GATE Material for Agriculture Engineering

Engineering Mathematics

- Linear Algebra
- Calculus
- Complex Analysis
- Vector Calculus
- Differential Equations
- Probability - I
- Probability (continued)
- Numerical Methods
  (above topics are successfully completed in Mathematics part)

TRANSFORM THEORY

- Fourier Transform
- Laplace Transform
- Z-Transform

(above topics are successfully completed in Instrumentation Engineering part)

SOIL AND WATER CONSERVATION ENGINEERING

Ground Water

Preface

As the salesmen sang in the musical *The Music Man*, "You gotta know the territory." This saying is also true when planning to buy or build a house. Learn as much as possible about the land, the water supply, and the septic system of the house before buying or building. Do not just look at the constructionaspects or the beauty of the home and surroundings. Be sure to consider the environmental conditions around and beneath the site as well. Try to visit the site under adverse conditions, such as during heavy rain or meltwater runoff, to observe the drainage characteristics, particularly the condition of the basement.

Many of the conditions discussed in this book, such as lowered well-water levels, flooded basements, and contamination from septic systems, are so common that rural families often have to deal with one or more of them. The purpose of this book is to awaken an interest in ground water and an awareness of where it is available, how it moves, how people can adjust to its patterns to avoid problems, and how it can be protected and used wisely.

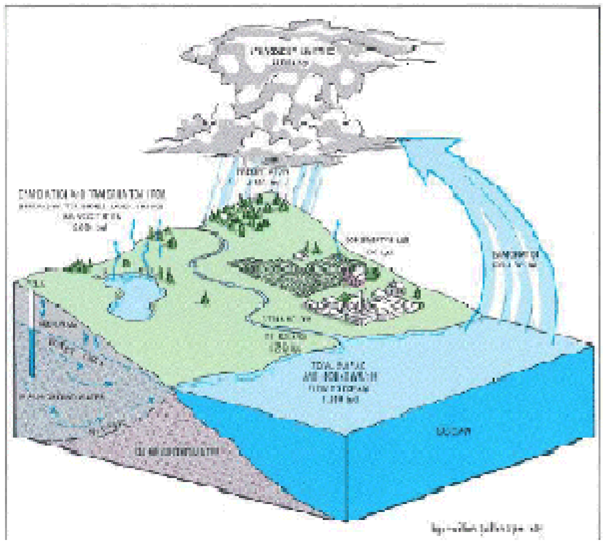
This booklet provides both present and prospective rural homeowners, particularly those in the glaciated northern parts of the United States, with a basic but comprehensive description of ground water. It also presents problems one may expect to encounter with ground water and some solutions or suggestions for help with these problems.

Introduction

When buying a home in the country, people need to consider certain factors that usually do not confront the urban homebuyer, such as whether or not the water supply is adequate and if the means of disposing of wastewater is safe. Disappointed rural homeowners have sometimes found out too late that the well drilled on their new land does not yield enough water or that the water is of poor chemical quality. Also, foundations can become unstable from excess surface runoff or from high ground-water levels. Septic systems, if not located properly or if soil conditions are not properly considered, can fail. Wells can be contaminated by septic systems or barnyard wastes. Shallow or dug wells on farms or near older homes that served adequately in earlier years are often inadequate for modern uses.

Preventing water problems or coping with them when buying or building a rural home can be either complex or relatively simple. Prospective homeowners need to know about the terrain, the proximity of the house to other structures, and the condition of the existing well and septic system. If building in an unpopulated area, drill a well first—or if buying an old house, find out if the water supply is adequate. This bookletdescribes the most common well problems encountered by rural homeowners, how to recognize them, solve them, or get help. But first, the characteristics and behavior of ground water and the relationship between ground water and the surrounding land are discussed briefly.

The Hydrologic Cycle

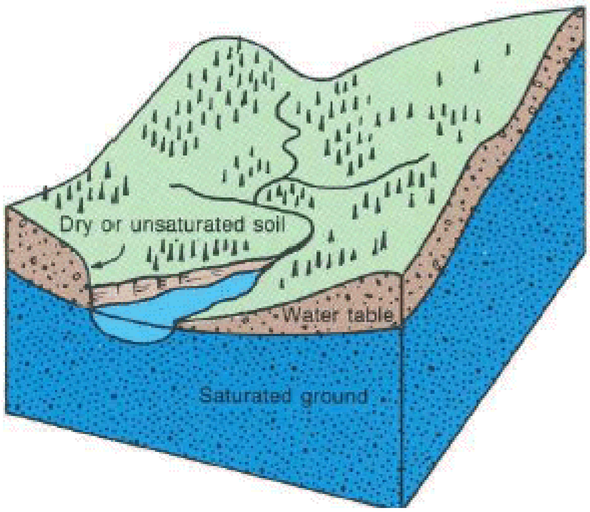


The continuous hydrologic cycle.

The hydrologic cycle is the continuous circulation of water from land and sea to the atmosphere and back again : water evaporates from oceans, lakes, and rivers into the atmosphere. This water later precipitates as rain or snow onto the land where it evaporates or runs off into streams and rivers ; or it infiltrates (seeps) into the soil and rock from which some is transpired back into the atmosphere by plants. The remainder becomes ground water, which eventually seeps into streams or lakes from which it evaporates or flows to the oceans.

Ground Water

Ground water is that part of precipitation that infiltrates through the soil to the water table. The unsaturated material above the water table contains air and water in the spaces between the rock particles and supports vegetation. In the saturated zone below the water table, ground water fills in the spaces between rock particles and within bedrock fractures.



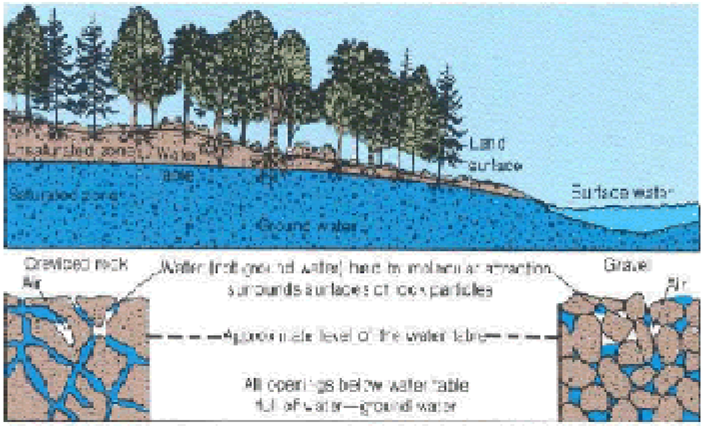
Occurrence of ground water.

Where ground water occurs

Rock materials may be classified as consolidated rock (often called bedrock) and may consist of sandstone, limestone, granite, and other rock, and as unconsolidated rock that consists of granular material such as sand, gravel, and clay. Two characteristics of all rocks that affect the presence and movement of ground water are *porosity* (size and amount of void spaces) and *permeability* (the relative ease with which water can move through spaces in the rock).

Consolidated rock may contain fractures, small cracks, pore spaces, spaces between layers, and solution openings, all of which are usually connected and can hold water. Bedded sedimentary rock contains spaces between layers that can transmit water great distances. Most bedrock contains vertical fractures that may intersect other fractures, enabling water to move from one layer to another. Water can dissolve carbonate rocks, such as limestone and dolomite, forming solution channels through which water can move both vertically and horizontally. Limestone caves are a good example of solution channels. Consolidated rock may be buried below many hundred feet of unconsolidated rock or may crop out at the land surface. Depending upon the size and number of connected openings, this bedrock may yield plentiful water to individual wells or be a poor water-bearing system.

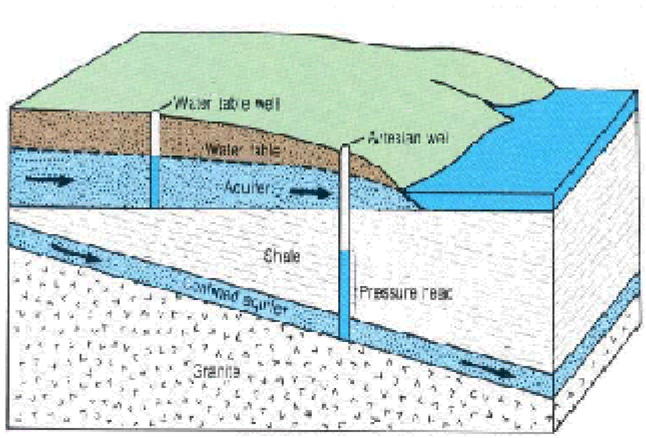
Unconsolidated material overlies bedrock and may consist of rock debris transported by glaciers or deposited by streams or deposited in lakes. It also may consist of weathered bedrock particles that form a loose granular or clay soil. Well-sorted unconsolidated material can store large quantites of ground water; the coarser materials—sand and gravel—readily yield water to wells.



How ground water occurs in rocks.

A close look at the rocks exposed in road cuts and along streams will show the types of openings in which ground water can occur. Especially noticeable in bedrock exposures are spaces between layers that can extend for miles-the void spaces between rock particles contain water that percolates into these spaces between the layers. In most sand and gravel deposits, water occupies and moves freely within granular material.

Road cuts reveal fractures, joints, and bedding planes.



Water-table and confined (artesian) aquifers.

Aquifers

Most of the void spaces in the rocks below the water table are filled with water. Wherever these water-bearing rocks readily transmit water to wells or springs, they are called *aquifers*.

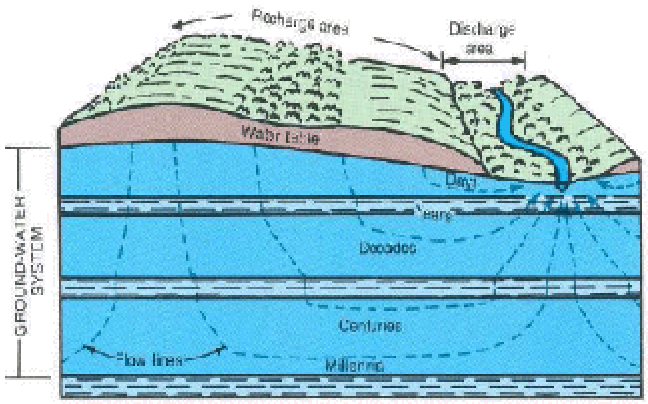
Although ground water can move from one aquifer into another, it generally follows the more permeable pathways within the individual aquifers from the point of recharge (areas where materials above the aquifer are permeable enough to permit infiltration of precipitation to the aquifer) to the point of discharge (areas at which the water table intersects the land surface and water leaves an aquifer by way of springs, streams, or lakes and wetlands). Where water moves beneath a layer of clay or other dense, low-permeability material, it is effectively confined, often under pressure. The pressure in most confined aquifers causes the water level in a well tapping the aquifer to rise above the top of the aquifer. Where the pressure is sufficient, the water may flow from a well.

Ground water is constantly moving

Ground water is always moving by the force of gravity fromrecharge areas to discharge areas. Ground-water movement in most areas is slow-a few feet per year. But, in more permeable zones, such as solution channels in limestone, movement can be as much as several feet per day. Evidence of the movement of ground water through rock and soil can be seen in road cuts, especially in winter, when the water freezes upon emerging from the rock. In some bedrock exposures, the water emerges along partings between rock layers ; in others, along vertical fractures.

Seasonal patterns of ground-water recharge and storage

In latitudes where freezing is common, there is less rechargefrom rain or snowmelt during winter, which causes the watertable to fall. Sporadic or differential freezing of the soil in the fall and winter inhibits recharge to the saturated zone, and the complete freezing of the soil in winter prevents all rechargeuntil the soil thaws in the spring.



Direction and rate of ground-water movement.

Ground water, emerging from bedding planes, has created spectacular frozen waterfalls along a road cut.

The saturated zone beneath the water table is recharged by the excess water that is not discharged to streams. The resulting rise in the water table increases ground-water *storage*(the volume of ground water stored within an aquifer system). In late spring, summer, and early fall, evaporation and transpiration by plants capture most of the water that would otherwise recharge the aquifer, while discharge to streams continues. A seasonal decrease in ground-water storage results, as indicated by declining water levels in wells. In winter, freezing of the soil prevents recharge, which again causes a decline in storage. In early spring, frequent precipitation coupled with water from snowmelt causes a rapid increase in storage and a rise in the water table.