Bulletin No. 3

AQUIFERS

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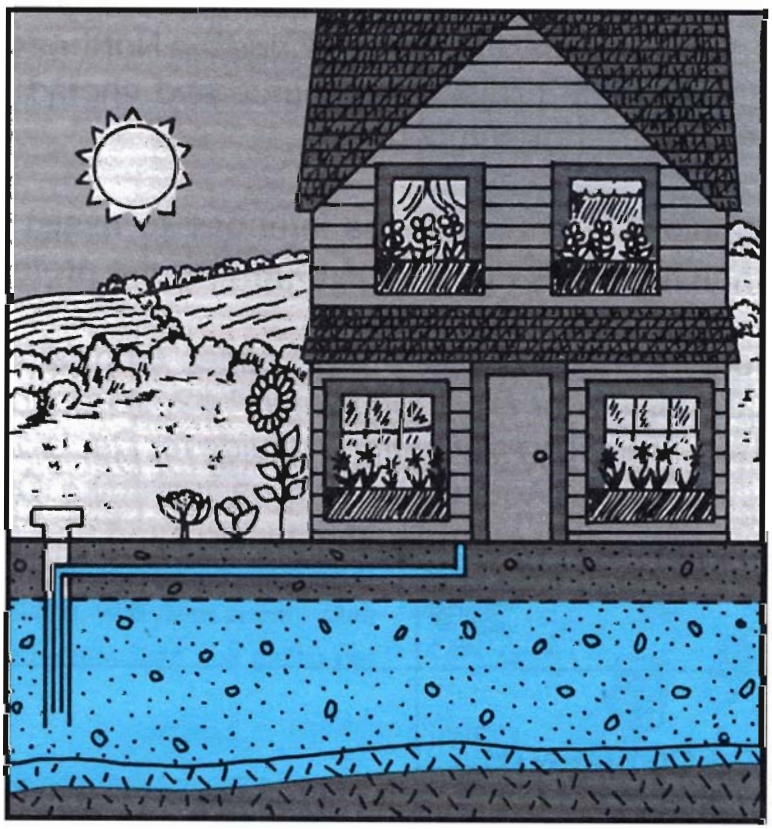

Aquifers are full of water!

What are aquifers?

Why are they important?

PURPOSE OF THIS BULLETIN

Aquifers are a rather mysterious and frequently misunderstood concept. Too often, the term is glibly used without a clear indication of what an aquifer is.

This bulletin explains what aquifers are in nontechnical language. Readers who wish to find out more about aquifers are referred to other sources, some of which are listed at the end of this bulletin.

Sand and gravel aquifers are emphasized because they are the most highly productive aquifers in New York and the Northeastern U.S. They are a significant local and regional resource and should receive protection commensurate with their importance.

The information in this bulletin is intended to assist local officials and citizens in making policy decisions regarding the protection of aquifers.

This is the third bulletin in a four-part series on groundwater. The other bulletins are #l, "*What Is Groundwater?*' #2, *"Groundwater Contamination,"* and #4, *"The Tug Hill Aquifer: A Guide for Decision Makers."* Bulletin #4 uses the Tug Hill Aquifer, located east of Lake Ontario, to illustrate options for local action to protect high yield sand and gravel aquifers.

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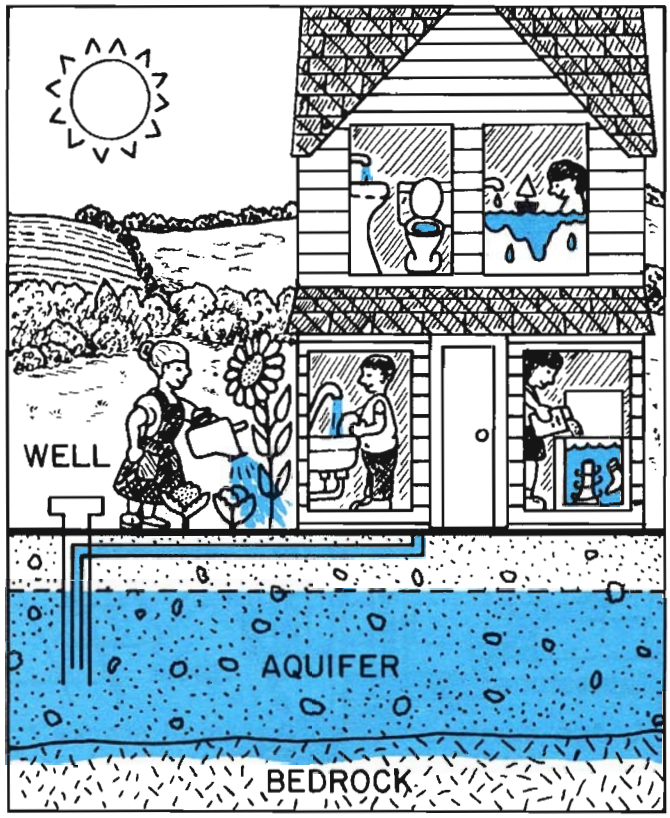
WHAT'S AN AQUIFER?

An aquifer is any soil or rock formation that contains water and permits sufficient water movement to yield water to wells and springs.

Low yield aquifers may supply only enough water for individual homes or farms.

Variable yield aquifers exhibit large differences in well yields, depending on the type and characteristics of material in the aquifer formation.

High yield aquifers are capable of supplying large quantities of water, sufficient to meet commercial, industrial and municipal needs.

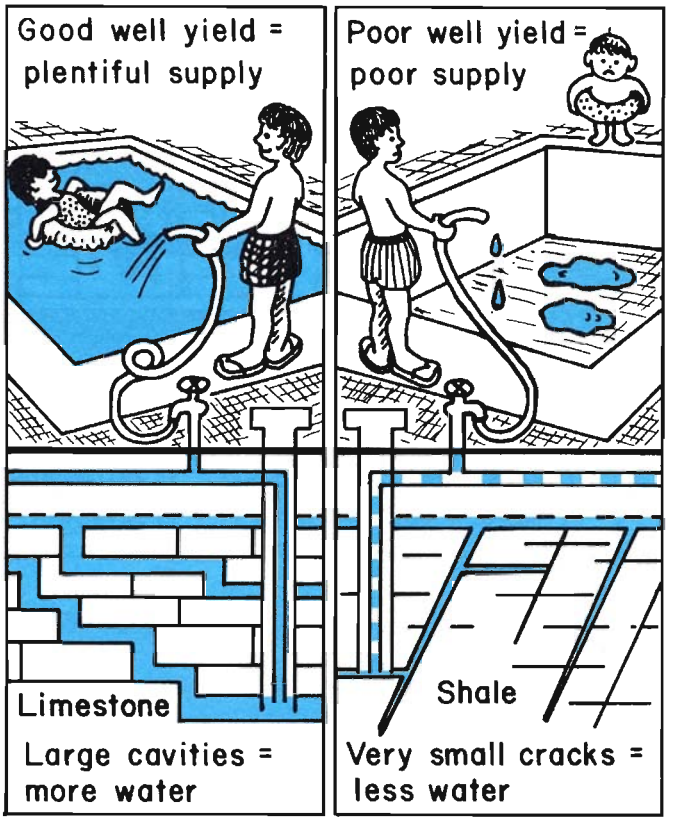


LOW YIELD AQUIFERS

Low yield aquifer formations have sustained well yields of less than 10 gallons per minute. Well yields at some sites in these formations may be less than one gallon per minute.

Thin till formations, containing a high percentage of clay and/or silt, have low well yields, for example. Till is a variable mixture of clay, sand, silt, gravel, and stones left behind by continental glaciers. It occurs throughout the northeastern U.S.

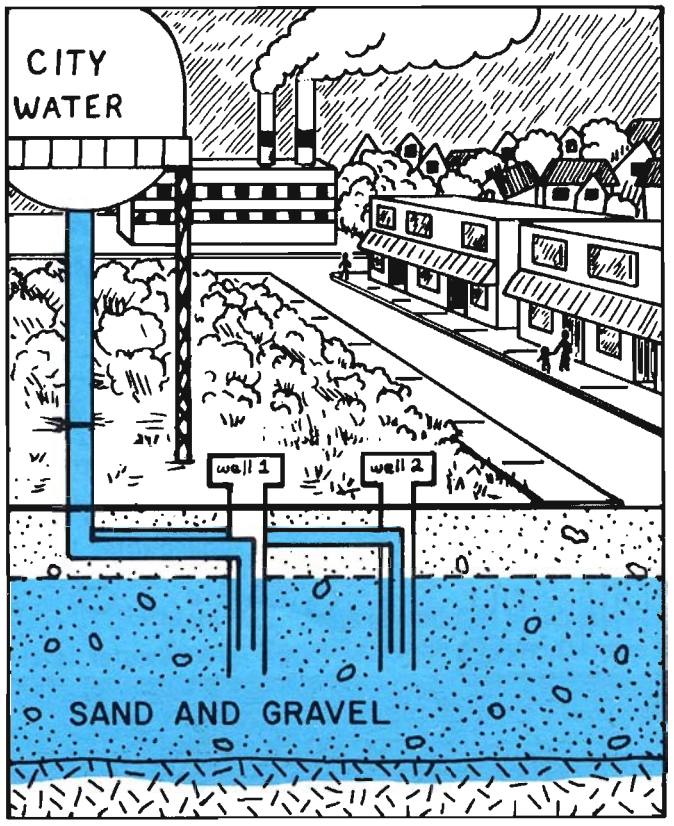
Thick till formations with a lower percentage of clay and/or silt have higher well yields.



VARIABLE YIELD AQUIFERS

Variable yield aquifer formations exhibit large differences in well yields. Well yields in bedrock, for example, may vary from less than one gallon per minute to more than 500 gallons per minute. These widely divergent well yields result from differences in bedrock formations.

The density and size of openings in bedrock determines the capacity for water movement to sustain well yields. Some rocks are more porous than others; sandstone, for example, is more porous than granite. Fracturing also creates cracks and fissures; the degree of fracturing varies widely. Limestone gradually dissolves in water; wells that penetrate the cavities that are created can sustain high well yields.

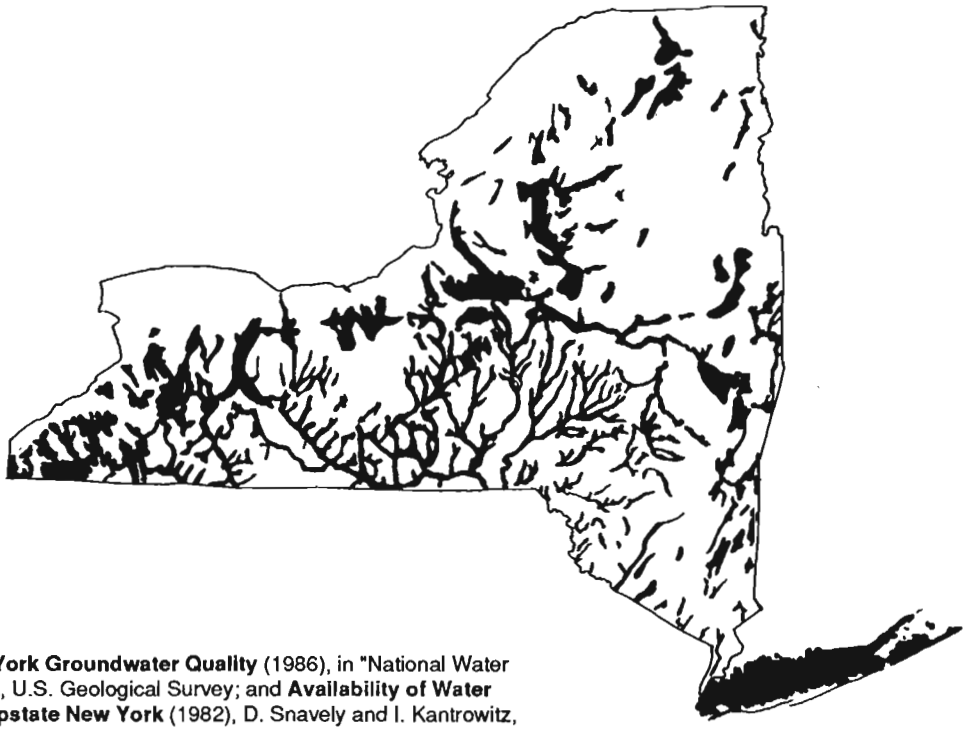


HIGH YIELD AQUIFERS

High yield aquifer formations can sustain well yields exceeding 10 gallons per minute. Well yields in the highest yielding aquifers reach hundreds to thousands of gallons per minute.

In the Northeastern U.S., the highest yielding aquifers are **sand and gravel** formations. Most of these sand and gravel formations were deposited by continental glaciers.

Low yield wells sometimes occur in otherwise high yield sand and gravel deposits due to the presence of interspersed layers of clay that block internal water movement in the aquifer.



Map Sources: **New York Groundwater Quality** (1986), in "National Water Summary: New York, U.S. Geological Survey; and **Availability of Water From Aquifers in Upstate New York** (1982), D. Snavely and I. Kantrowitz, USGS Open File Report 82-437, U.S. Geological Survey.

MAJOR SAND AND GRAVEL AQUIFERS IN NEW YORK

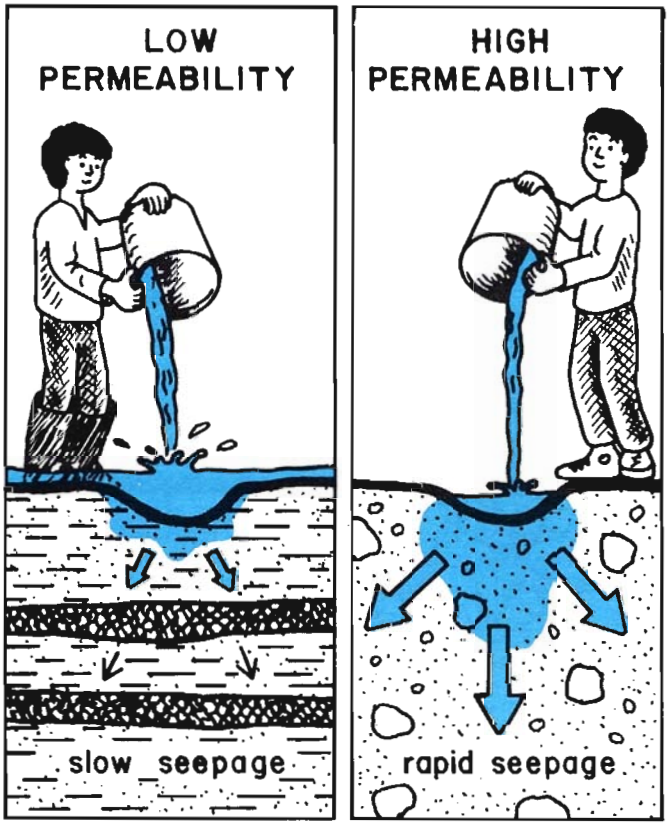
Sand and gravel formations were created as continental glaciers melted and retreated from the state. Valleys where glacial meltwater streams flowed usually contain extensive sand and gravel deposits. This includes nearly every major river valley. Deposits are also found in many smaller valleys not shown on a map of this scale.

Glacial lakes also formed in many valleys. Lake-clay deposits formed in the beds of these lakes, frequently covering sand and gravel beds deposited earlier. Sand and gravel beaches were formed, creating productive beach deposit aquifers if they are of sufficient thickness. Some glacial lakes were of enormous size, such as Lake Iroquois, that was much larger than present-day Lake Ontario. Lake Iroquois beach deposits are particularly well-formed along the western edge of Tug Hill, east of Interstate 81 north of Syracuse, NY.

Tremendous sand and gravel deposits were also formed along the outer fringes of the continental ice sheet at its farthest extent. Long Island and Cape Cod, for example, are composed of extensive deposits of sand and gravel formed in this manner. Long Island is the largest high yield sand and gravel aquifer in New York State.

WHY SAND AND GRAVEL AQUIFERS SHOULD BE PROTECTED

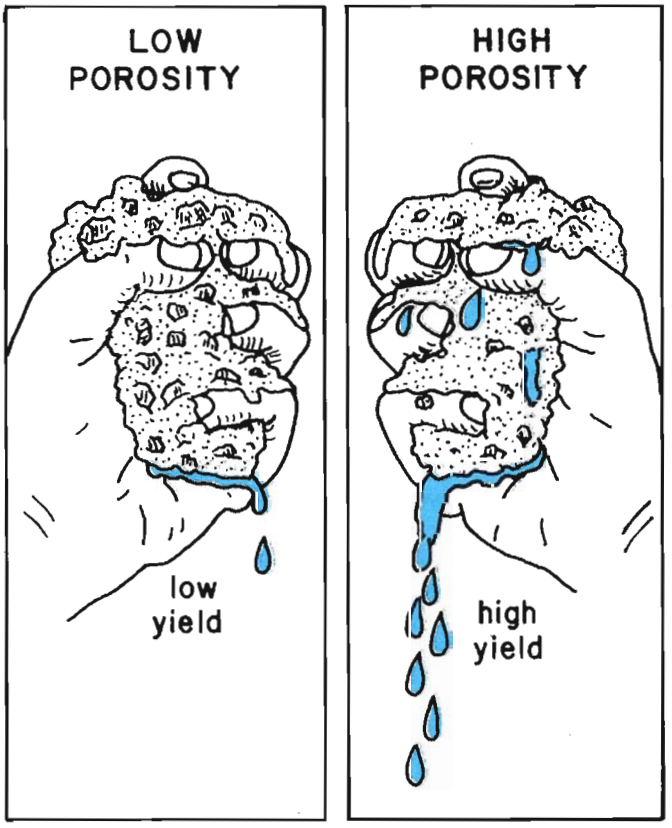
All aquifer formations, including low yield ones, should receive some degree of protection to prevent contamination of water supply wells and to maintain well yields. However, high yield sand and gravel aquifers need special protective measures because they have a combination of characteristics that set them apart from other water-bearing formations as a water supply source. These characteristics involve (1) permeability, 2) porosity, 3) pollution vulnerability, 4) uniqueness, and 5) regional significance.



High Yield Sand & Gravel Aquifers:
PERMEABILITY

Permeability is a measure of water movement through porous material. Sand and gravel aquifers have high permeability, allowing water to be readily transmitted through these formations. The average permeability of an aquifer formation is known as transmissivity, or capability to transmit water.

Sand and gravel formations can capture large quantities of rain and snowmelt if no overlying impermeable formations prevent infiltration. If overlying formations prevent infiltration from the surface, water is readily transmitted from adjacent areas to create a confined aquifer. Sand and gravel aquifers can sustain high well pumping rates and provide copious flows to springs, streams and wetlands.



High Yield Sand & Gravel Aquifers:
POROSITY

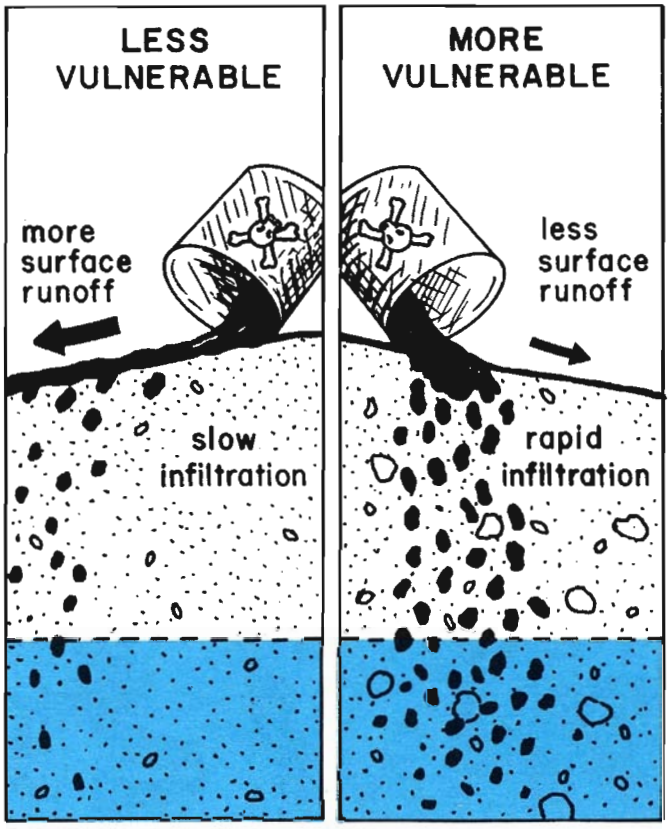
High yield sand and gravel aquifer formations are capable of storing large volumes of water. This is called high porosity. An outstanding characteristic of high yield sand and gravel aquifers is that they have **both high porosity and permeability**.

Porosity varies with the specific makeup of the sand and gravel aquifer. It is important because it indicates the maximum amount of water that the aquifer can hold when it is saturated. Only part of this water is available to supply wells or springs, however, because some will remain in the aquifer as a film on particle surfaces and in very small openings. The amount that will drain out is called the specific yield.

High Yield Sand & Gravel Aquifers:
POLLUTION VULNERABILITY

Sand and gravel formations that lie close to the land surface are **easily contaminated**. Contaminants can rapidly infiltrate the water table before degradation takes place to reduce their concentrations. This also means there is less response time to take remedial actions after contaminant spills.

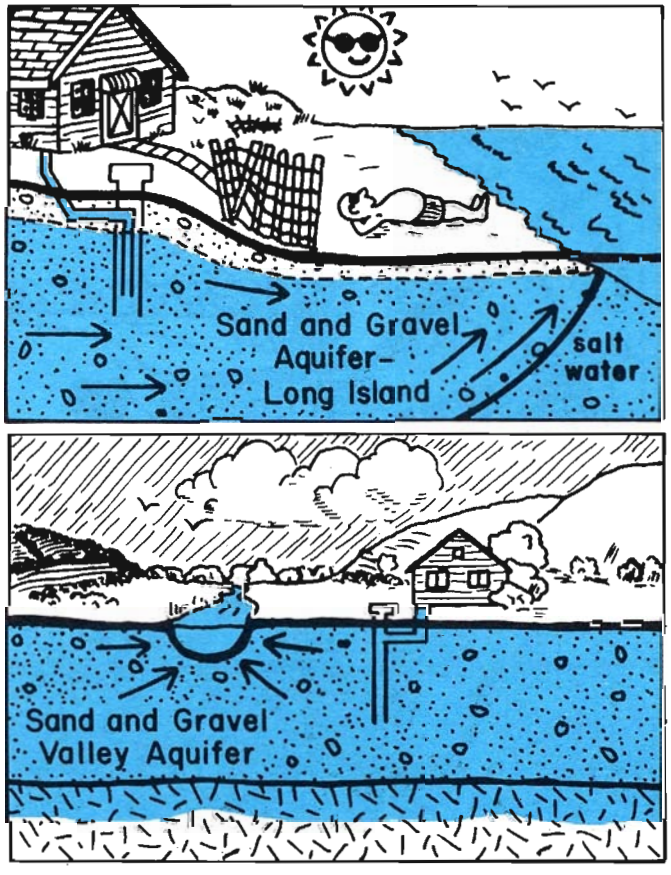
Once contaminants enter the aquifer, they are transmitted rapidly through the permeable sand and gravel. This contamination plume may threaten wells and nearby streams, lakes and wetlands that receive aquifer discharges. A large groundwater supply may be affected due to the high porosity of sand and gravel formations.

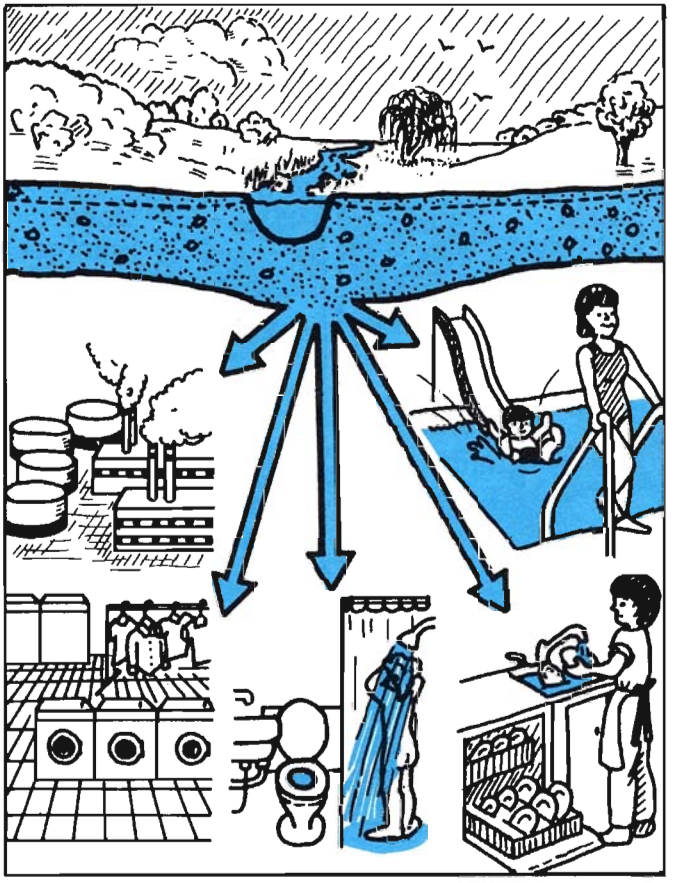


High Yield Sand & Gravel Aquifers:
UNIQUENESS

High yield sand and gravel formations are a **unique groundwater resource**. About 11 percent of New York State contains sand and gravel deposits, including the Long Island sand and gravel aquifer. Excluding Long Island, only about 9 percent of upstate New York is underlain by these highly productive sand and gravel deposits.

Sand and gravel deposits occur only in specific areas due to the nature of their formation. In New York, these are primarily river valleys, the Long Island formation and glacial lake beach deposits. These areas are also frequently considered to be prime development sites.



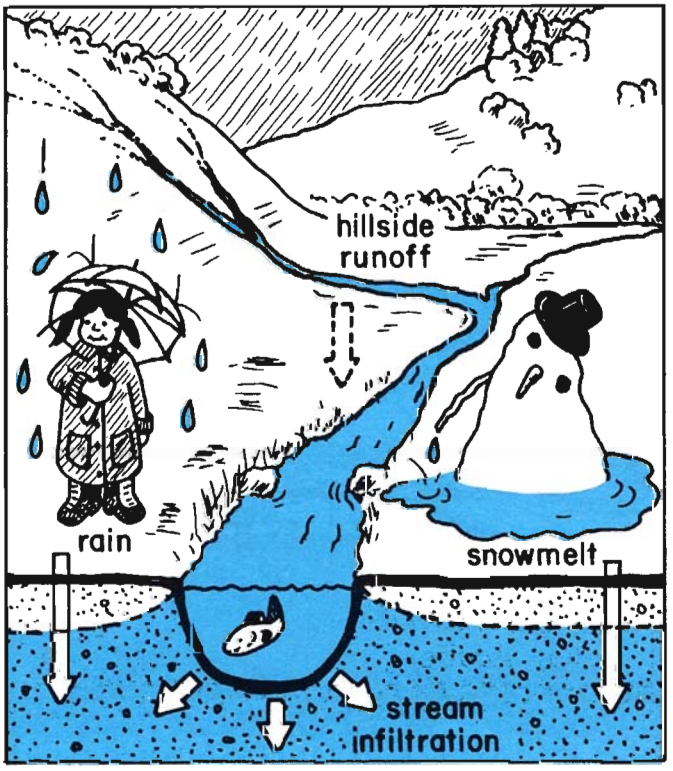


High Yield Sand & Gravel Aquifers:
REGIONAL RESOURCE

High yield sand gravel aquifers are a significant **regional water supply resource.** This becomes a critical issue when water supplies for communities in the area become polluted or inadequate to meet water supply needs.

The Long Island aquifer and 18 other high yield sand and gravel aquifers in upstate New York have been classified as Primary Water Supply Aquifers.

Other high yield sand and gravel aquifers not currently receiving significant use in upstate New York are potential water supply reserves for future needs. The most significant ones have been classified as Principal Aquifers.



WHERE DOES AQUIFER WATER COME FROM?

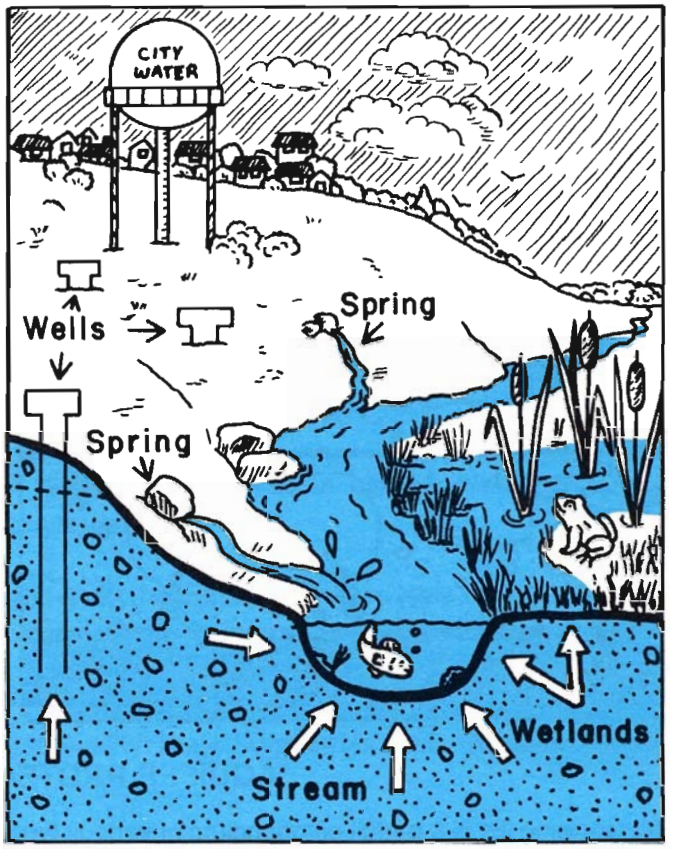
Water that replenishes an aquifer is known as **recharge**. Recharge of sand and gravel aquifers originates with rain and snowmelt infiltration from the ground surface, and infiltration from streams or underground flow from adjacent areas. Most groundwater recharge takes place from late fall to early spring, when plants are dormant and are not removing large amounts of soil moisture by transpiration that returns to the atmosphere.

A determination of the rate of replenishment, or recharge, and the aquifer's porosity and capability to transmit water (permeability) will indicate the density and size of wells that can be accommodated without harm to the aquifer supply.

WHERE DOES AQUIFER WATER GO?

Water leaves an aquifer by **discharging** into streams, wetlands, and lakes. This occurs by bank seepage and discharges from springs. During dry periods, water flowing in streams may be composed largely of discharges from stored groundwater. In this manner, aquifers are similar to reservoirs, slowly releasing stored water during rainless periods. Water well pumping is also a significant discharge route in some areas.

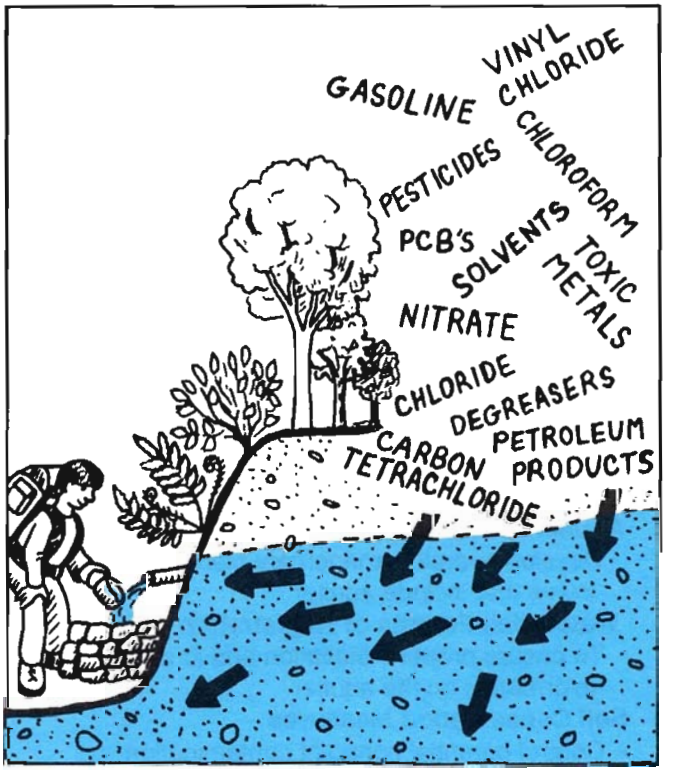
Under natural conditions, aquifer **recharge and discharge** are in balance. Whereas recharge is intermittent, discharge is continuous because the aquifer acts as a storage reservoir to maintain outflow. However, aquifer discharges will cease when the water table level falls below discharge points.

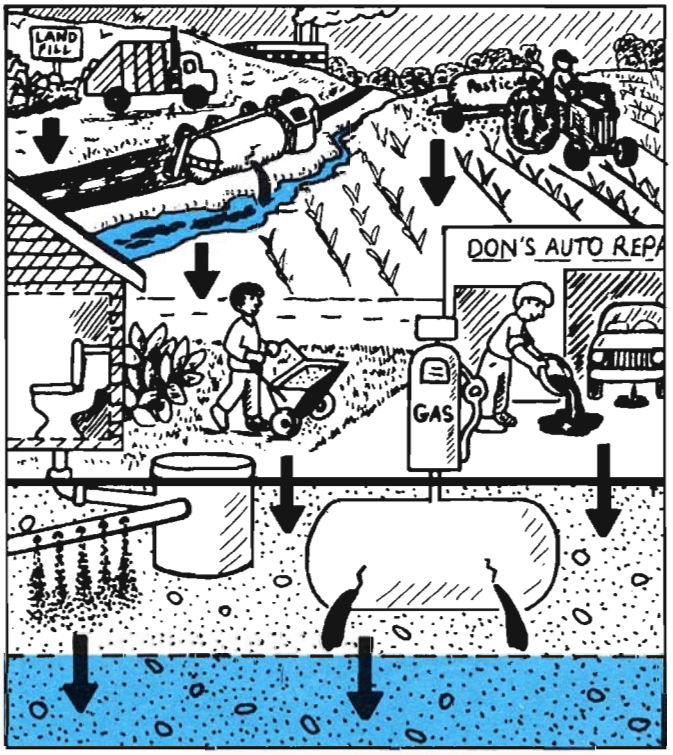


AQUIFER POLLUTION

Major contaminants that have been found in groundwater in New York State include: (1) degreasers; (2) gasoline and other petroleum products; (4) pesticides; (5) nitrates; and (6) chlorides. Bacteriological contamination is also a common problem.

Other contaminants that have been found include polychlororinated biphenyls (PCB's), chloroform, vinyl chloride, carbon tetrachloride, and toxic metals. A variety of natural substances may also adversely affect groundwater for human use, such as excessive amounts of sulfur, salt, iron, manganese, or barium, for example.





AQUIFER POLLUTION SOURCES

Common **sources of groundwater contamination** are: (1) leaks and spills at industrial and commercial facilities; (2) improper commercial and industrial disposal; (3) improper use and disposal of pesticides by farmers, homeowners, businesses and industries; (4) landfills; (5) septic systems; (6) storage and use of road deicing salts; (7) liquid waste storage lagoons; (8) agricultural and lawn fertilization; (9) disposal of animal wastes; (10) leaking underground storage tanks; (11) pipeline breaks; and (12) inadequately sealed wells. Saltwater intrusion is a problem on Long Island due to excessive well pumping from the aquifer.

AQUIFER PROTECTION MEASURES

The following list is a partial compendium of various types of actions that may be considered for aquifer protection.

1) **Septic Tank Regulations**
2) **Subdivision Regulations**
   Density, waste discharges, runoff control, for example
3) **Highways**
   - Design and maintenance, such as use of deicing salts
4) **Critical Area Controls**
   - Example: Purchase land or easements in well contribution zones
5) **Development Moratoriums**
   - Until a plan can can be devised to minimize development impacts
6) **Public Education Programs**
   - To promote proper practices, such as proper hazardous chemical disposal
7) **Aquifer Protection Plans**
   - Develop overall management plan with other towns that include aquifer
8) **Water Well Permits or Registration**
   - To ensure proper installation and to develop information on the aquifer
9) **Soil Conservation Measures**
   - Control potential nonpoint contamination from runoff and infiltration
10) **Forest Management**
    - Preserve forest cover in critical areas
11) **Wastewater Treatment Standards**
    - Volume and type of wastewater discharges into aquifer
12) **Critical Areas**
    - Designate critical aquifer recharge areas, contribution zones for public well supplies
13) **Water Supply Rules and Regulations**
    - To control land use practices that can lead to contamination of public water supply wells
14) **Waste Disposal Regulations**
    - In addition to state regulations to further protect aquifer from leachate contamination
15) **Incentive Programs**
    - To encourage practices that will protect the aquifer
16) **Monitoring**
    - Early detection of aquifer contamination so that control actions can be taken
17) **Underground Storage Tanks**
    - In addition to state program, inventory all UST's and develop local controls as needed
18) **Environmental Quality Review Act (SEQRA)**
    - Environmental assessments and/or environmental impact statements

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