious threat a quarter-mile away — because of soil.

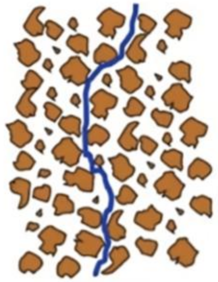
Sand & Gravel
HIGHEST RISK

- Very high permeability
- Lower porosity
- Minimal filtration
- Contaminants travel fast
- Common in VT river valleys
- Often overlays productive aquifers



Loam / Mixed
MODERATE RISK

- Moderate permeability
- Higher porosity
- Some biological treatment
- Depends on clay content
- Most common VT agricultural soil.



Clay / Silts
LOWER RISK

- Very low permeability
- Highest porosity
- Good contaminant adsorption
- Can cause preferential flow paths
- Varved clay common in Champlain Valley

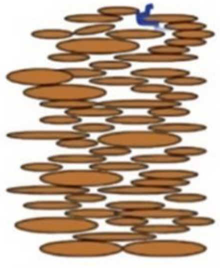


Image: An Easy Guide to Physical Soil Properties: Texture, Density, Porosity, and Permeability | Southern Scientific Ireland

Vermont's Geology: Why it is Complicated

Glacial overburden

Much of Vermont is blanketed in glacial till and stratified drift left by the Laurentide Ice Sheet. Depth and composition vary dramatically across short distances.

Fractured bedrock wells

Majority of drilled wells draw from bedrock fractures. Groundwater in fractures can move fast and unpredictably — traditional setback rules developed for porous media may underestimate risk.

Karst and carbonate rock

Parts of Vermont (especially Franklin and Addison counties) have carbonate bedrock susceptible to dissolution features. Contaminants can travel very quickly through these systems.

Key implications

Standard setback distances were largely developed for uniform, porous aquifers.

Vermont's fractured bedrock and heterogeneous glacial soils mean the same rule may be highly protective in one location — and inadequate in another.

Source Permitting: Private Water

Vermont Wastewater System and Potable Water Supply Rules · Effective November 6, 2023

Who Must Obtain a Permit

- Permit required to construct, replace, or modify a potable water supply serving any building, structure, or campground
- "Clean Slate" exemption for improved lots meeting specified criteria
- Additional exemptions for minor repairs, replacements, and specified low-risk activities

Permit Requirements

- Potable water supply design application submitted to DEC; must include - lot data, design flows, site conditions, and designer credentials
- Site plans and design must be certified by a licensed Designer or Professional Engineer
- Applicant must notify adjacent landowners when a presumptive isolation zone extends onto abutting lots

Permit Process & ANR Role

- Permits may include conditions - monitoring, land use restrictions, operation & maintenance requirements
- Permit must be filed in town land records prior to construction
- Licensed Designer or PE must certify construction/installation was completed per permit

Source Permitting: Public Water

Vermont Water Supply Rule · Effective January 1, 2026

Who Must Obtain a Permit

- Community water systems
- Non-transient non-community systems
- Transient non-community systems serving
- Any system adding or replacing a source
- Systems modifying sources; change in use, drilling deeper, hydrofracturing or otherwise modifying source

Permit Requirements

- Source must meet isolation distance standards
- Hydrogeologic assessment, including pumping test required for groundwater sources
- Source capacity must meet demand
- Source water quality must meet drinking water standards

Permit Process & ANR Role

- Application submitted to VT DEC Drinking Water & Groundwater Protection Division
- ANR reviews isolation distances, site conditions, and source evaluation report
- Permit may include conditions (monitoring, treatment, etc.)
- Operating permit required before serving water

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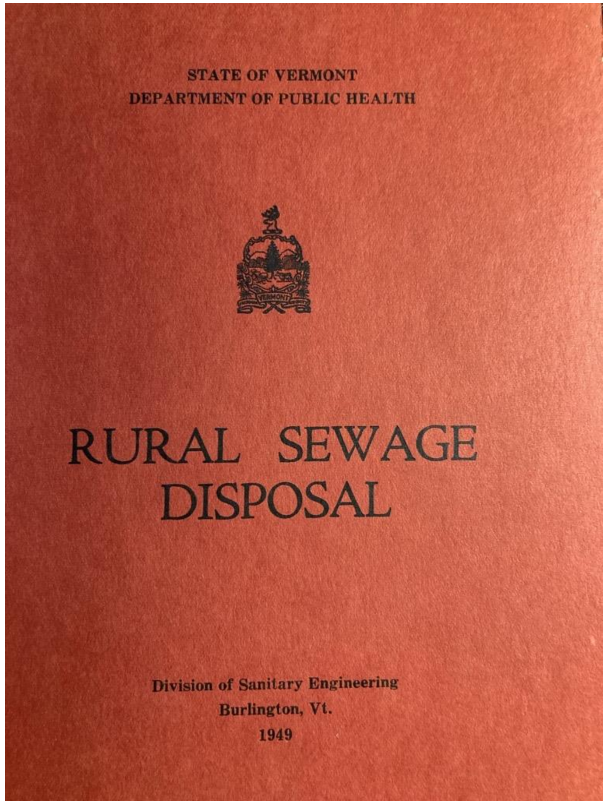
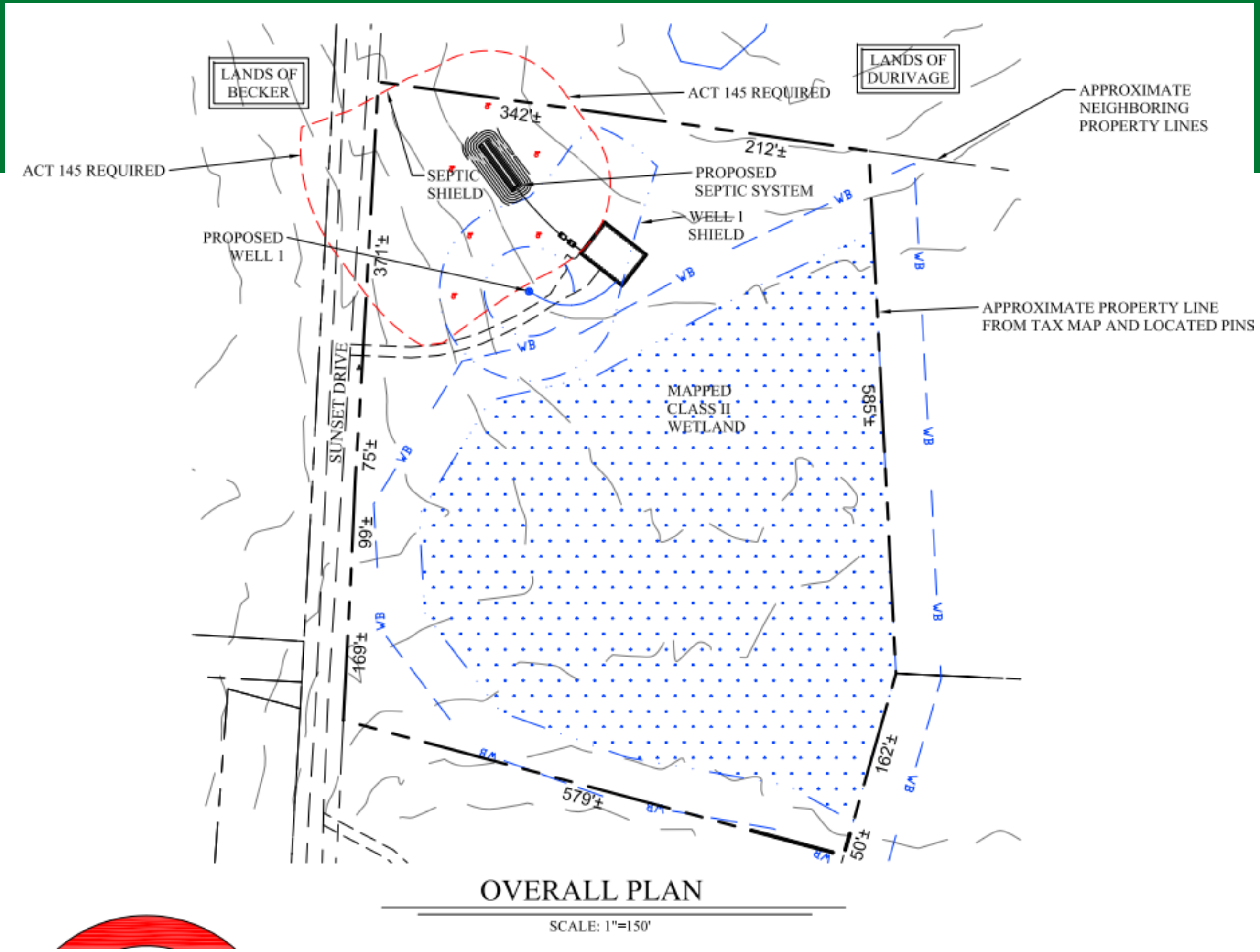
Isolation distances

- The core concept

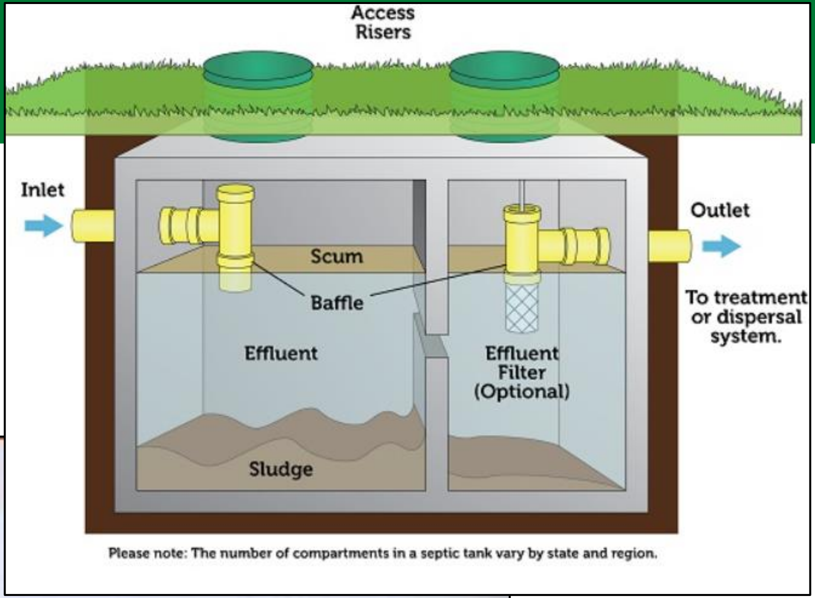


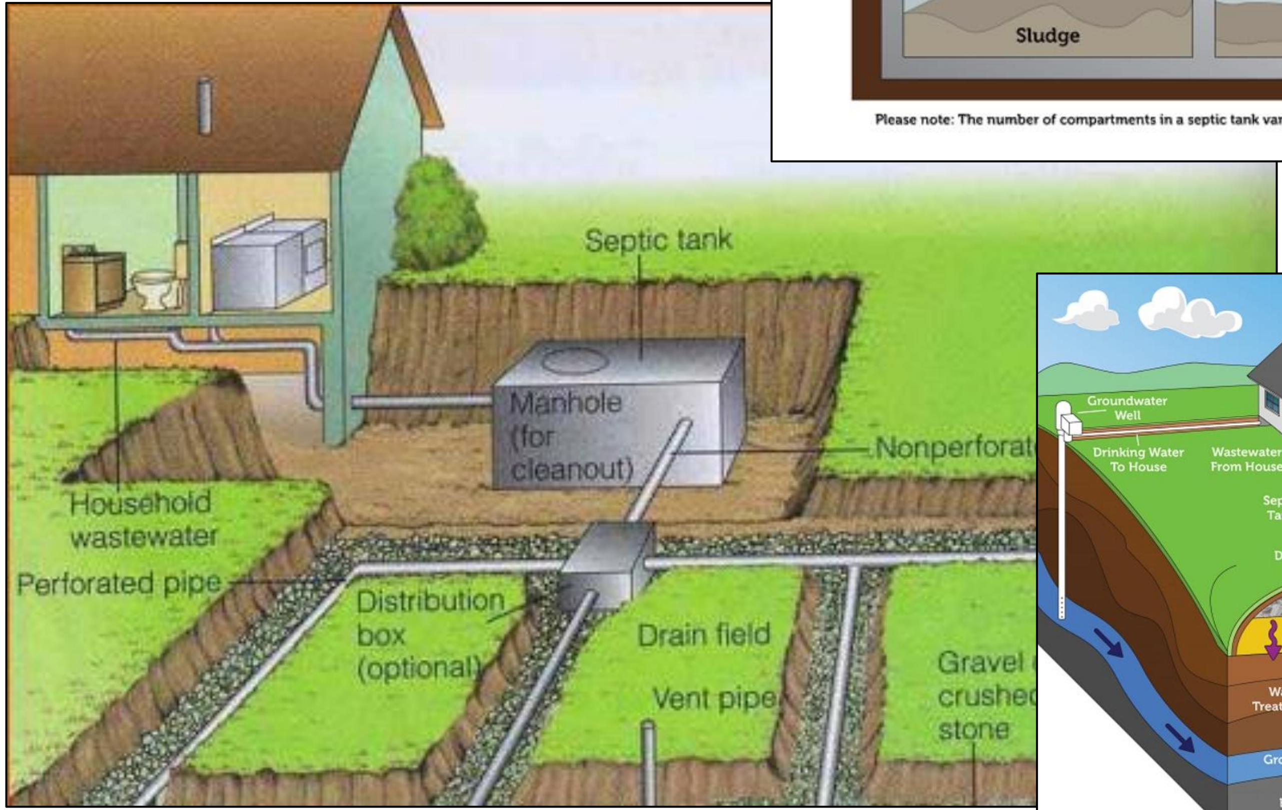


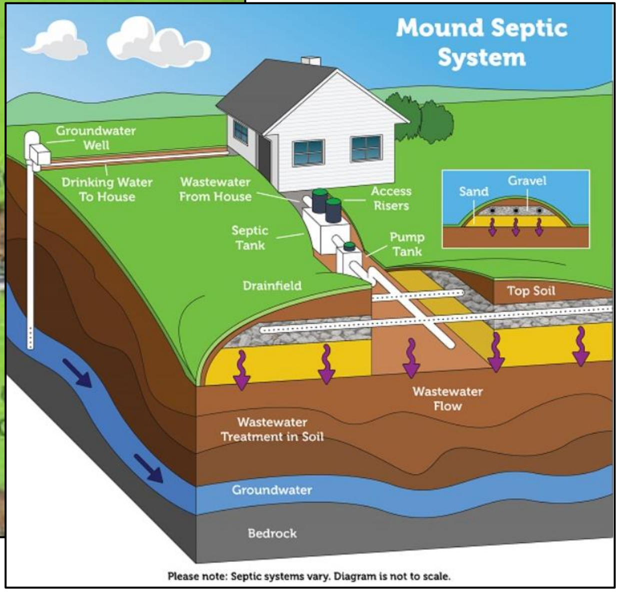
How septic systems work

Process:

- Tank holds the water
    - solids can settle
    - Grease and oil float to the top
- Effluent keeps solids from leaving
- Distribution box splits flow
- Leach field distributes to soils



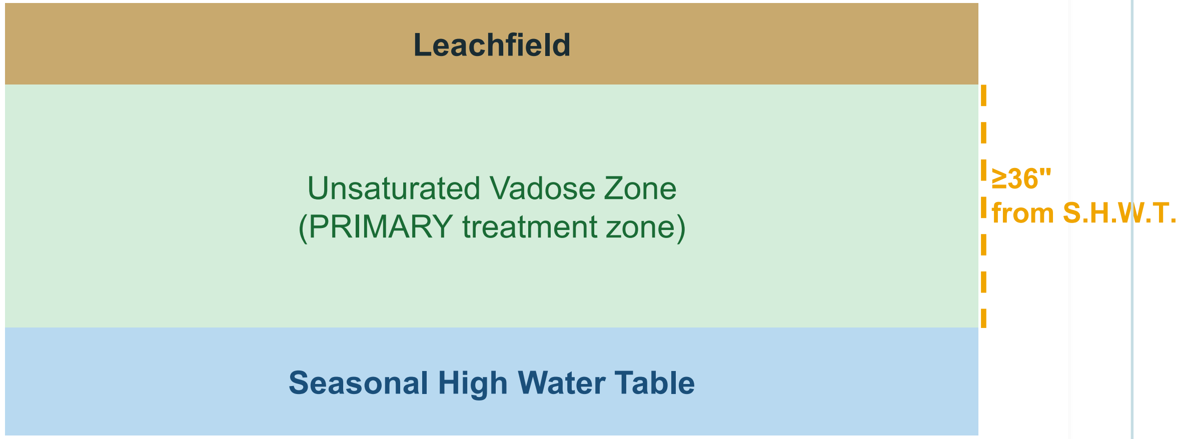




[Types of Septic Systems | US EPA]

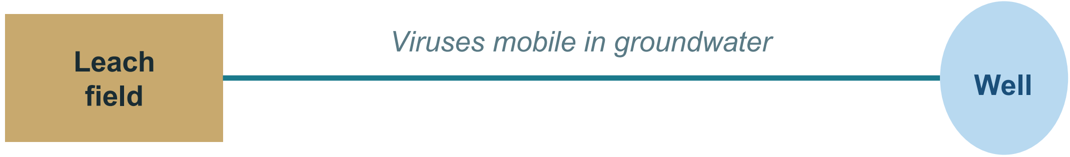
How Soil Removes Viruses

↑↓ VERTICAL SEPARATION



• Unsaturated (vadose) zone is the primary treatment site for viruses
• Mature biomat promotes even effluent distribution
• Saturated flow reduces removal efficiency – which is why we need a min. of 36” of soils to SHWT

←→ HORIZONTAL SEPARATION



• Greater distance = more time for inactivation in groundwater
• VT presumptive isolation zone: depends on size of ww-system and pump-rate of dw-system. Can be reduced if 2-year time of travel (2YTOT) analysis show that the distance between septic and well is greater than the 2YTOT zone, but cannot be reduced beyond the following:
(1) If grouted source, no less than 50 feet.
(2) If source is not grouted, no less than 100 feet.

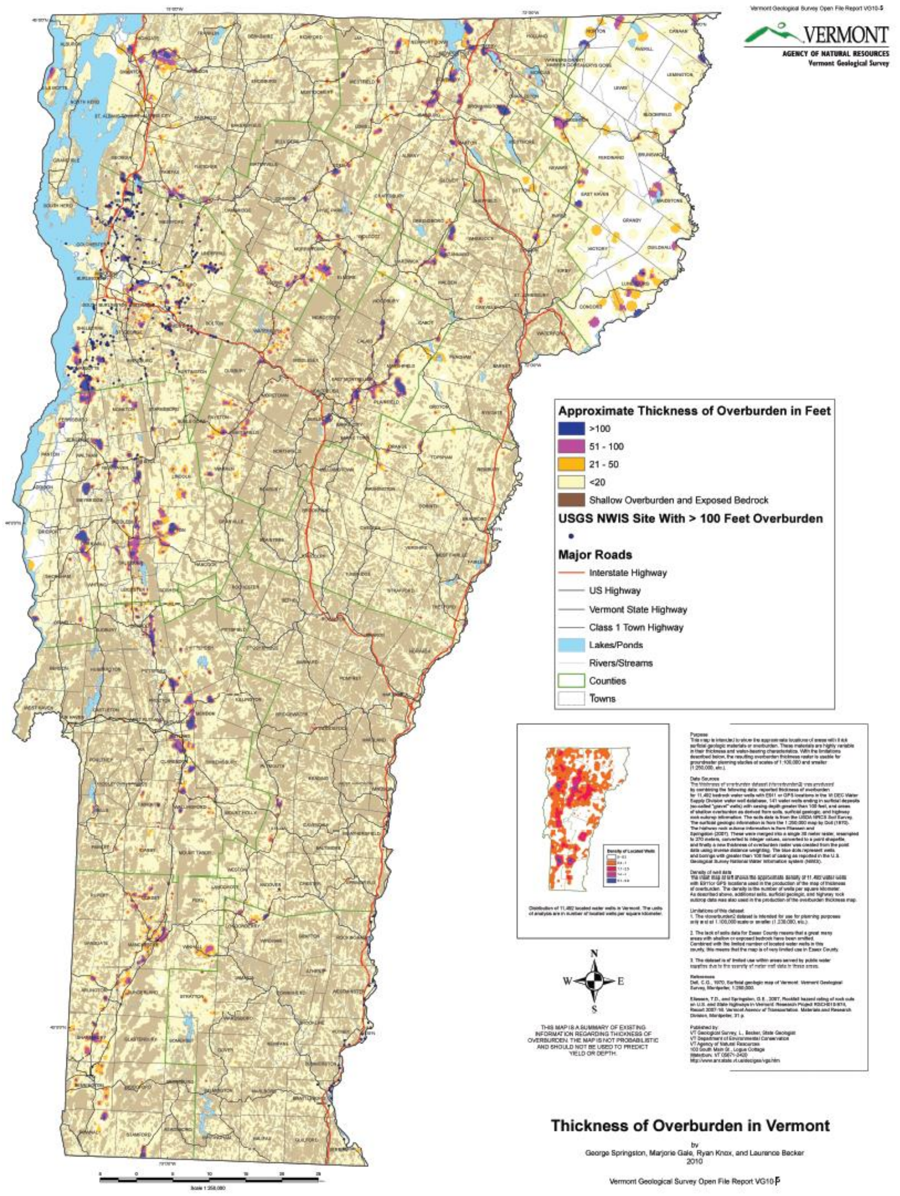
How does geology impact septic systems in Vermont?

Depth to bedrock and seasonal high groundwater table

Overburden Thickness
Depth to bedrock defines the groundwater storage capacity.
Shallow overburden = rapid saturation of soil profile.

Seasonal High Groundwater Table
Shallow overburden on top of bedrock results in near to surface (shallow) seasonal high groundwater table.

Virus Reduction
Virus attenuation primarily occurs in the unsaturated zone – which is why we need a min. of 36” of natural soils to seasonal high groundwater table or a mound system to provide for primary treatment.



Why Virus Removal Matters

Viruses in Wastewater

Human waste contains viral pathogens — including enteroviruses, norovirus, and hepatitis A — at concentrations capable of causing illness at extremely low doses.

Groundwater at Risk

Studies have found viruses traveling >100 ft from leach systems.

Groundwater movement is highly variable across different soil and geology.

Standard Systems Work

Research showed standard septic tank-leachfield systems can remove >99.9% of viruses (3 log) through 5 ft of suitable soil - when properly sited and designed.

EPA regulation currently require >99.99% (4 log) virus removal for safe drinking water consumption.

Source: Barnstable County Dept. of Health & Environment, 1998–2001 and EPA Groundwater Rule

Isolation Distances for Different Categories of Water Systems

Wastewater System and Potable Water Supply Rule – Chapter 1

PRIVATE/POTABLE - SOURCES

- Horizontal setback distances based on table 11-1

Water Supply Rule – Chapter 21

NON-COMMUNITY WATER SYSTEM - SOURCES

- Horizontal setback distances based on table A11-1

COMMUNITY WATER SYSTEMS - SOURCES

- Permitted and Prohibited activities in Zone 1 (200FT)
- Own and control Zone 1

Implications of land use regulation

- Once a source is developed, other landuse regulations are required to protect that source.
  - Septic systems
  - Stormwater practices
  - Above/below ground storage tanks
  - Application of manure
  - Etc.
- Overshadowing:
  - Prohibited activities on neighboring properties due to isolation distances

Isolation Distances – wastewater components

Water Supply Rule – Chapter 21

NON-COMMUNITY WATER SYSTEMS

- **Table A11-2 – Required Minimum Horizontal Separation Distances To Sewage System Disposal Fields**

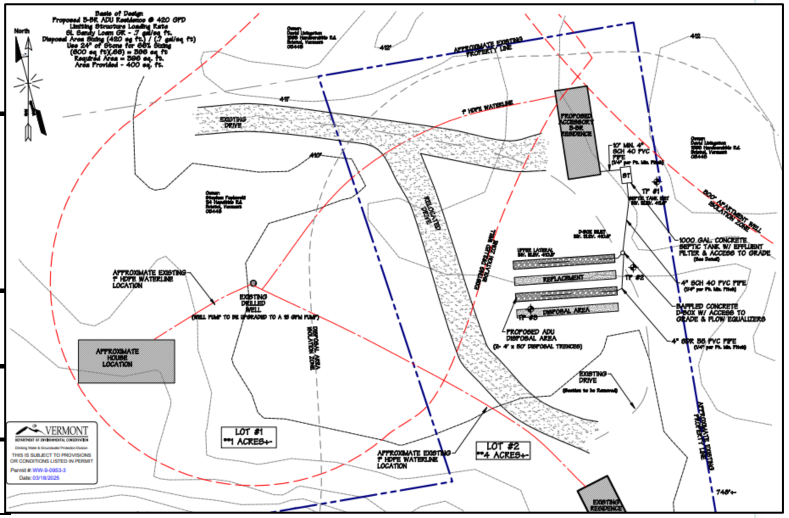
REQUIRED MINIMUM HORIZONTAL SEPARATION DISTANCES TO SEWAGE SYSTEM DISPOSAL FIELDS[1,2] (Feet)

Design Flow of Domestic Sewage System Disposal Field (GPD)	Water Source Maximum Daily Demand (GPM) 0-1.9	2.0-4.9	5.0-7.9	>8.0
Fewer than 2,000	100	150	200	200+[a]
2,000 through 6,499	150	150	200	200+[a]
Equal to or Greater than 6,500	200++[b]	200++[b]	200++[b]	200+[a]

Wastewater Systems and potable Water Supply Rules – Chapter 1

POTABLE SUPPLIES

- **Table 11-2 - Distances, in Feet, Used to Create Isolation Zones Around Components of Wastewater Systems and Replacement Areas**



If a well is proposed within the determined isolation distance of a soil-based wastewater system, or vice versa, a 2 Year Time of Travel assessment can be done to reduce the isolation distance.

Two Year Time of Travel (2YTOT)

What is a 2 Year Time of Travel Management Zone?

- Identifies the distance traveled by groundwater in a 2-year timeframe
- Used because viruses are identified to die off or become non-infectious in Vermont GW temperatures after 2 years
- The 2YTOT zone is determined using groundwater flow modeling or a simplified analytical calculation based on:
  - **Hydraulic conductivity** of the aquifer (how easily water moves through the material)
  - **Hydraulic gradient** (the slope of the water table, which drives flow direction and velocity)
  - **Effective porosity** of the aquifer material (what fraction of the volume is actually transmitting water)
- Not relevant for surface water – need treatment no matter what

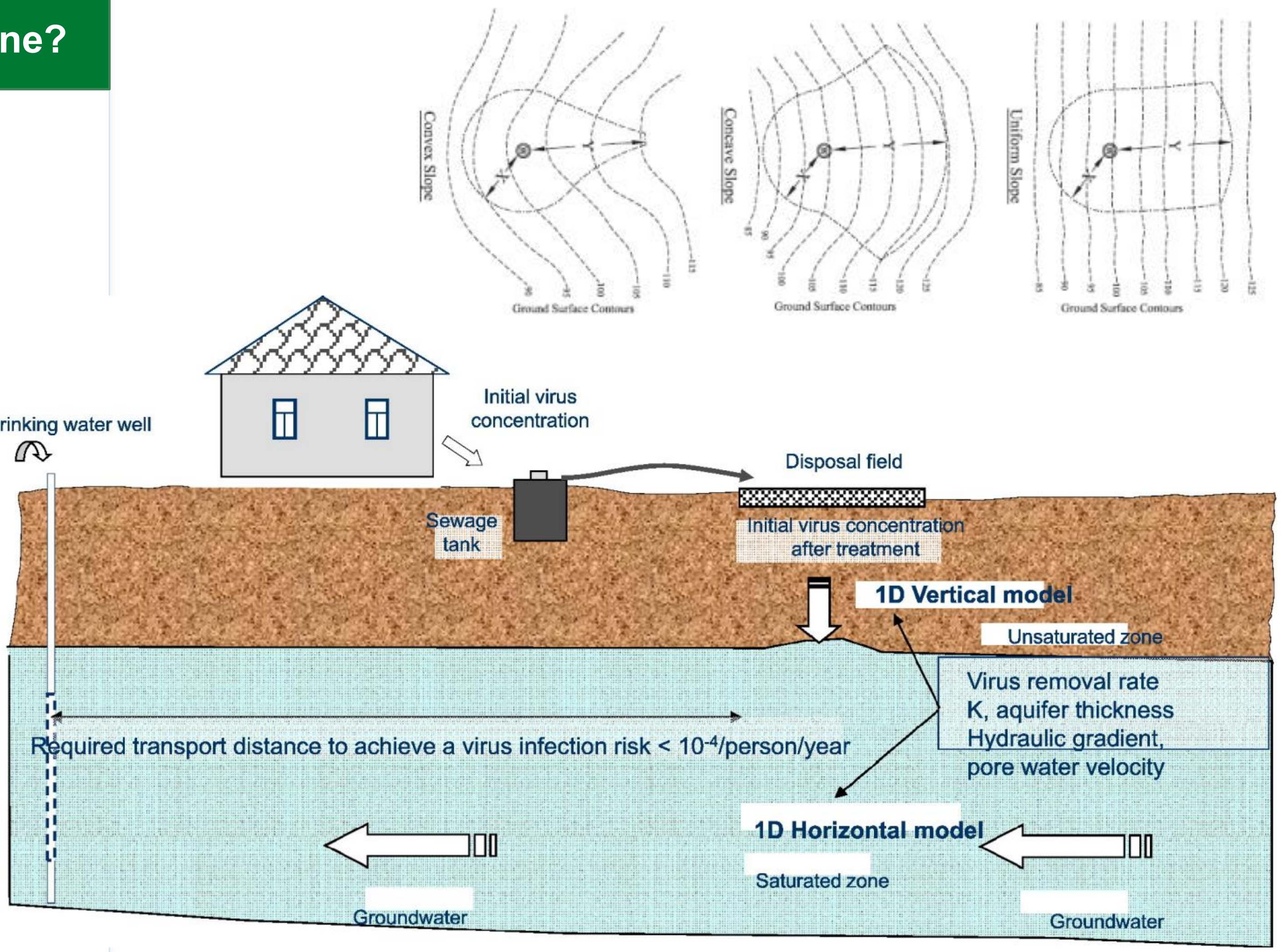


Image: Setback distances between small biological wastewater treatment systems and drinking water wells against virus contamination in alluvial aquifers - ScienceDirect

Two Year Time of Travel (2YTOT)

Why it's hard to assess? - Assumptions and limitations

1. A lot of site-specific data is necessary to understand hydraulic conductivity, gradient and porosity, without it assumptions must be made.
2. Majority of drilled wells draw from bedrock fractures. Groundwater in fractures can move fast and unpredictably.
3. Viruses are highly mobile in groundwater, but how mobile and what's the loading rate is still an unanswered scientific question – and not included in the 2YTOT analysis.

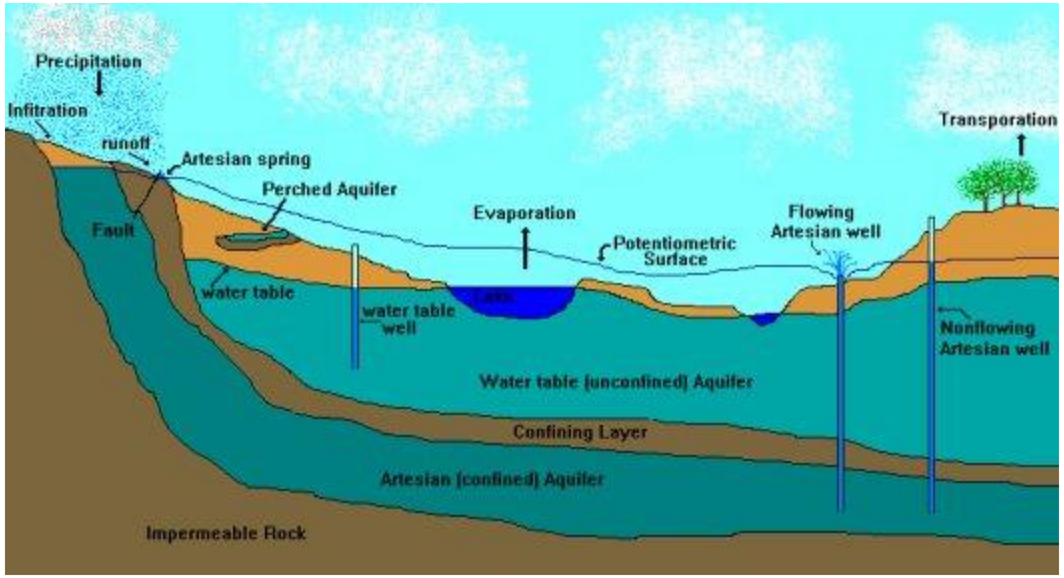


Image: Glossary | Environmental Health & Safety | Michigan State University

Isolation Distances – non-wastewater components

Water Supply Rule – Chapter 21

NON-COMMUNITY WATER SYSTEMS

- Table A11-1 - Required Horizontal Minimum Separation Distances

Wastewater Systems and potable Water Supply Rules – Chapter 1

POTABLE SUPPLIES

- Table 11-1 - Horizontal Isolation Distances, in Feet for Potential Sources of Contamination (when siting a source)

Example

Non-wastewater components

Potential Source of Contamination	Water Sources in Bedrock or confined surficial aquifer (ft)	Water Sources in unconfined surficial aquifer (ft)
Cropland	100	200
Cemeteries	100	150
Herbicide application	100	200
Sewer lines	50	75
Stormwater treatment practice (unlined and subsurface systems)	100	150

Key Takeaways

- Human waste contains pathogens that can travel far in groundwater.
- The min. isolation distance of 100ft between septic system and drinking water sources has been in place since 1949.
- The isolation distance can be reduced, but it requires a complicated analysis (2YTOT).

Source: https://pikeconservation.org/protecting-your-drinking-water-source/

Other sources of contamination

- And the pathways to drinking water sources

Source: https://pikeconservation.org/protecting-your-drinking-water-source/

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Road Salt (Chloride) Contamination

20M+ tons

road salt used
in US per year

No federal standard

for chloride in
drinking water

Permanent

once in aquifer —
not biodegraded

Sources

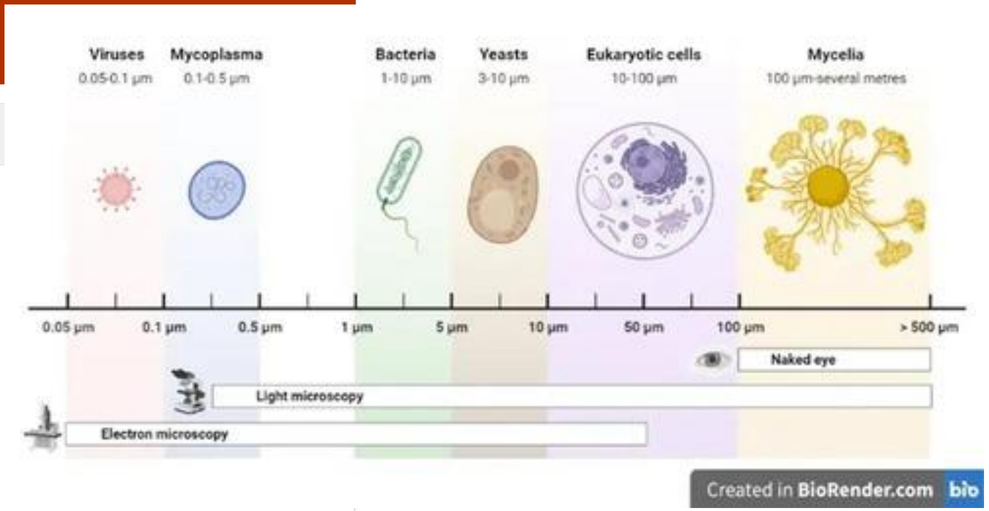
- Winter road maintenance — sodium chloride (NaCl) and calcium chloride ($CaCl_2$) applied to highways, roads, parking lots, and bridges
- Unprotected salt storage facilities — stockpiles leach chloride directly to soil and groundwater, especially from unlined pads
- Residential and commercial de-icing products applied to driveways and sidewalks
- Water softener regeneration brine discharged to septic systems or drywell

Pathway to Supply

- Snowmelt runoff carries dissolved chloride directly into streams, rivers, and lake intakes — concentrations spike sharply following melt events
- Infiltration through road shoulders and drainage ditches transports chloride conservatively (no attenuation, no degradation) to shallow unconfined aquifers
- Long-term trend: background chloride in northeastern US streams rising ~3% per year; private well contamination near roads is increasingly common

Biological & Agricultural Contaminants

Pathogens



SOURCES

- Septic systems and leach fields (bacteria, viruses, protozoa)
- Failing sewer lines and combined sewer overflows (CSOs)
- Animal waste from farms, pastures, and stormwater runoff
- Wildlife (geese, deer, beavers) near surface water intakes

PATHWAY TO SUPPLY

- Runoff carries pathogens directly into streams and reservoir intakes during rain events
- Shallow infiltration through sandy or gravelly soils transports microbes to the water table — especially near septic systems
- Fractured bedrock creates rapid transport channels bypassing natural soil filtration
- Risk increases when wells are shallow and/or poorly constructed.

Biological & Agricultural Contaminants

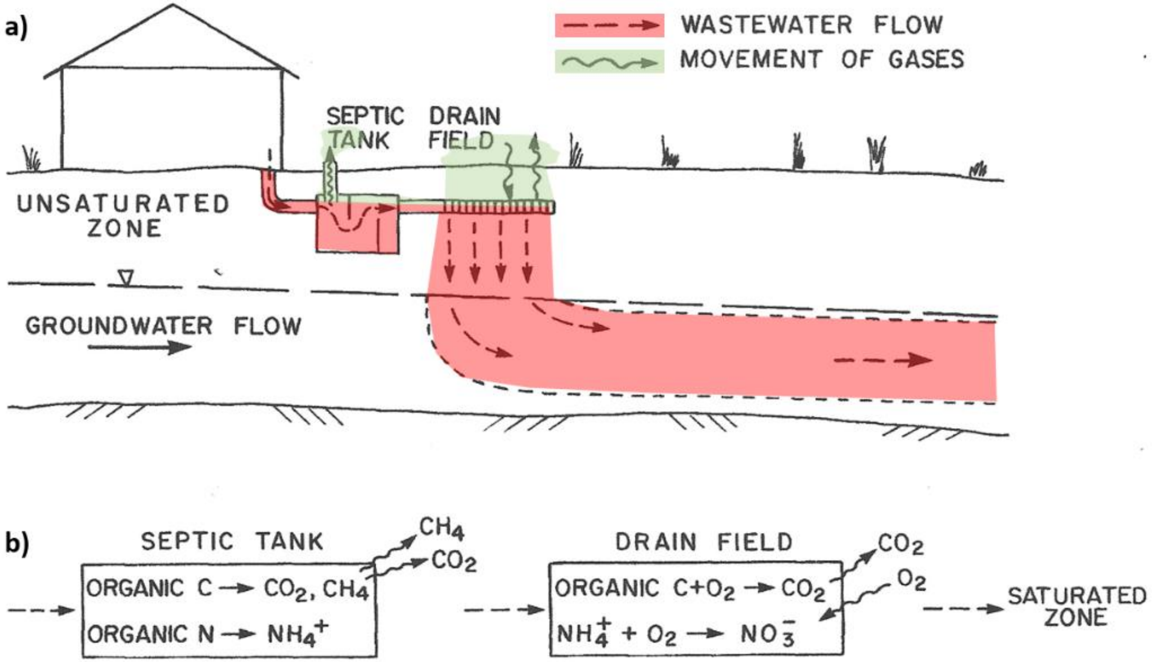
Nitrate (NO_3^-)

SOURCES

- Agricultural fertilizers (synthetic nitrogen — ammonia, urea) applied to cropland
- Manure management — land application and lagoon leakage
- Septic system effluent (residential and commercial)
- Urban lawn fertilizers and golf course inputs

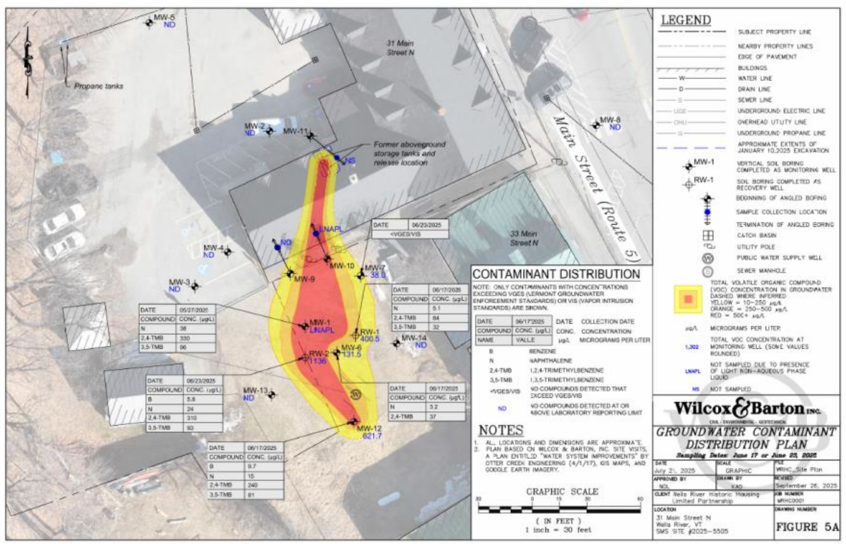
PATHWAY TO SUPPLY

- Highly water-soluble and not adsorbed by soil — leaches readily through the vadose zone to groundwater
- Surface runoff carries nitrate into streams and lakes, driving eutrophication upstream of intakes
- Can migrate far from the source
- Anthropogenic inputs can exceed the natural rate of denitrification
- Drinking water MCL: 10 mg/L as N — risk of methemoglobinemia (blue baby syndrome) in infants



Industrial & Chemical Contaminants

Volatile Organic Compounds (VOCs)



SOURCES

- Underground storage tanks (USTs) — leaking fuel oils (benzene, toluene, MTBE)
- Dry cleaning facilities — tetrachloroethylene (PCE/PERC)
- Industrial degreasing — trichloroethylene (TCE)
- Spills and improper disposal at industrial and commercial sites

PATHWAY TO SUPPLY

- LNAPL (light non-aqueous phase liquid, e.g. fuel oil) floats on the water table and migrates downgradient, slowly dissolving VOCs into groundwater
- DNAPL (dense, e.g. PCE/TCE) sinks through the aquifer, creating deep and persistent contamination plumes that are difficult to remediate
- Dissolved VOCs travel with groundwater flow
- Vapor intrusion into building foundations and utility corridors is a secondary exposure pathway

Industrial & Chemical Contaminants

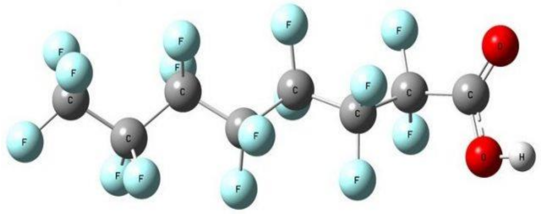
PFAS: Per- & Polyfluoroalkyl Substances

SOURCES OF PFAS

- AFFF (aqueous film-forming foam) used at military bases and fire training facilities among other accident sites
- Industrial manufacturing — fluorochemical plants and metal plating facilities, treatment of fabrics and materials
- Consumer products — non-stick cookware, food packaging, stain-resistant fabrics
- Municipal biosolids (treated sewage sludge) applied to agricultural land

PATHWAY TO WATER SOURCE

- Highly mobile in groundwater — not adsorbed by soil particles; migrates rapidly and far from the source to supply wells based on site-specific conditions
- Extremely persistent — resists biodegradation ("forever chemicals"); contamination persists for decades after the source is removed



PFAS in Schools

- 2018 Pilot:
  - 10 schools selected
    - 2 systems exceeded 20 ppt Health Advisory
    - 3 systems had detections but below 20 ppt
    - 5 systems were non-detect.
- PFAS sampling since 2019:
  - 36 schools/childcare water systems have had at least one detection for PFAS
  - 7 schools exceeded the 2020 PFAS MCL
  - 1 school has already exceeded the 2026 MCL (it had also exceeded the 2020 MCL multiple times)
- Based on historic results, we expect at least 7 more schools to exceed the 2026 MCL(s).

Not all contaminants behave the same

Contaminant type	Common sources	Mobility	Persistence	VT relevance
Road salt (chloride)	Roads, parking lots	**Very high — highly soluble**	**Permanent — no breakdown**	Growing VT concern
Bacteria / pathogens	Septic, manure, wildlife	**Moderate — filtered by soil**	**Short — dies off**	Key driver of setback rules
Nitrate	Septic, manure, fertilizer	**High — doesn't bind to soil**	**Long — doesn't degrade**	Issue in ag areas and near septic systems
Petroleum (BTEX)	ASTs, USTs, fuel spills	**Moderate — some sorption**	**Variable — biodegrades slowly**	Many VT sites, esp. rural
Chlorinated solvents (PCE, TCE)	Dry cleaners, industrial	**High — moves with water**	**Very long — decades**	Urban/industrial VT sites
PFAS	Industrial, septic, biosolids	**High — moves with water**	**Very long — decades**	Urban/industrial VT sites/septic

Source Protection – Public Sources

What and Why

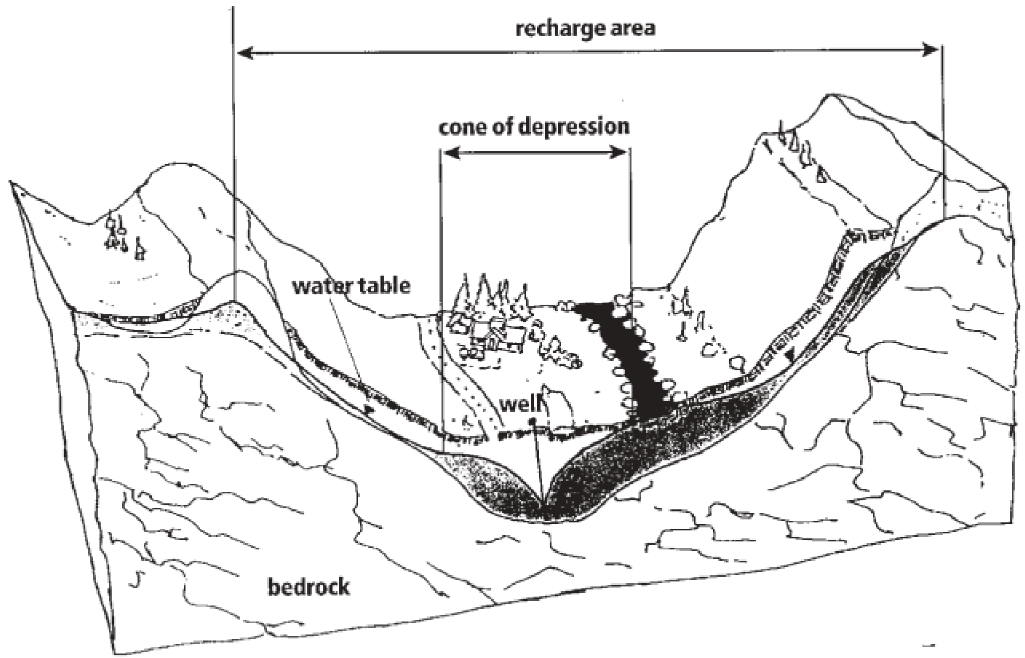
What

- Proactive, land-use-based strategy to protect the recharge area around a drinking water source — a well's capture zone or a surface water watershed — from activities that could introduce contaminants before they reach the intake.
- Multi-barrier approach to public health protection:
  - **Source Water Protection**
  - Treatment
  - Distribution System Integrity

Why

- Prevention beats treatment
  - Cheaper
  - Less energy intensive

RECHARGE AREA



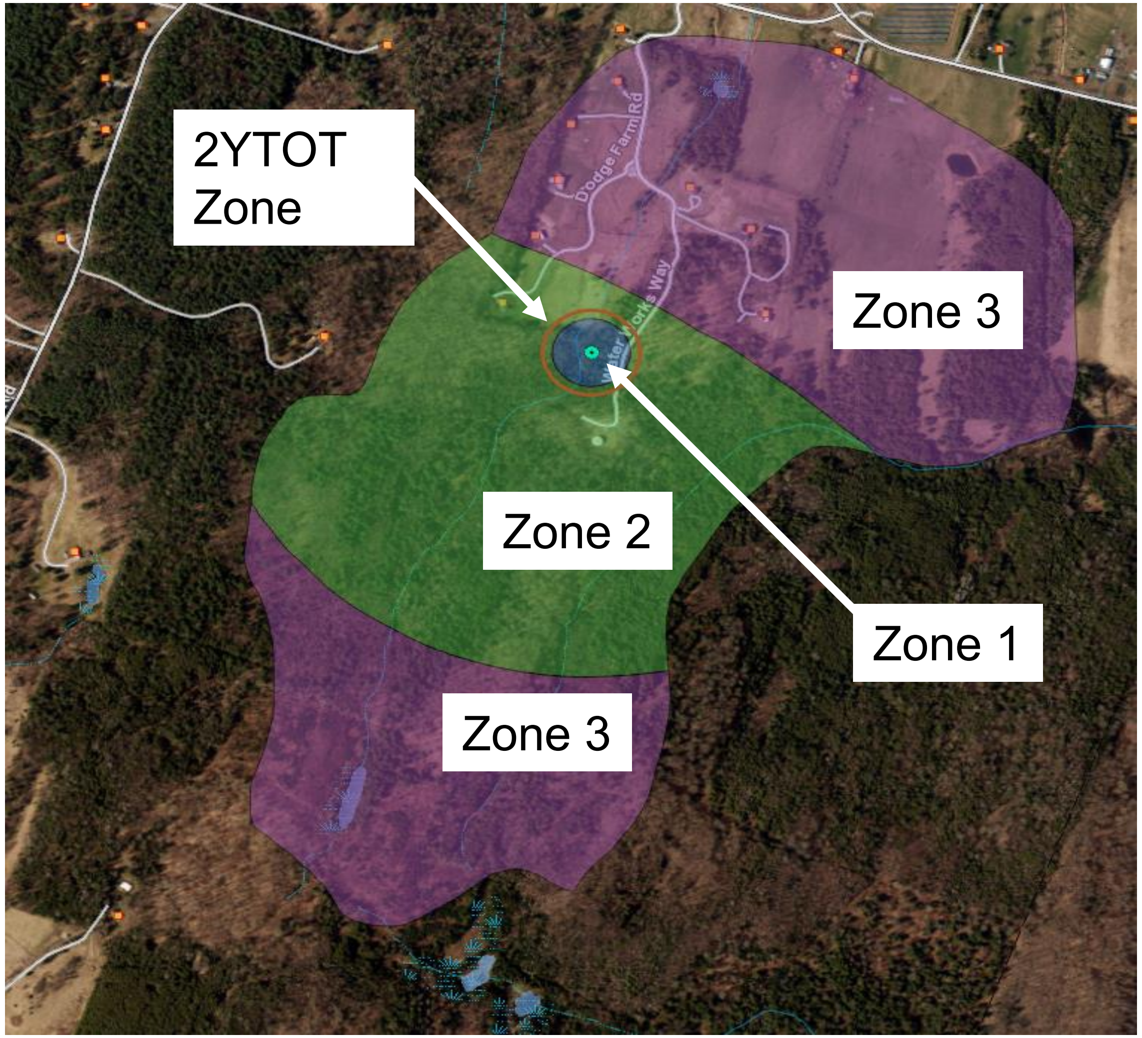
Source: Hust, R. and J. Murphy. *Protecting Connecticut's Groundwater: A Guide for Local Officials.* CTDEP. Hartford. 1997

Source Protection Area (SPA)

Public Water Systems, Water Supply Rule – Chapter 21

COMMUNITY WATER SYSTEMS – GROUNDWATER

- **Zone 1 (Isolation Zone)** – circle around well/spring (usually 200 ft radius) where impacts from potential sources of contamination are likely to be *immediate and certain*. Only zone a new system is required to own/control.
- **Zone 2** – areas outside Zone 1 where there will be *probable impacts* from potential sources of contamination.
- **Zone 3** – remaining recharge area or area of contribution to the source not delineated as Zone 2, and where there may be *possible impacts* from potential sources of contamination.



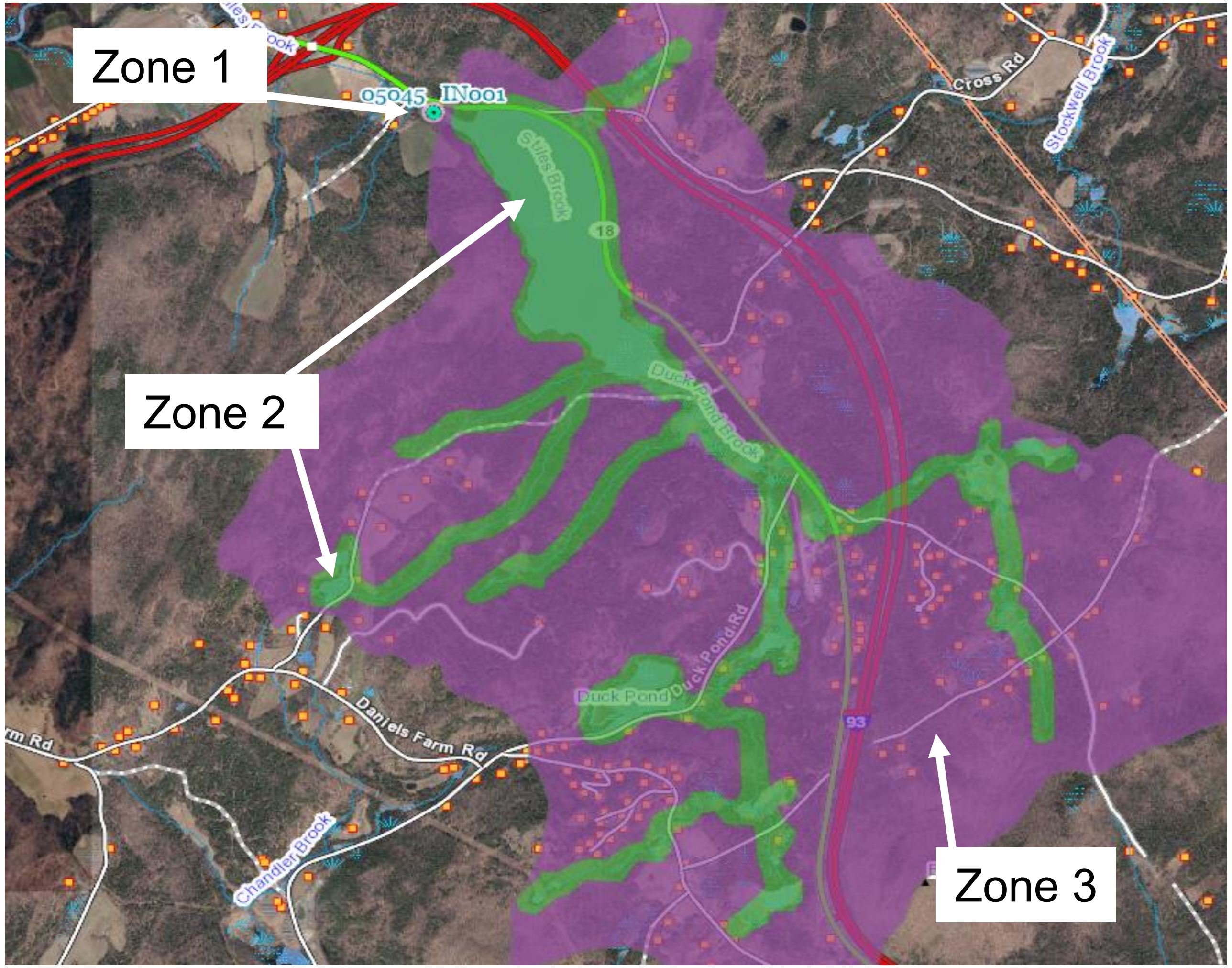
Source Protection Area (SPA)

Public Water Systems, Water Supply Rule – Chapter 21

SURFACE WATER

- **Zone 1** – circle around intake (usually 200 ft radius).
- **Zone 2** – areas within the watershed located within 200 feet of perennial surface water and limited to 17,000 acres.
- **Zone 3** – remaining watershed area beyond Zones 1 and 2. May be reduced on a case-by-case basis considering the size of the watershed and the likelihood of contamination of the source.

- Watershed: "a land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean." - NOAA



Source Protection Area (SPA)

Zone 1

Circle around well/spring (usually 200 ft radius) where impacts from potential sources of contamination are likely to be immediate and certain.

Must be owned/controlled by the Water System

Public Water Systems, Water Supply Rule – Chapter 21

PROHIBITED ACTIVITIES IN ZONE 1

(i) application of nitrogen or pesticides or herbicides;
(ii) buildings other than those required for the water system;
(iii) parking of motor vehicles;
(iv) chemical or fuel storage except natural gas or propane and other chemicals that are required by the water system;
(v) swimming pools;
(vi) driveways, roadways, parking lots;
(vii) septic tanks, leach fields, sewer lines, wastewater disposal spray area and lagoons and wastewater tanks;
(viii) use of preservative treated wood;
(ix) transformers containing PCBs;
(x) cemeteries;
(xi) salvage yards;
(xii) concentrated grazing or holding of animals and silage and manure storage systems;
(xiii) Stormwater conveyance, treatment, or control practices and storm sewers;
(xiv) commercial or agricultural composting sites;
(xv) flood ways;
(xvi) non-sewage wastewater disposal field;
(xvii) solid waste transfer facilities;
(xviii) solar power systems and battery energy storage systems associated components and appurtenances; and
(xix) any other activity which may contaminate the water source

PERMITTED ACTIVITIES IN ZONE 1

(i) source operation and maintenance;
(ii) playgrounds, ball fields, tennis courts;
(iii) seasonal light duty access roadway or driveway;
(iv) conservation zones;
(v) controlled use of potassium and phosphorous fertilizers; and
(vi) other uses which have the approval of the Secretary

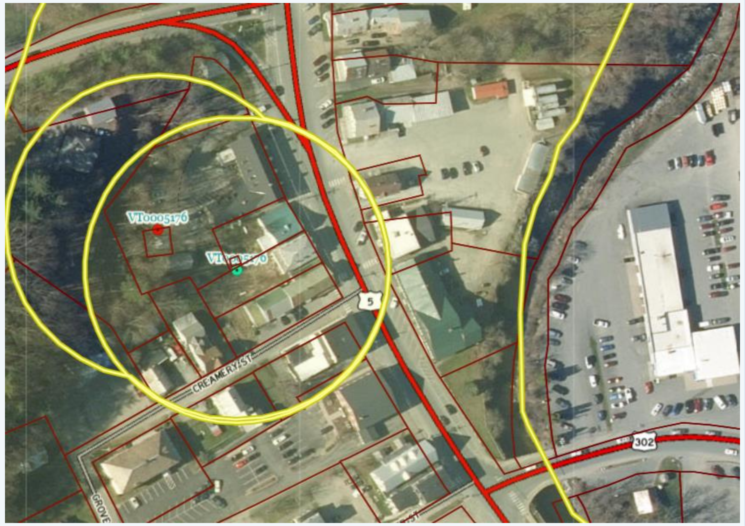
No portion of a wastewater system shall be located in a Zone 1 of a Public Community Water System Source Protection Area, except a replacement system that replaces an existing wastewater system located in the same Zone 1.

VT Case Study – Wells River Village Water System

31 Main Street N, Wells River, VT · SMS Site #2025-5505 · Corrective Action Plan, October 2025 · Wilcox & Barton, Inc.

Well Description & Location

- Public supply well installed circa 1956
- Located ~85 ft south of the heating oil spill source
- Serves all village residents and commercial businesses
- Well taken offline July 21, 2025; water trucked from alternate source; planned restart November 2025



Contamination Status

- LNAPL detected in monitoring well MW-1 within ~8 weeks of spill, just 30 ft from supply well
- Groundwater flow direction: south-southeast toward well; advective transport rate estimated at ~700 ft/year (not accounting for retardation or pumping)
- Neither LNAPL nor dissolved-phase contamination detected in water supply well while in operation
- ANR-DWGPD will NOT permit repair or replacement of WL001 if damaged during remediation, as the source does not meet current isolation setback requirements per WSR.

Key Concerns & Protective Factors

CONCERNS

- Proximity of LNAPL plume (~30 ft) creates acute risk to sole village supply
- Pumping well cycling may accelerate downward migration of contamination to well intake
- Downgradient plume extent not yet delineated; may be beyond recovery well

PROTECTIVE FACTORS

- Deep screened interval (73–85 ft bgs) provides vertical separation from shallow contamination
- Partially confining glacial till layer may limit downward contaminant migration
- Recovery wells RW-1/RW-2 maintaining hydraulic control of LNAPL and dissolved-phase plumes
- No contamination detected in supply well while in operation; well offline as precaution

VT Case Study – Cont.

Village of Wells River Water System · Source Contamination Memorandum of Alternatives · Otter Creek Engineering, Inc., 2025

Short-term solutions

Alt. 1 — Connect to Woodsville, NH

Total Project Cost

$4,062,000

30-yr Present Worth: $8,329,000

- *Est. timeline: 12+ months*
- *Multi-state permits required*

Alt. 2 — Temporary GAC Treatment

Total Project Cost

$1,178,000

30-yr Present Worth: $5,153,000

- *Est. timeline: ~6 months*
- *Fewer permits*

Additional costs

Bulk Hauling of Water

$60K/Month

July through November

Remediation

$1,700,000

Already over budget

Long term solution – Supplemental Supply

- *Significant amount of time; well siting, easement negotiations (when necessary), testing, permitting and final connections*
- *Significant cost associated with well drilling, consultant fee, permitting fee, infrastructure costs to connect the source*

VERMONT
AGENCY OF NATURAL RESOURCES
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Key Takeaways

Vermont Geology

- Contamination does not stop at property lines
- What gets into the water moves with the water.
- Soil type is a primary factor
- Vermont's fractured bedrock geology means standard setback rules may underestimate risk

Isolation Distances

- Many unanswered questions regarding factors that influence transport
- Hydrogeological assessments are site-specific
- Conservative setback distances are critical for public health protection
- Different contaminants move through the ground in different ways

Source Protection

- Source Protection beats treatment
- Critical for public health protection
- Reduce water treatment costs
- Reduce costs to water system users
- Economic Development
- Increased housing
- Planning for the future