OPEN-FILE REPORT 86-240

WATER FACT SHEET

U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

CONFINED-DRIFT AQUIFERS IN MINNESOTA

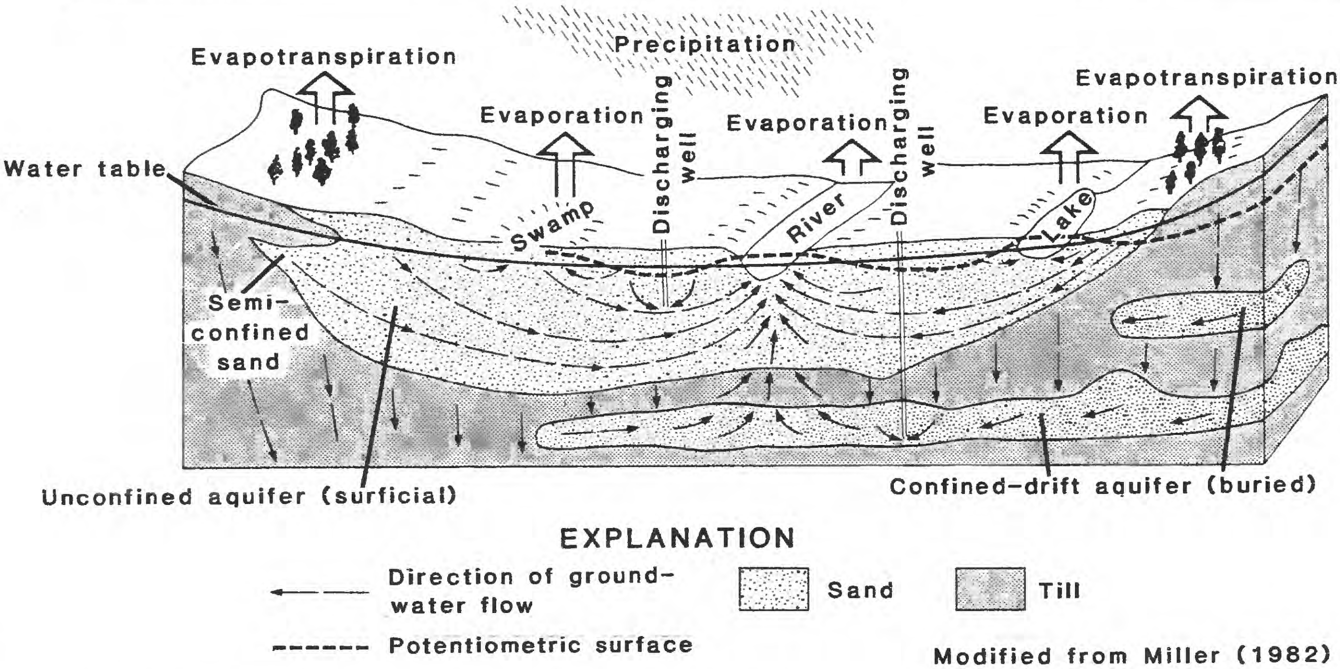


Figure 1.--Generalized ground-water-flow system showing occurrence of confined-drift aquifers

WHAT ARE CONFINED-DRIFT AQUIFERS?

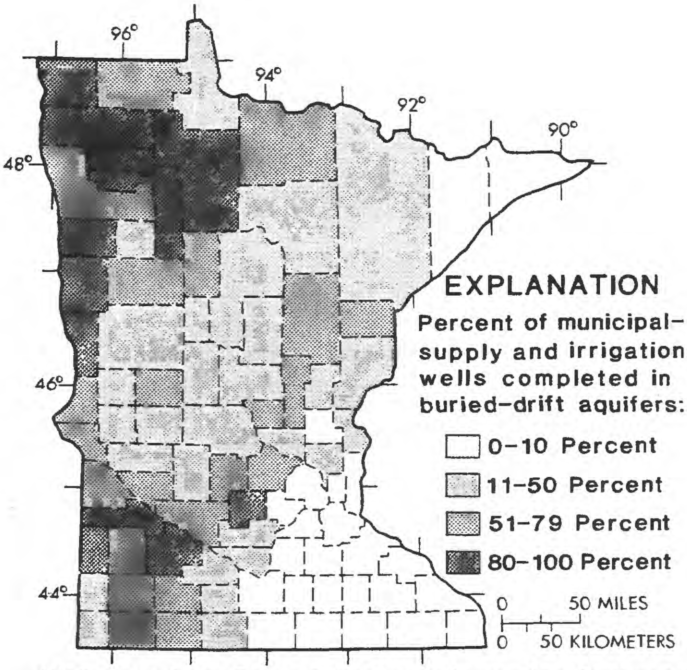
Confined-drift aquifers in Minnesota, frequently referred to as buried-drift aquifers, are saturated sand and gravel deposits that are covered by till (fig. 1). Till, an unsorted mixture of clay, silt, sand, and gravel, has a relatively low permeability in comparison to sand and gravel. Consequently, till does not transmit water readily; but may confine water in underlying sand and gravel aquifers.

The hydraulic behavior of confined-drift aquifers is different from unconfined aquifers. An unconfined aquifer contains a water table at which the water pressure is atmospheric. Water in a confined aquifer, however, typically is under significantly greater pressure than atmospheric, and water in a well open to a confined aquifer stands at a level higher than the top of the aquifer. The water levels in many wells open to a confined aquifer define an imaginary surface called the potentiometric surface. The potentiometric surface for a confined aquifer may be above or below the water table in an overlying unconfined aquifer (fig. 1). The difference in level between the potentiometric surface and the water table indicates the direction of vertical seepage through the till confining unit.

Another difference between confined and unconfined aquifers is that when a confined aquifer is pumped, only a very small amount (less than 0.01 percent) of the water pumped comes from storage in the aquifer. When an unconfined aquifer is pumped, the amount of water that comes from storage in the aquifer is very large initially (nearly 100 percent) and then declines gradually over time.

WHY ARE CONFINED-DRIFT AQUIFERS BEING STUDIED?

Confined-drift aquifers in Minnesota are the primary source of water supplies in areas where unconfined aquifers are thin or absent. Confined aquifers cannot be seen or inferred at land surface and little is known of their areal extent, thickness, continuity, hydraulic properties, and water quality. Pumpage of water from wells in confined aquifers increased dramatically in western Minnesota during the 1970's. At present, the aquifers provide a significant percentage of the water used in the western part of the State (fig. 2).



Well data from Ground-Water Information Summary (GWIS) database maintained by Minnesota Land Information Management Center, St. Paul

Figure 2.--Distribution of wells in confined-drift aquifers for municipal and irrigation supplies.

There is an increasing need for additional information on confined aquifers because many unconfined aquifers have been contaminated in recent years. Unconfined aquifers are highly susceptable to contamination from a variety of sources due to their close proximity to land surface and their generally high permeability. High concentrations of nitrate in water from surficial aquifers, for example, typically result from application of fertilizers in conjunction with crop irrigation, infiltration of water from livestock feedlots, or infiltration of water from septic systems. Areas where nitrate concentrations exceed guidelines of the Minnesota Pollution Control Agency for drinking water have been identified in some highly irrigated areas in western Minnesota. To avoid using contaminated water from an unconfined aquifer, a well owner must install a new well in a deeper (confined) aquifer. In regards to the confined aquifers, the Minnesota Department of Natural Resources is particularly concerned about the uncertainty of (1) long-term yields of wells, (2) effect of pumping on water levels and water quality, (3) possible interference between nearby wells, and (4) possible migration of poor-quality water from overlying or underlying deposits into the confined aquifers.

HOW ARE CONFINED AQUIFERS BEING LOCATED?

Because the location and extent of a confined aquifer are not apparent at land surface, attempts to map the aquifer rely on test drilling and indirect exploration methods. The most common method used to locate confined aquifers is by correlation of sand and gravel deposits penetrated by wells and test holes. This method requires a large number of accurate logs of wells and test holes. For some ground-water studies, well logs, supplemented by appropriately placed test holes, provide adequate information to locate regionally extensive confined aquifers in the area of interest. In other areas, however, less-expensive exploration methods are needed. In recent years, seismic geophysical methods have been used successfully in parts of western Minnesota to identify confined aquifers. The chief advantage of seismic methods is that they provide continuous profiles or sections of the subsurface between widely spaced test holes. Although labor intensive, these methods provide a relatively inexpensive alternative to drilling a large number of test holes.

PRODUCTS OF A CONFINED AQUIFER STUDY

One of the most useful products from a study of confined-drift aquifers is a set of hydrogeologic maps showing aquifer thickness, transmissivity, configuration of the potentiometric surface, and potential well yields. With these maps, a property owner, irrigator, well driller, or municipal or rural water-system manager can better determine where to drill for water and the probable depth and yield of the proposed well. Consequently, use of the maps saves money by reducing the need for test drilling. In addition, water-level observation wells installed for the studies can continue to be used to monitor water levels in the confined aquifers. The quality of water in the confined aquifers is assessed as part of the studies also. Therefore, the studies provide information concerning the issues of long-term yield to wells, effect of pumping on water levels, well interference, and possible migration of poor-quality water from overlying or underlying deposits. A model that simulates flow in the ground-water system typically is constructed as part of the studies. The model is used to determine the probable effects of future ground-water development and increased pumping during droughts on water levels and streamflow. A ground-water model enables the Minnesota Department of Natural Resources to improve management of this important natural resource.

REFERENCE

Miller, R.T., 1982, Appraisal of the Pelican River sand-plain aquifer, western Minnesota: U.S. Geological Survey Open-File Report 75-312, 87 p.

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