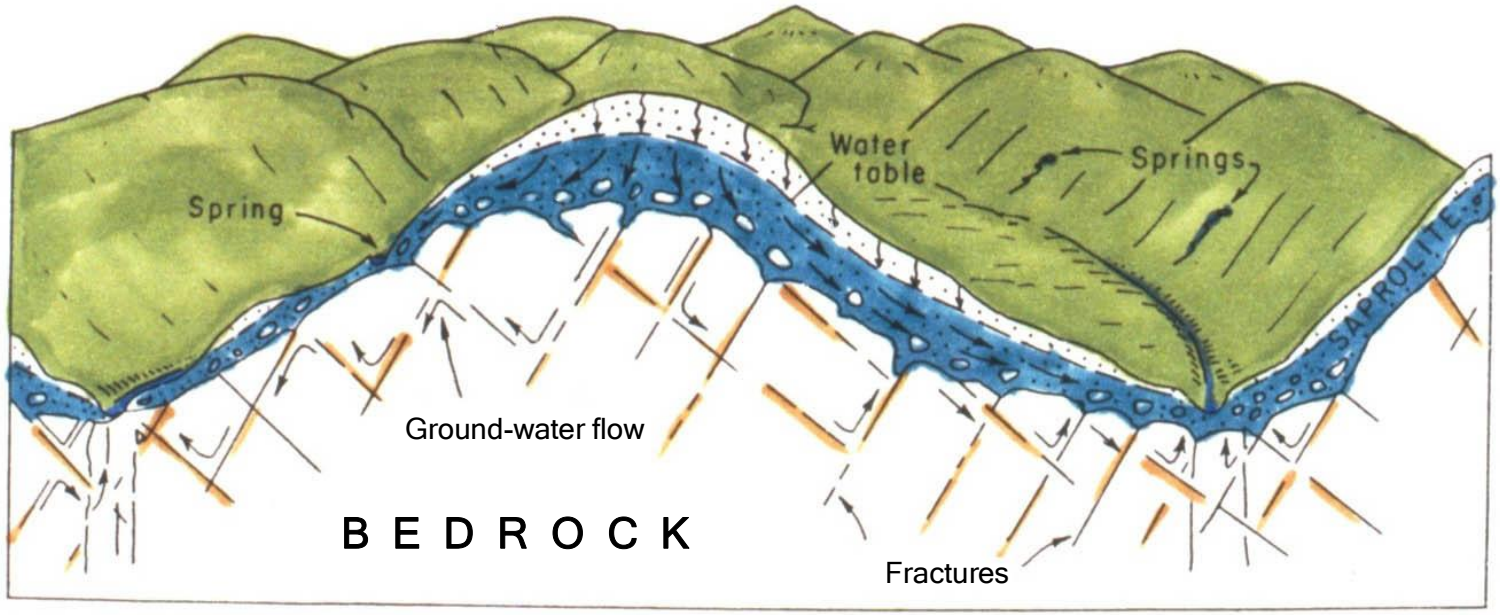
Ground Water in Orange County, North Carolina



With reference to conditions in the Piedmont and Blue Ridge

Ground Water Represents the Largest Reservoir of Readily Available Freshwater

FRESHWATER OF THE HYDROSPHERE

(Ice sheets and glaciers included)

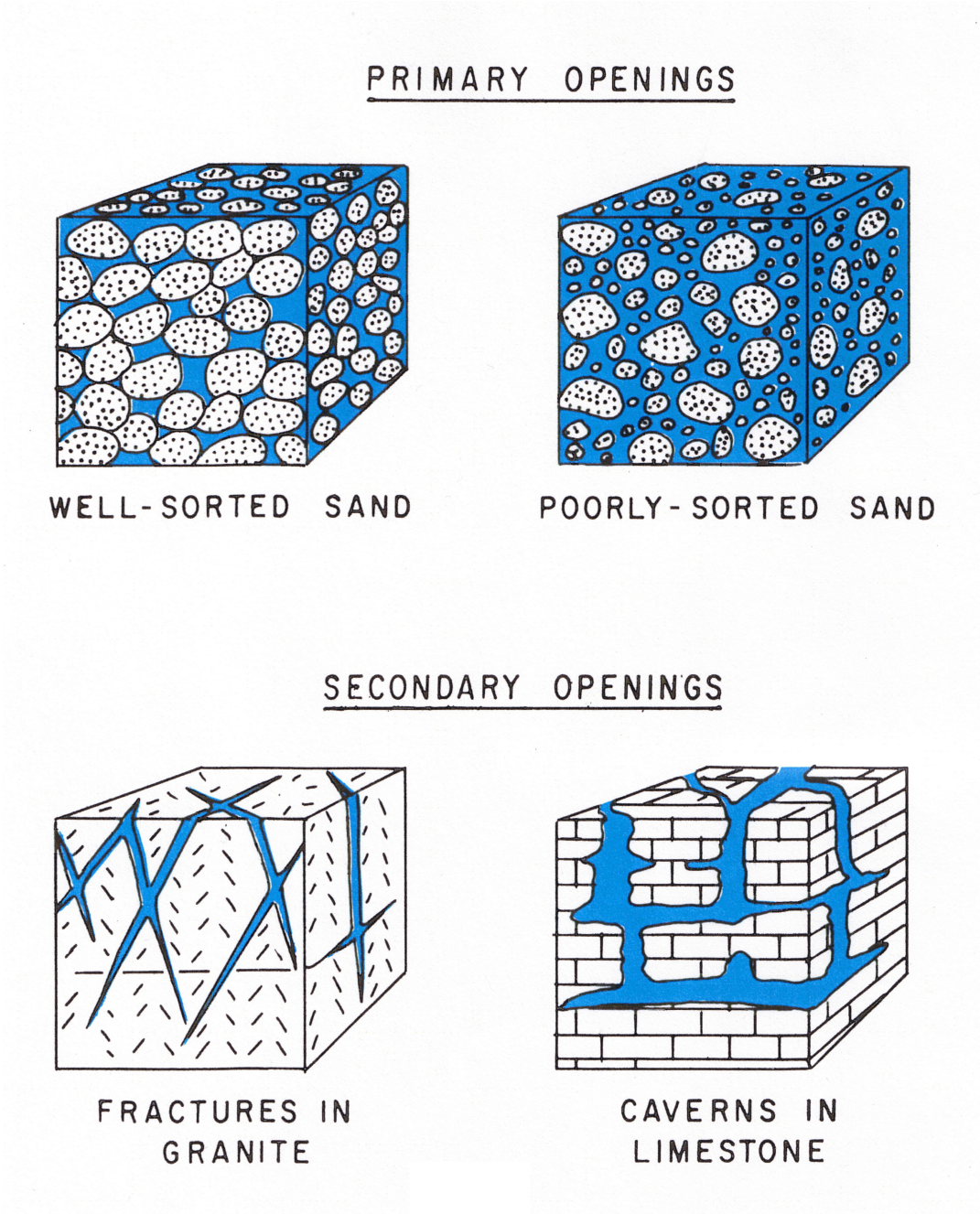
[Modified from L'vovich (1979), tables 2 and 10]

Parts of the hydrosphere	Volume of freshwater		Share in total volume of freshwater (percent)
	km^3	mi^3	
Ice sheets and glaciers	24,000,000	5,800,000	84.945
Ground water	4,000,000	960,000	14.158
Lakes and reservoirs	155,000	37,000	.549
Soil moisture	83,000	20,000	.294
Vapors in the atmosphere	14,000	3,400	.049
River water	1,200	300	.004
Total	28,253,200	6,820,700	100.000

(Ice sheets and glaciers excluded)

	Share in volume of freshwater (percent)
Ground water	94.05
Lakes and reservoirs	3.62
Soil moisture	1.96
Vapors in the atmosphere	.33
River water	.03

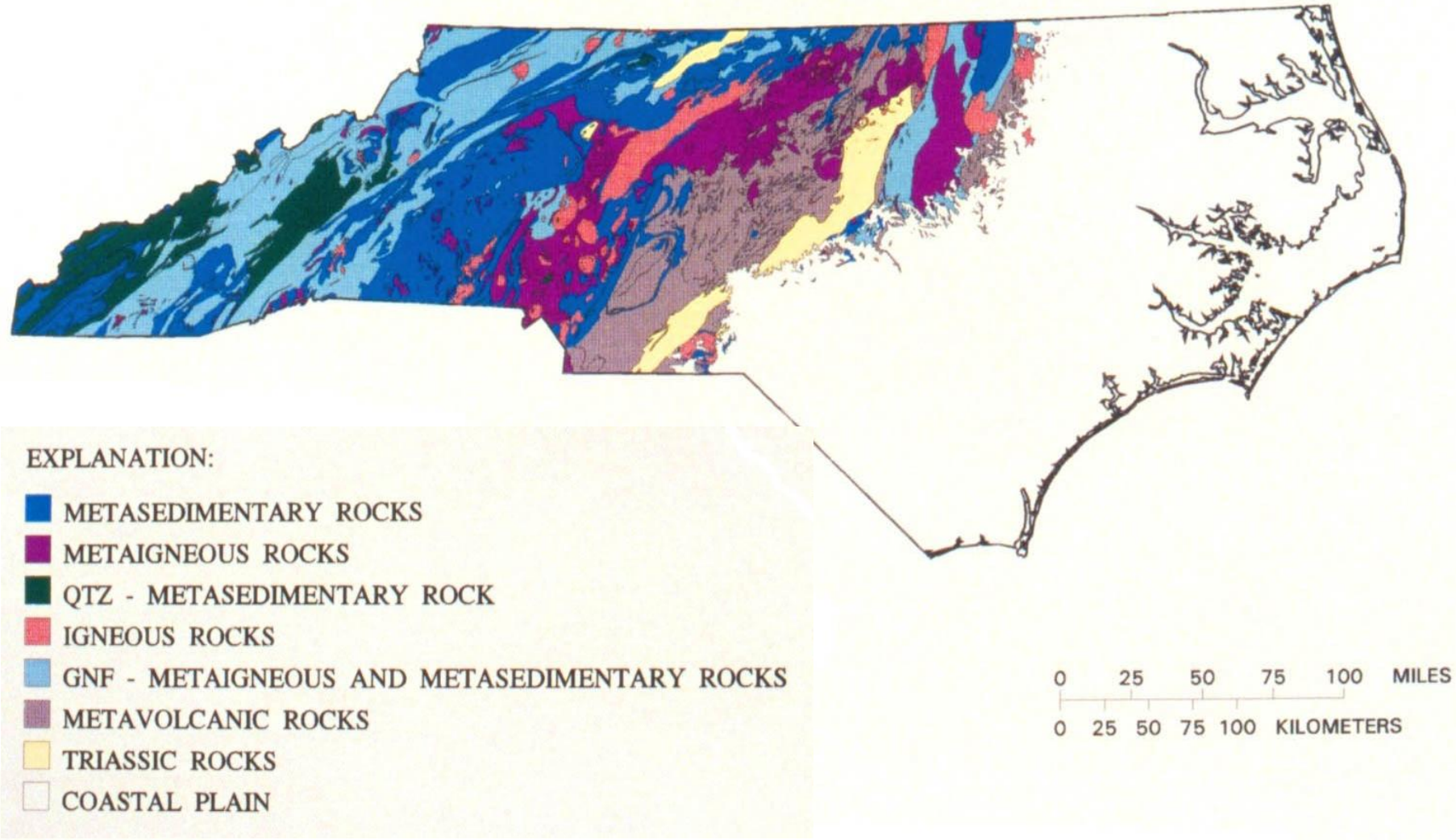
Rocks and Water



POROSITY

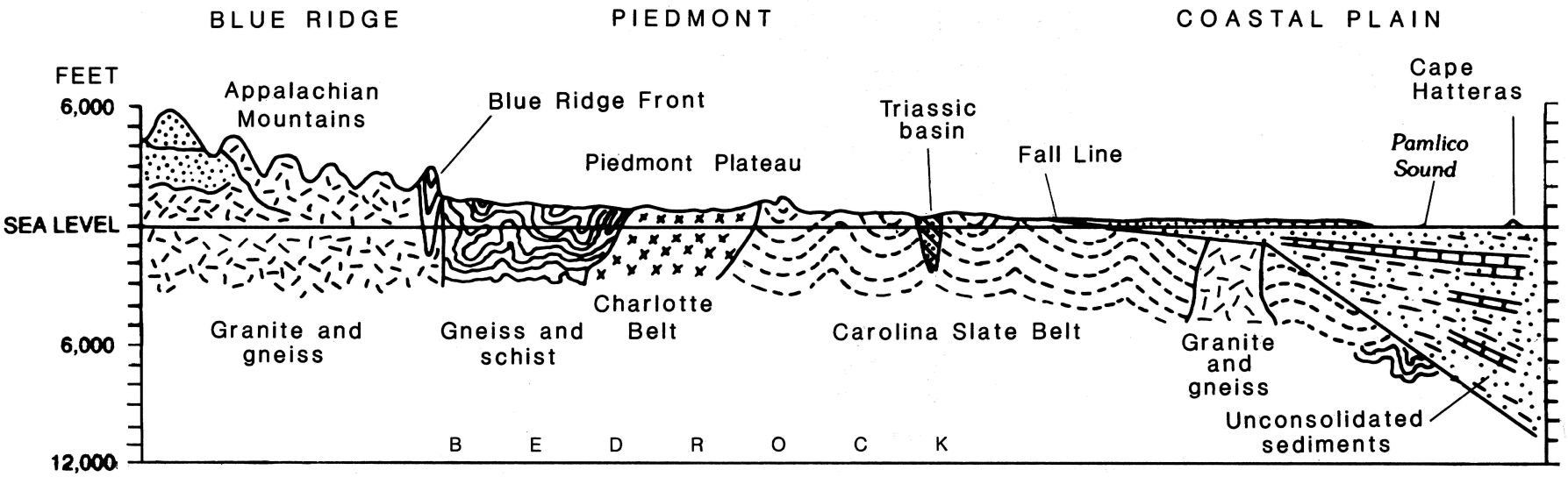
The ratio of openings (voids) to the total volume of a soil or rock is referred to as its porosity. Porosity is expressed either as a decimal fraction or as a percentage.

Soil	**55**
Sand	**25**
Granite	**.1**



Hydrogeologic Unit Map of North Carolina

PHYSICAL SETTING OF THE GROUND-WATER SYSTEM IN NORTH CAROLINA

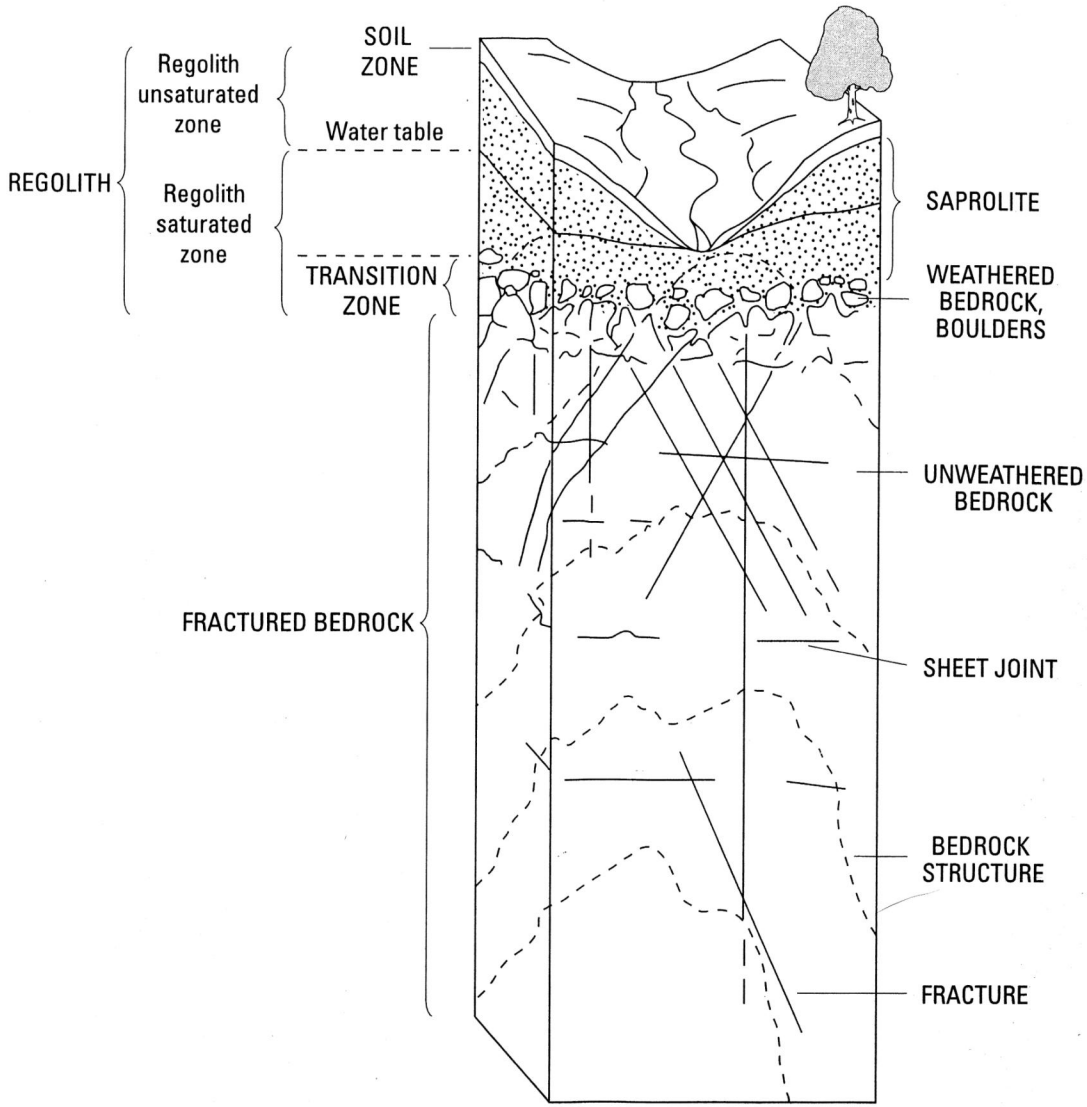


West-to-east geologic section across North Carolina (modified from Heath, 1980)

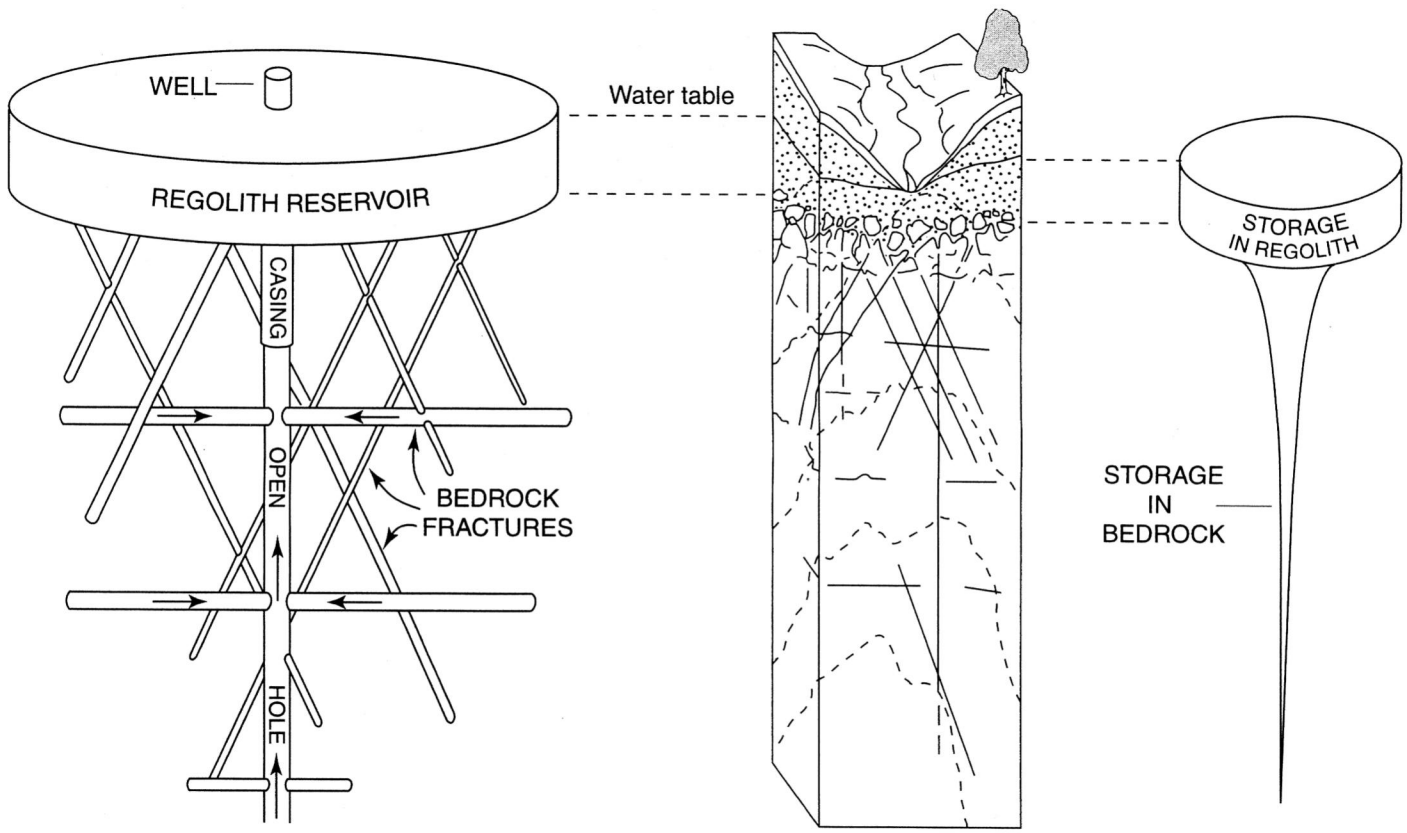
FRACTURES IN BEDROCK

High angle joint sets intersected by sub horizontal sheet fractures

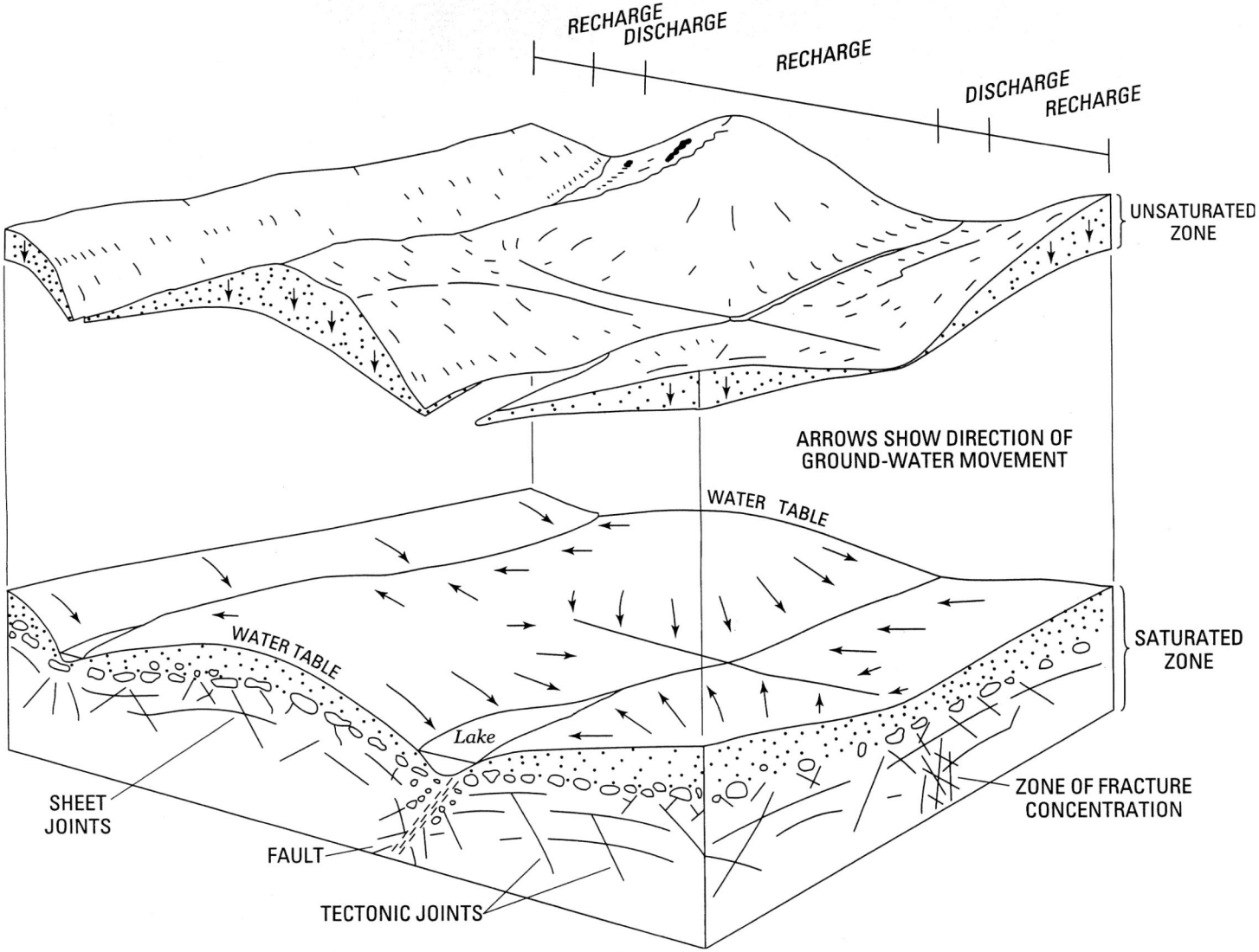
Photograph taken during construction of Interstate 40 through western Wake County.



Principal components of the ground-water system in the Blue Ridge and Piedmont Provinces of North Carolina (from Harned and Daniel, 1992)

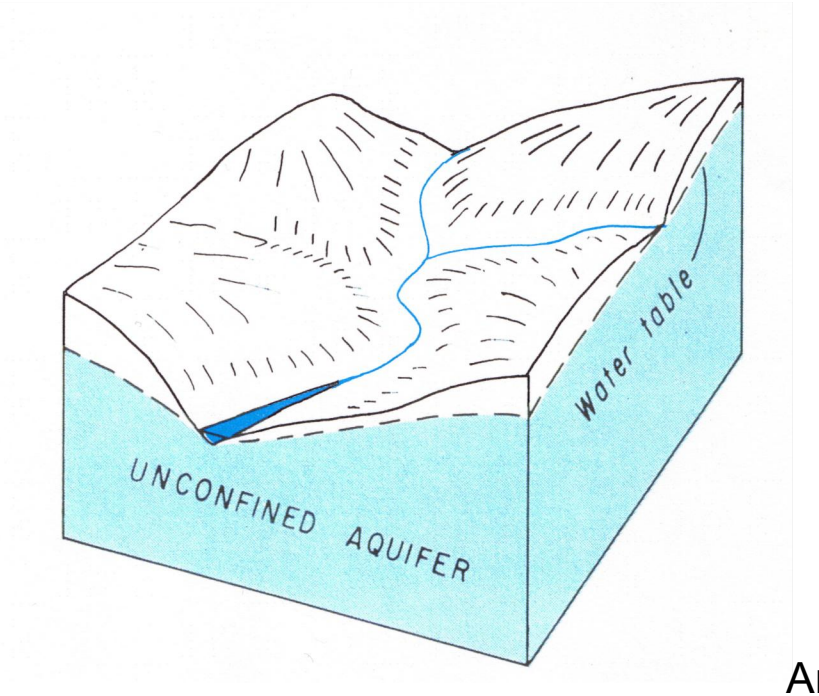


The reservoir-pipeline conceptual model of the Blue Ridge-Piedmont ground-water system and the relative volume of ground-water storage within the system (modified from Heath, 1984)

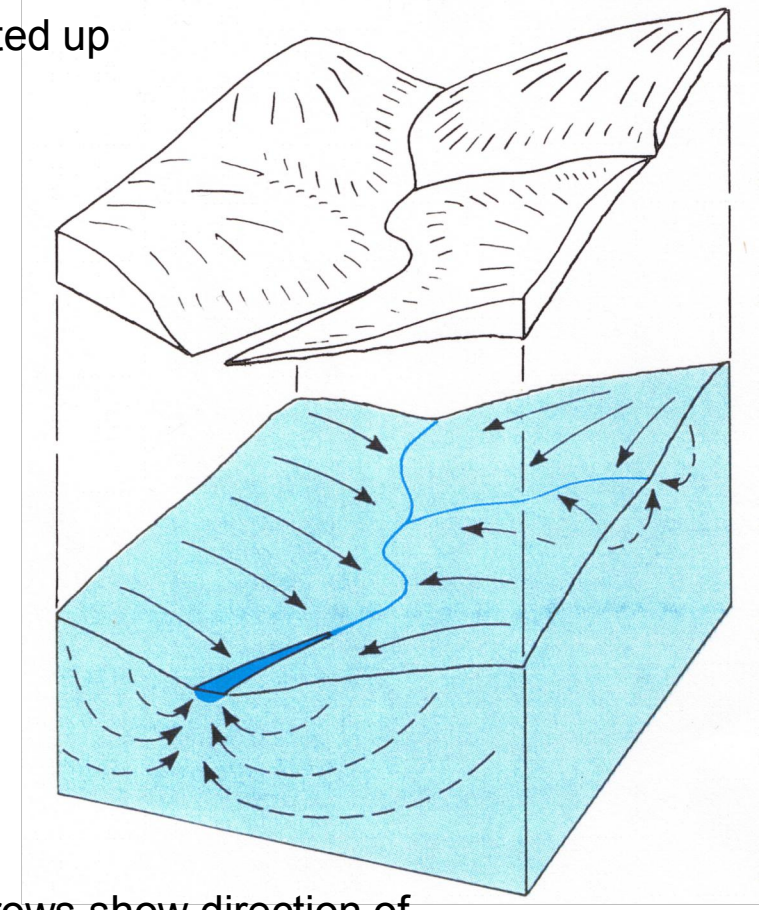


Conceptual view of the North Carolina Blue Ridge and Piedmont ground-water flow system showing the unsaturated zone (lifted up), the water table, the saturated zone, and directions of ground-water flow (from Daniel, 1990)

Ground-water Movement and Topography

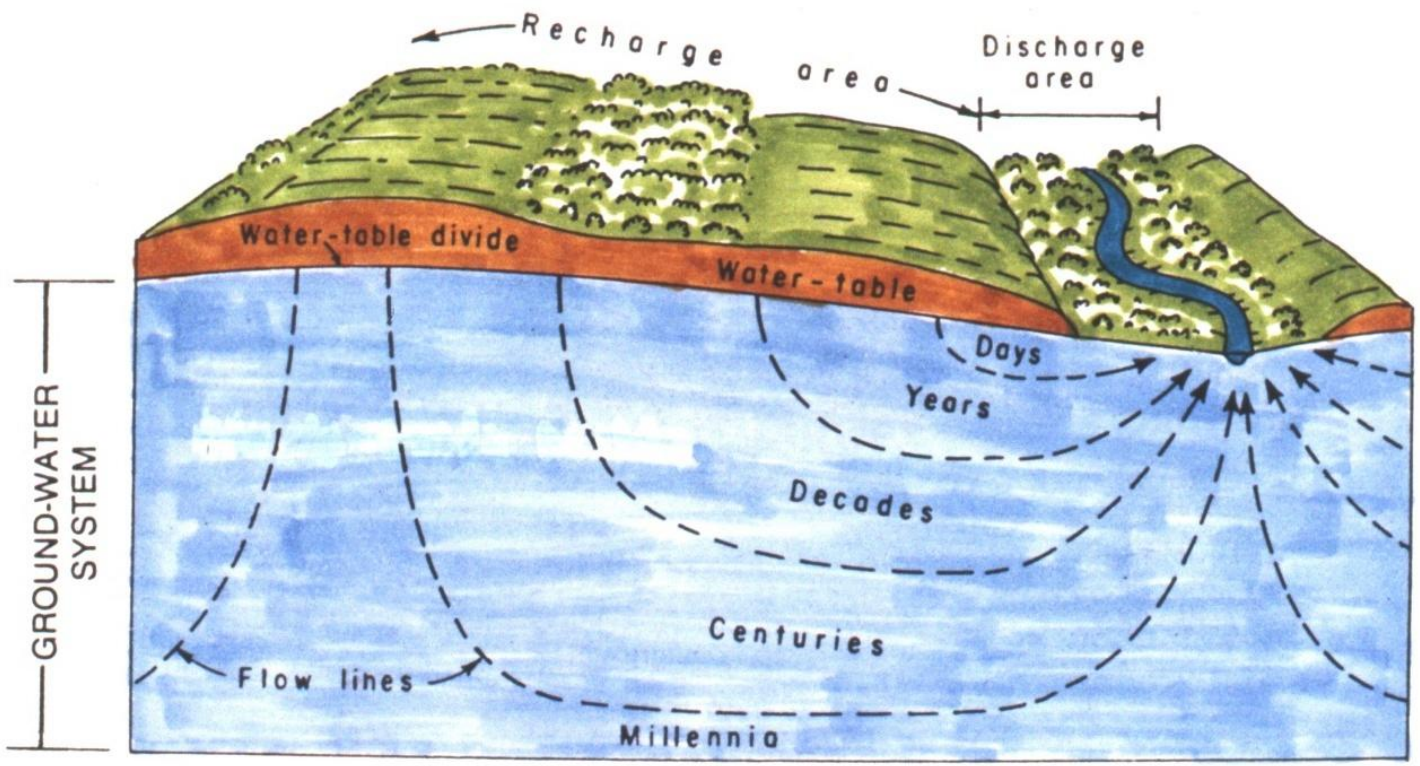


Unsaturated zone
lifted up



Arrows show direction of
ground-water movement

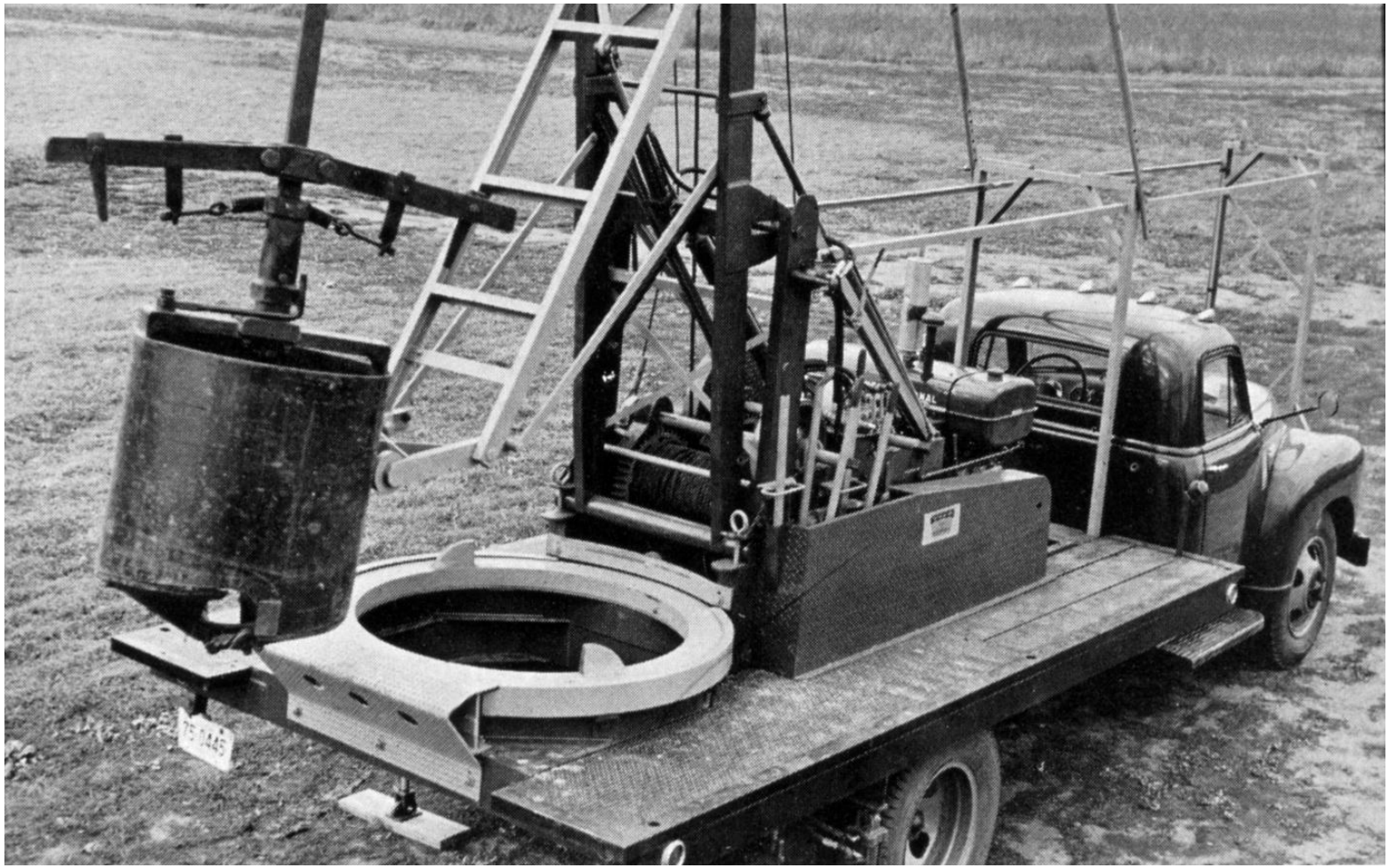
GROUND WATER FLOW SYSTEM



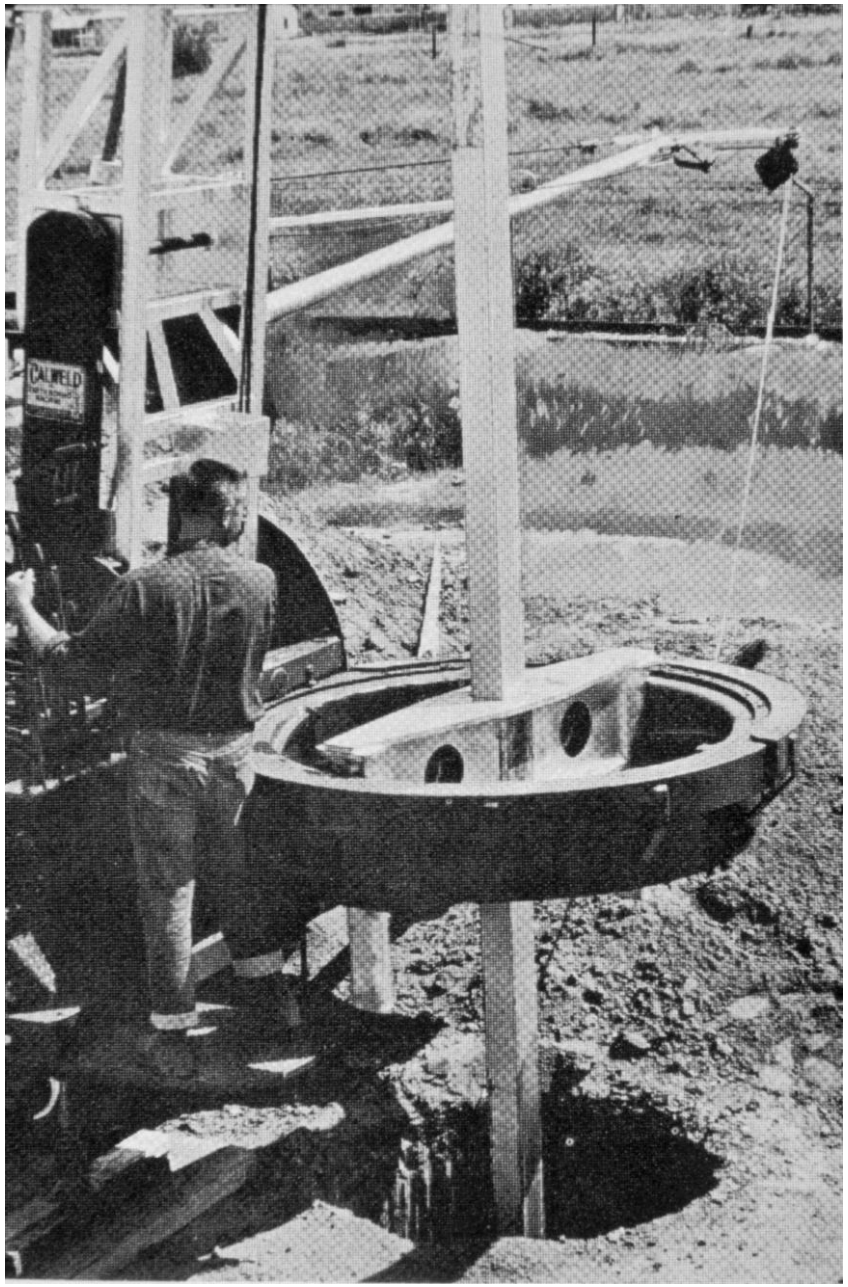
Hydraulically, this system serves two functions: (1) it stores water to the extent of its porosity, and (2) it transmits water from recharge areas to discharge areas. Thus, a ground-water system serves as both a **reservoir** and a **conduit** (Heath, 1983).

BUCKET (EARTH) AUGER MACHINE

When loaded with material, the auger bucket is lifted above the ring gear and pushed or pulled aside to dump



Courtesy Gus Pech Manufacturing Co., Inc.

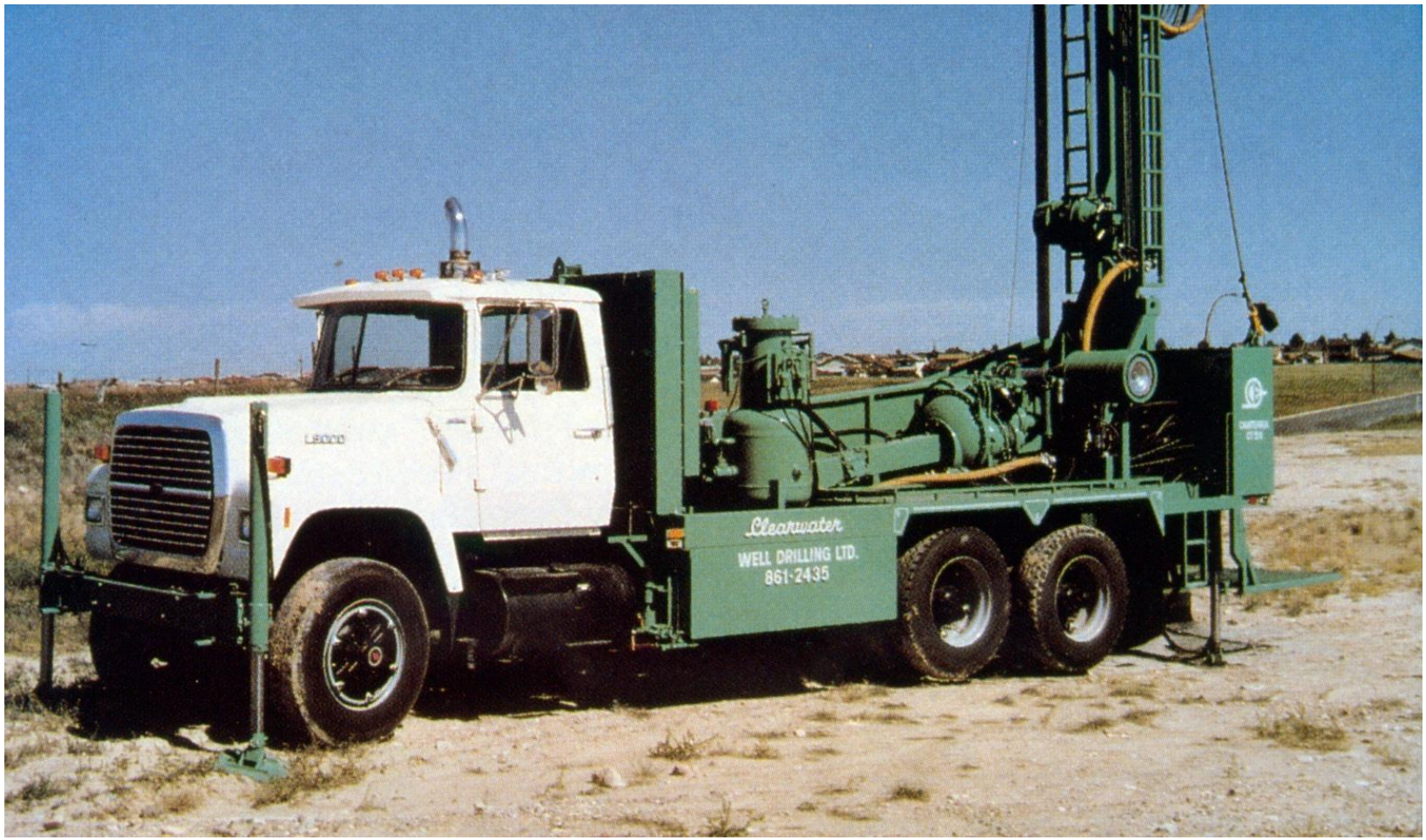


Drilling a large diameter well with a bucket auger

A large ring gear and kelly bar operate the rotary bucket to drill the open hole.

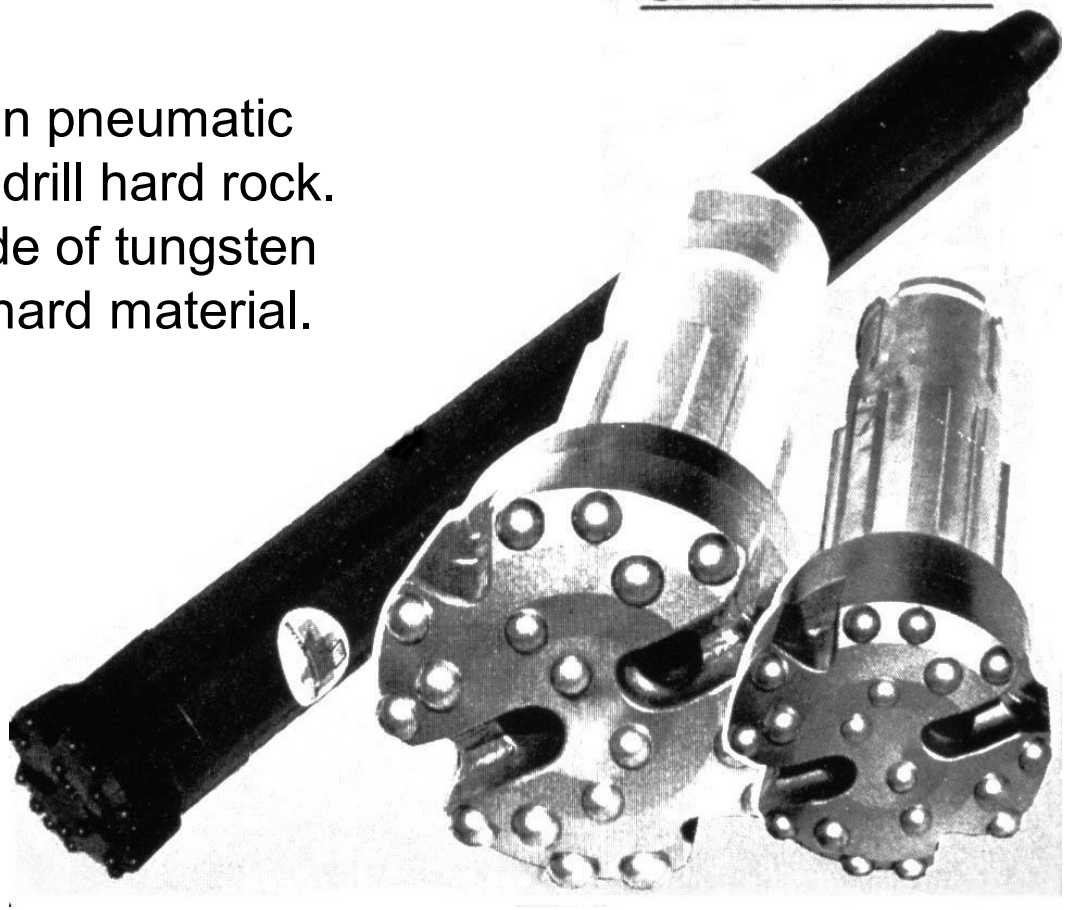
AIR ROTARY DRILL RIG WITH MAST RAISED

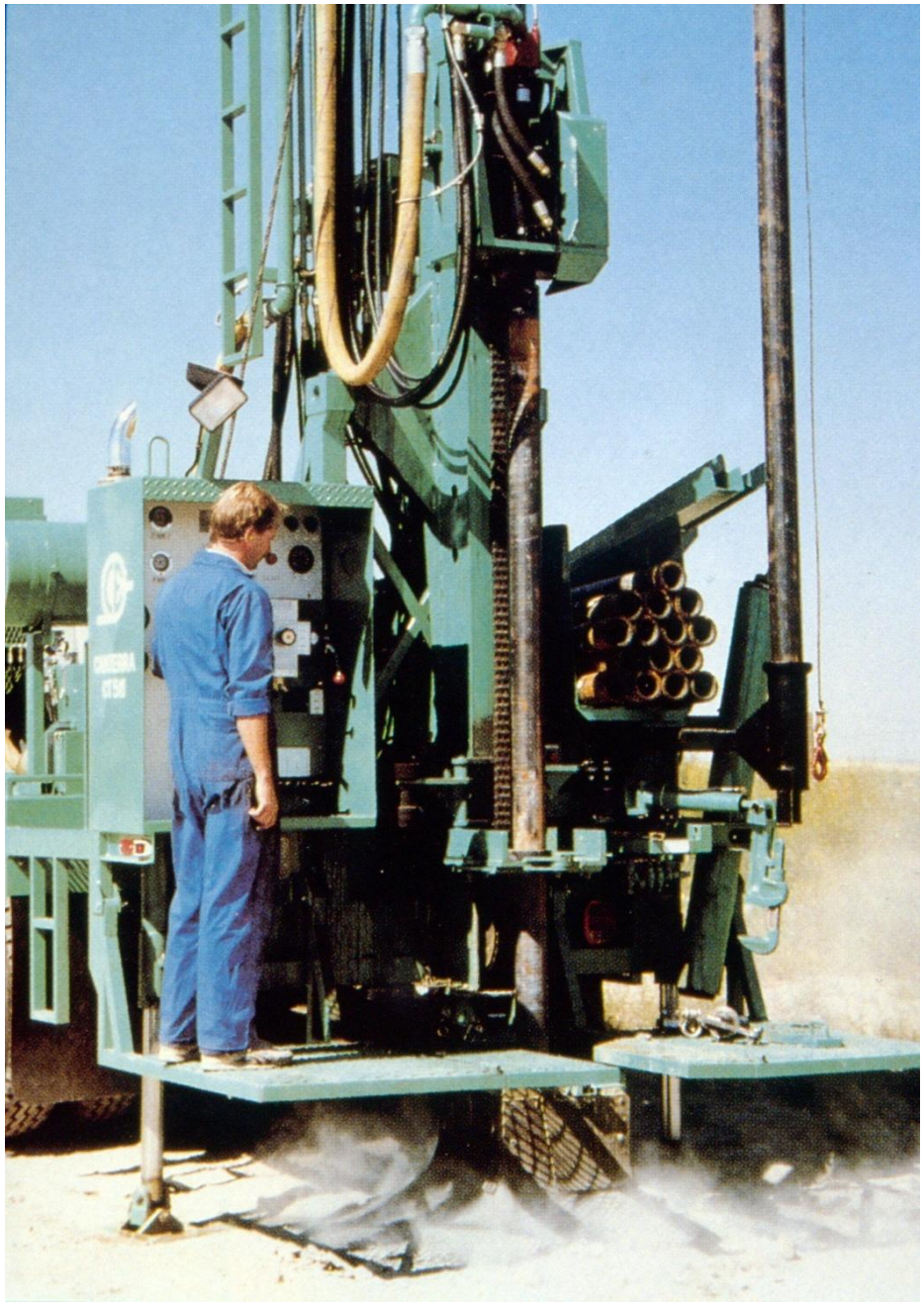
AIR ROTARY DRILL RIG
Mast raised and hydraulic levelers extended



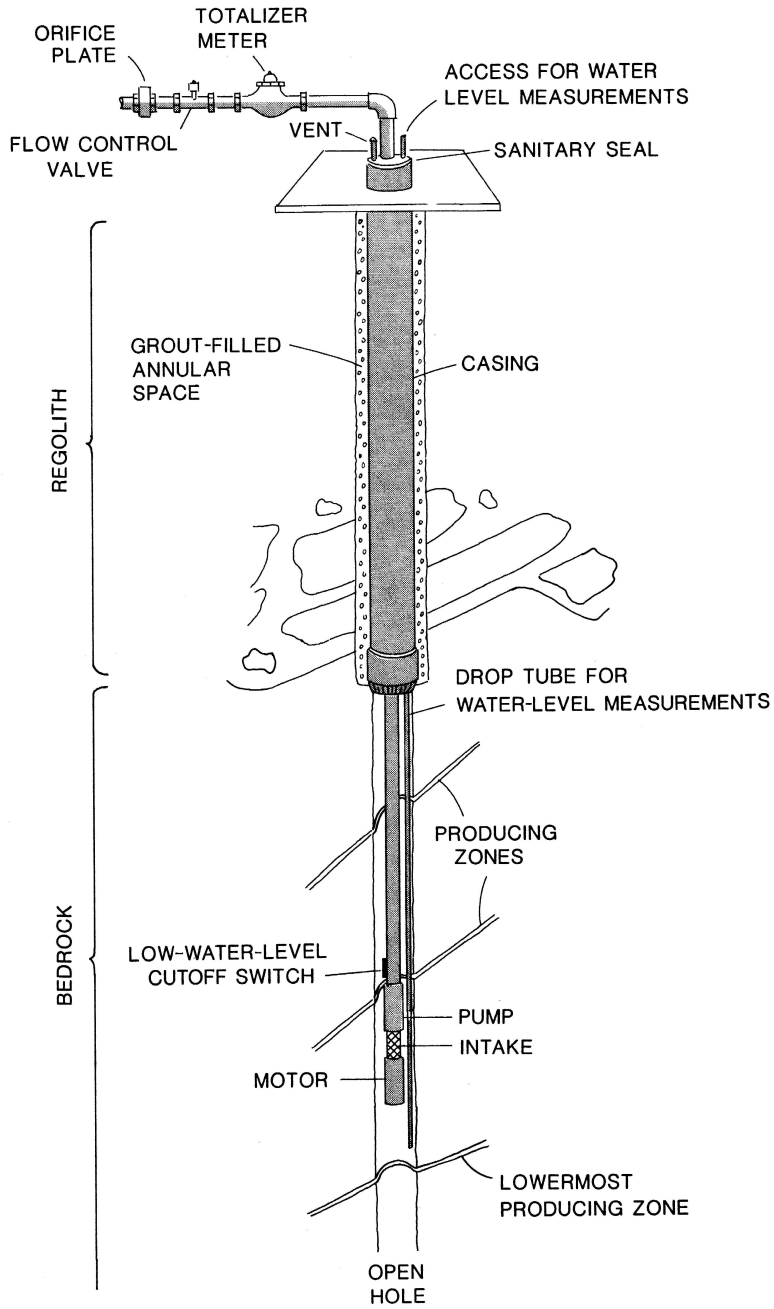
HAMMERS and BITS

Button bits mounted on pneumatic hammers are used to drill hard rock. The “buttons” are made of tungsten carbide or other very hard material.



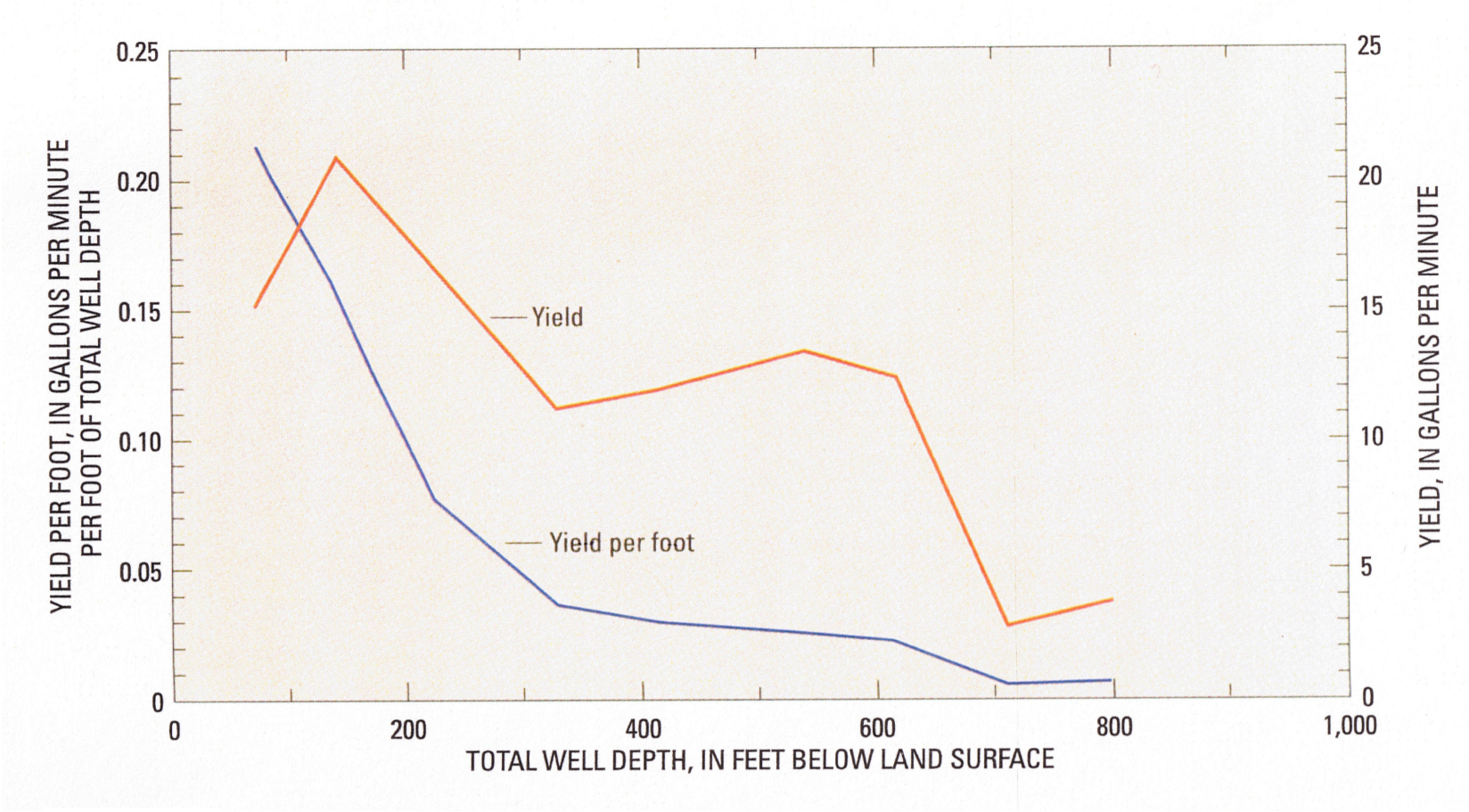


AIR ROTARY DRILLING –
Drilling the well



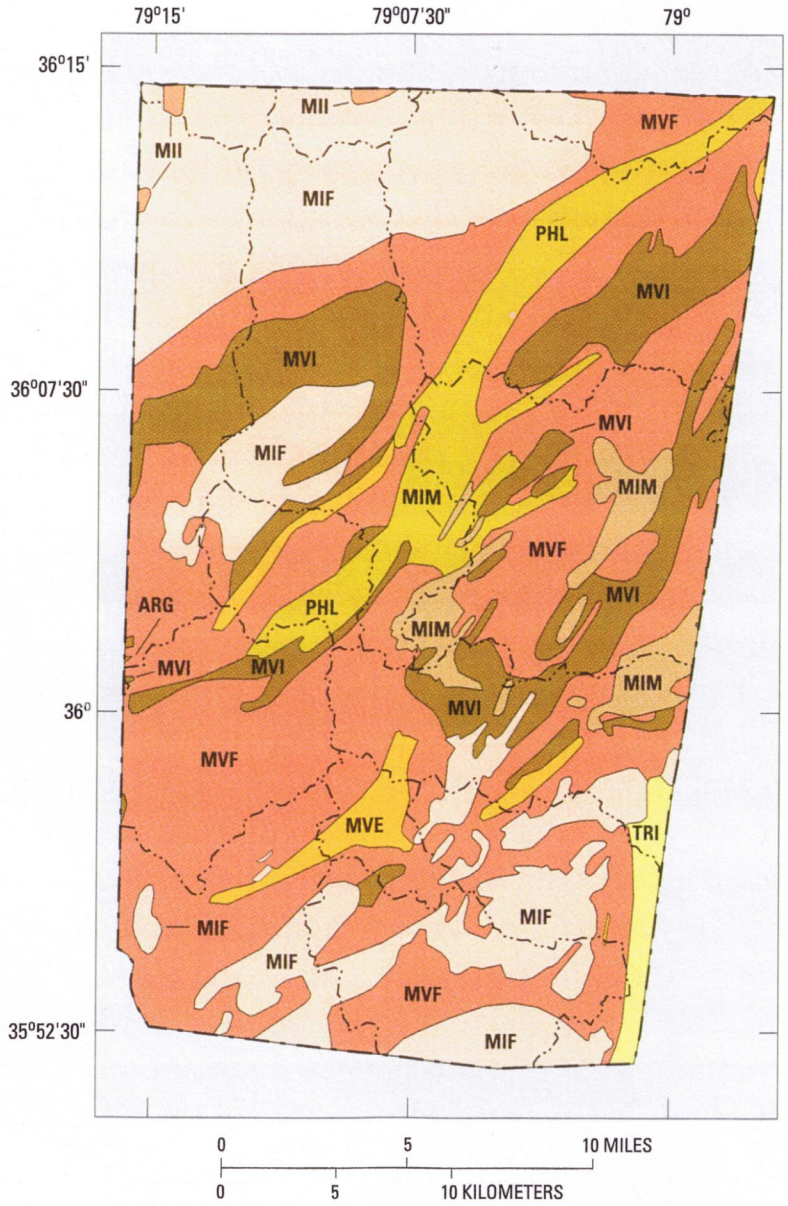
WELL COMPLETION

Typical construction of a municipal supply well in Cary, N.C. illustrating optimal installation of a pump assembly having provisions for monitoring the pumping rate and water levels (from Daniel, 1990, fig. 12)



Relation of yield and yield per foot of total well depth in Orange County, N.C. to total well depth (from Cunningham and Daniel, 2001).

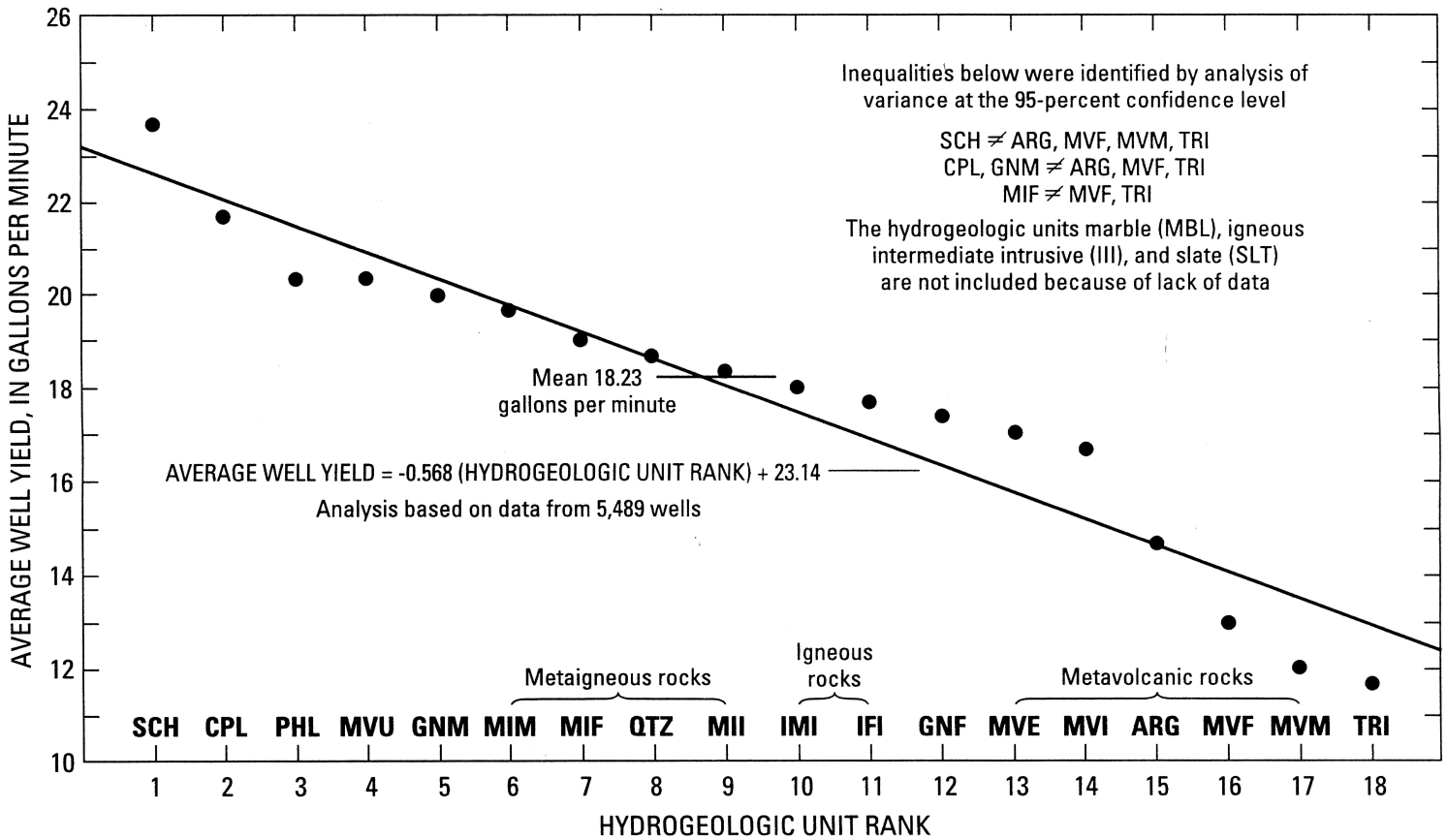
Hydrogeologic units in Orange County, N.C.



EXPLANATION

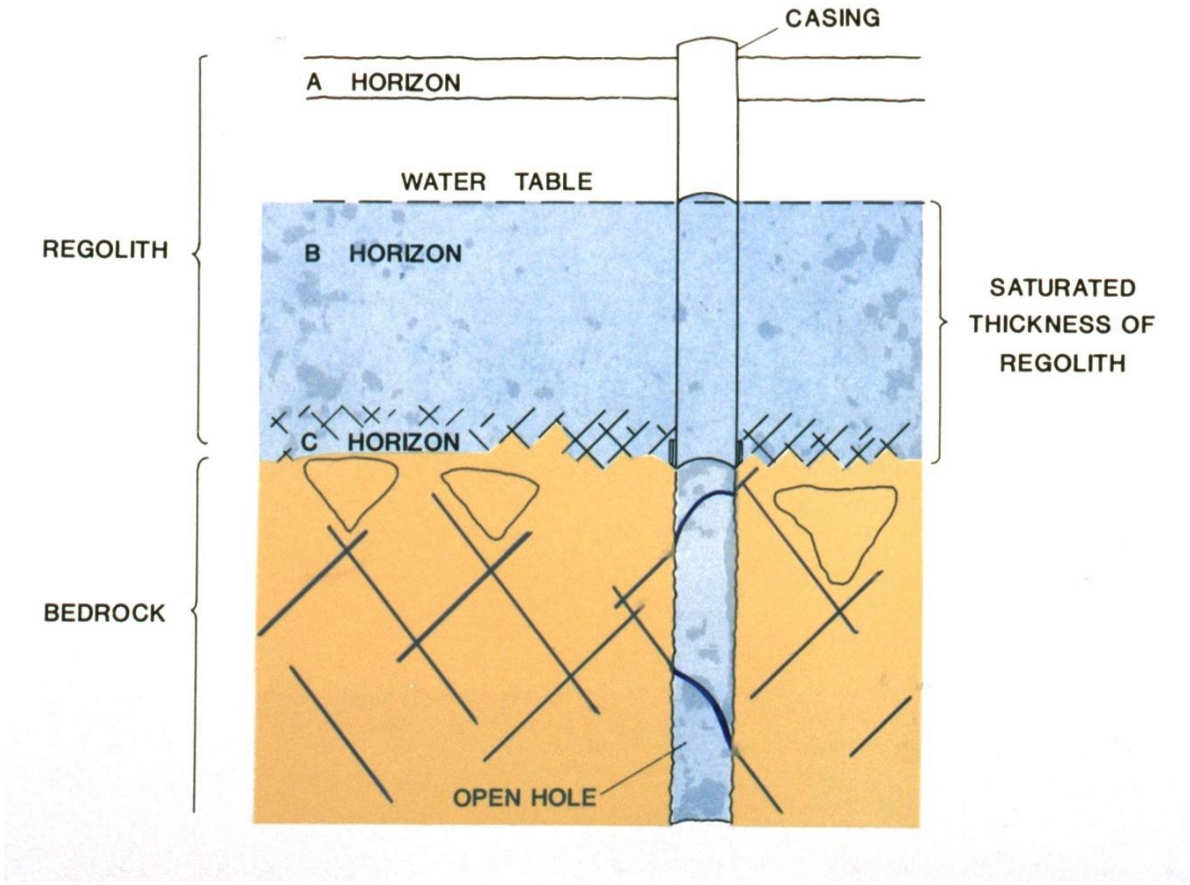
HYDROGEOLOGIC UNITS

- (ARG) ARGILLITE
- (MIF) METAIGNEOUS, FELSIC
- (MII) METAIGNEOUS, INTERMEDIATE
- (MIM) METAIGNEOUS, MAFIC
- (MVE) METAVOLCANIC, EPICLASTIC
- (MVF) METAVOLCANIC, FELSIC
- (MVI) METAVOLCANIC, INTERMEDIATE
- (PHL) PHYLLITE
- (TRI) TRIASSIC SEDIMENTARY ROCKS
- BASIN BOUNDARY



Average yield of wells of average construction in the hydrogeologic units of the Blue Ridge and Piedmont Provinces of North Carolina (modified from Daniel, 1989)

ESTIMATING THE SATURATED THICKNESS OF REGOLITH



Depth of casing below land surface (assume casing extends to top of bedrock)

Minus

Depth to water table below land surface

Equals

Saturated thickness of regolith

Orange County	**27.0 ft.**
Piedmont	**24.0 ft.**
Blue Ridge	**28.0 ft.**

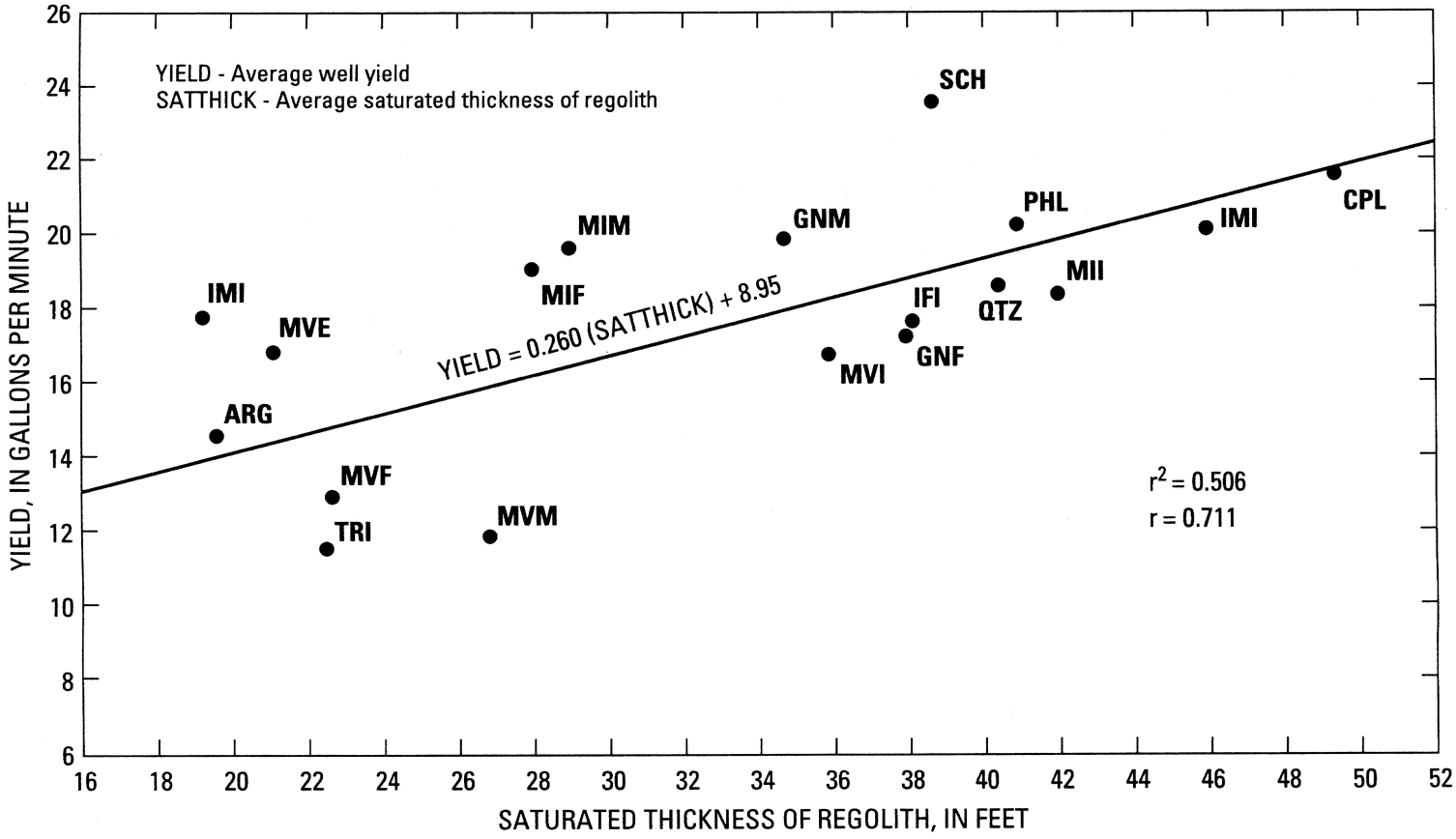
EXPLANATION

Hydrogeologic unit[a]		Hydrogeologic unit[a]	
Symbol		Symbol	
IMI	Igneous, mafic intrusive	**MVI**	Metavolcanic, intermediate
ARG	Argillite	**GNF**	Gneiss, felsic
MVE	Metavolcanic, epiclastic	**IFI**	Igneous, felsic intrusive
TRI	Triassic sedimentary rocks	**SCH**	Schist
MVF	Metavolcanic, felsic	**QTZ**	Quartzite
MVM	Metavolcanic, mafic	**PHL**	Phyllite
MIF	Metaigneous, felsic	**MII**	Metaigneous, intermediate
MIM	Metaigneous, mafic	**MVU**	Metavolcanic, undifferentiated
GNM	Gneiss, mafic	**CPL**	Coastal Plain basement

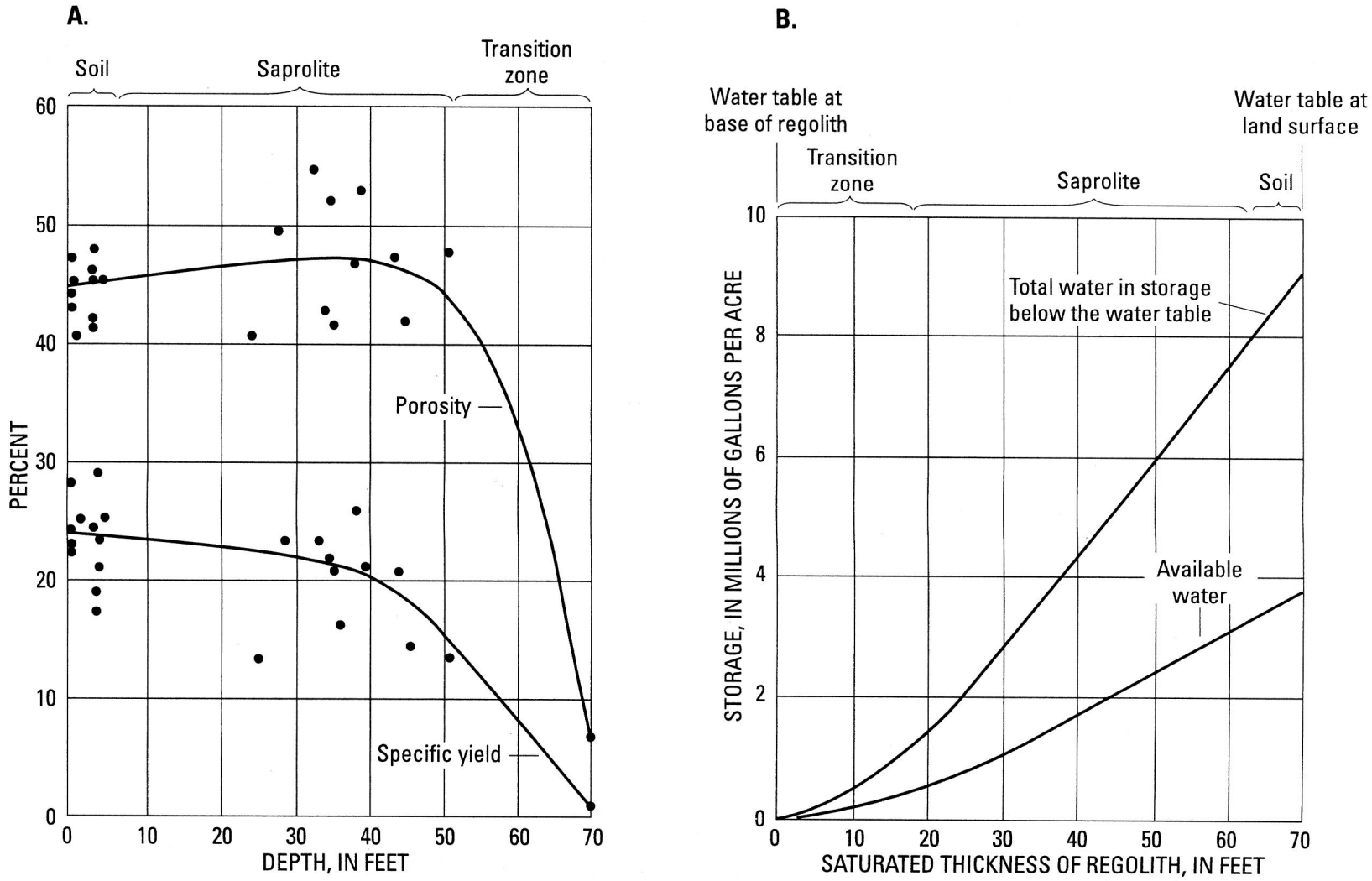
[a]Unit descriptions are given in table 1.

Explanation of hydrogeologic unit symbols used in graph showing relation of average well yield to the average saturated thickness of regolith.

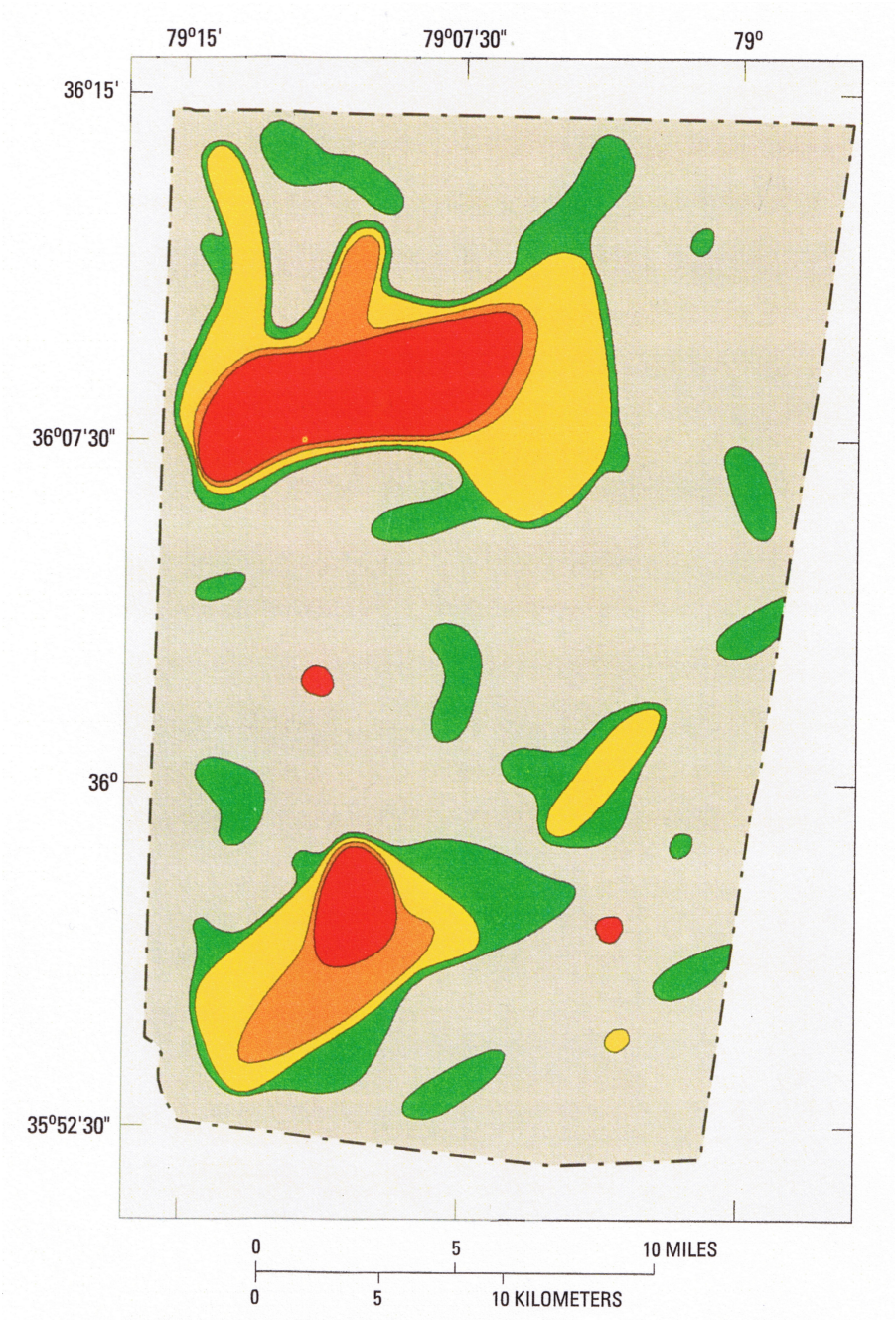
Units presented in order of increasing saturated thickness of regolith.



Relation of average well yield to the average saturated thickness of regolith for hydrogeologic units in the Blue Ridge and Piedmont Provinces of North Carolina



A. Variation of porosity and specific yield with depth in the regolith (modified from Stewart, 1962); **B.** Total ground water in storage below the water table and water available by gravity drainage (from Daniel and others, 1997).

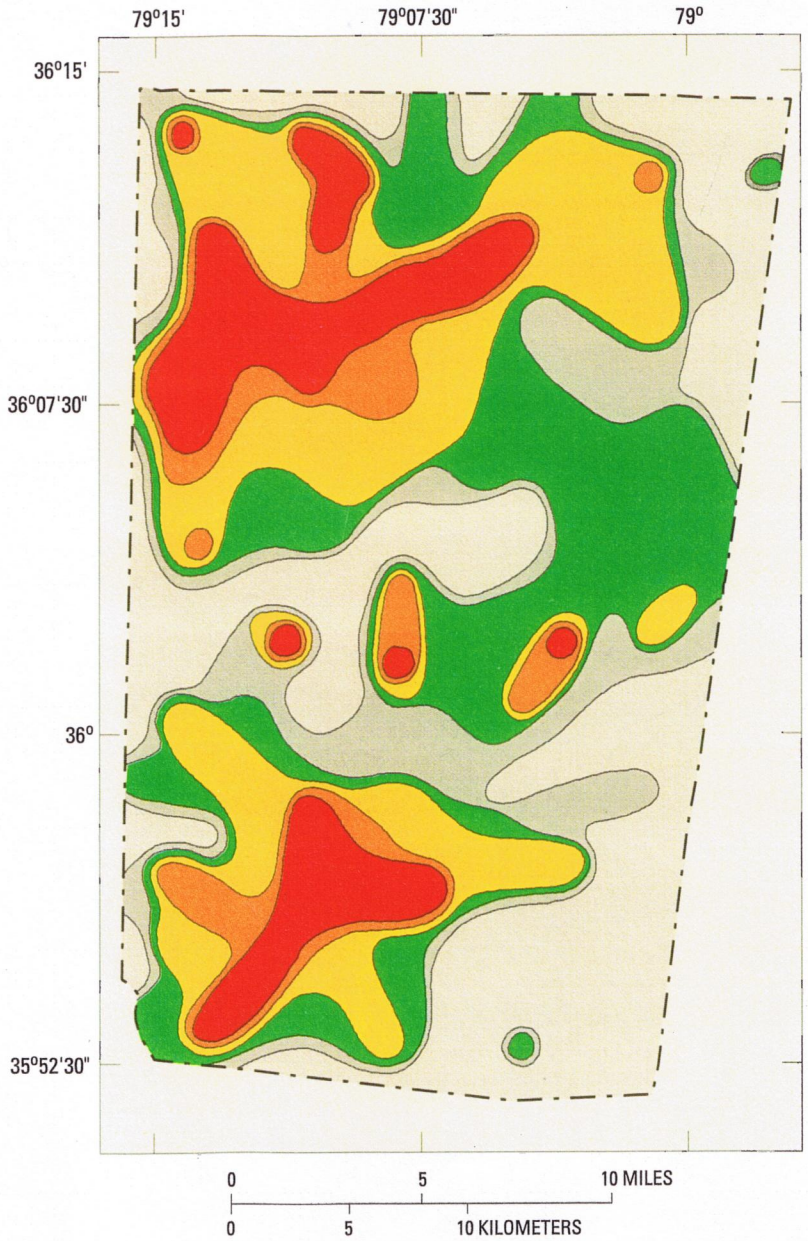


Distribution of maximum well yields in Orange County, N.C.

EXPLANATION

MAXIMUM WELL YIELD
(in gallons per minute)

- 0 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- > 100

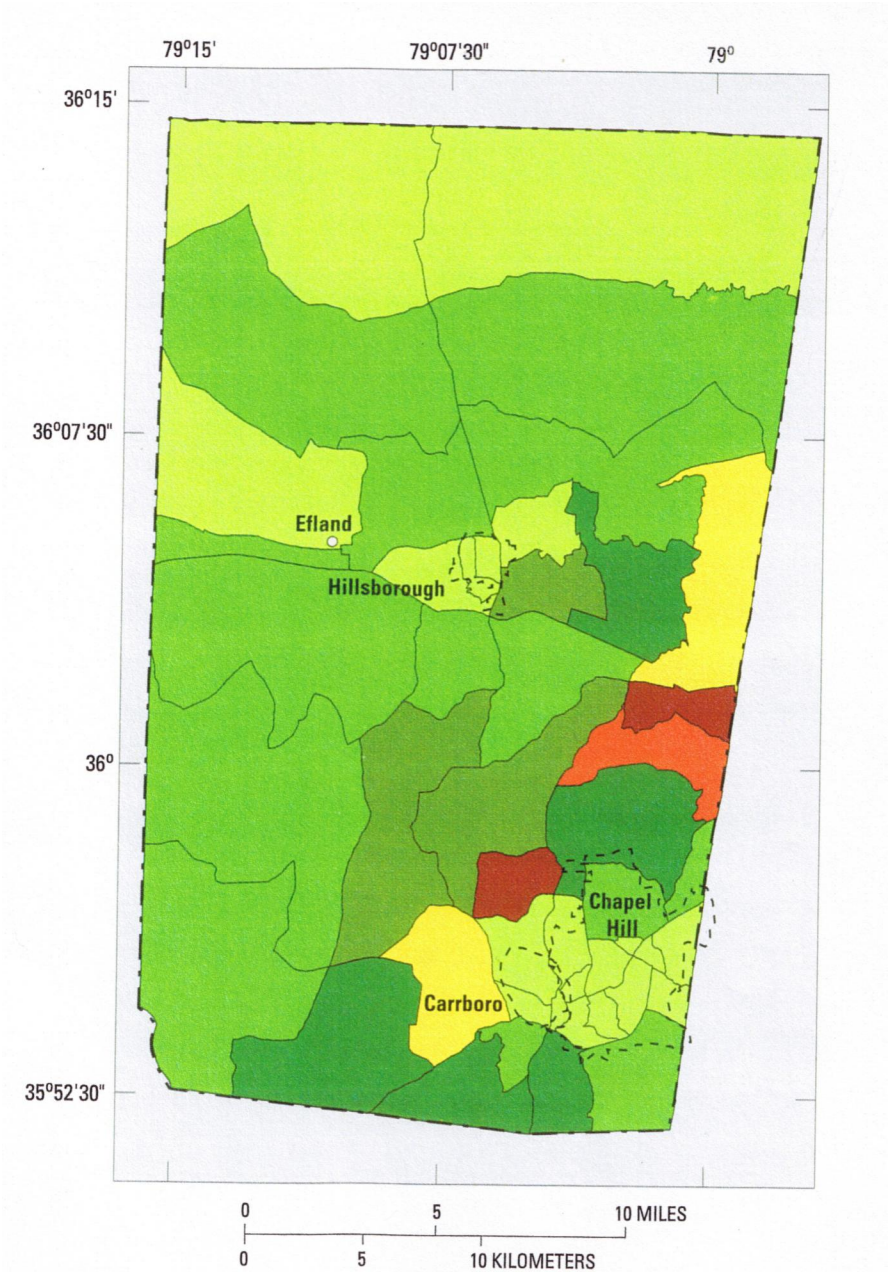


Distribution of maximum values of yield per foot of total well depth in Orange County, N.C.

EXPLANATION

MAXIMUM WELL YIELD (in gallon per minute per foot of total well depth)

- 0 - 0.05
- 0.06 - 0.10
- 0.11 - 0.20
- 0.21 - 0.30
- 0.31 - 0.40
- > 0.40

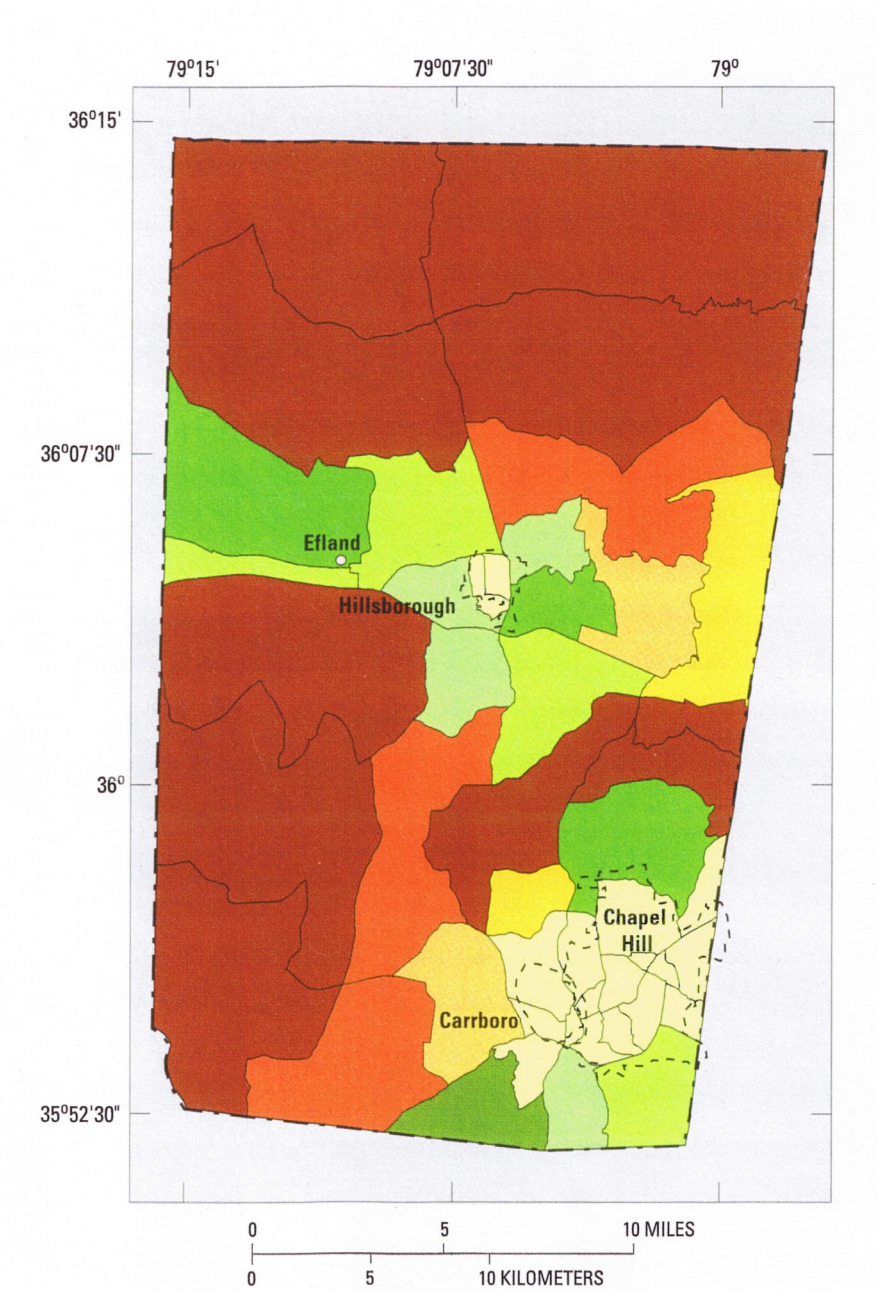


Number of wells per square mile in Orange County, N.C., 1990

EXPLANATION

NUMBER OF WELLS PER SQUARE MILE, BY CENSUS BLOCK GROUP, 1990

- 0 - 20
- 20.1 - 30
- 30.1 - 40
- 40.1 - 50
- 50.1 - 60
- 60.1 - 70
- 70.1 - 90



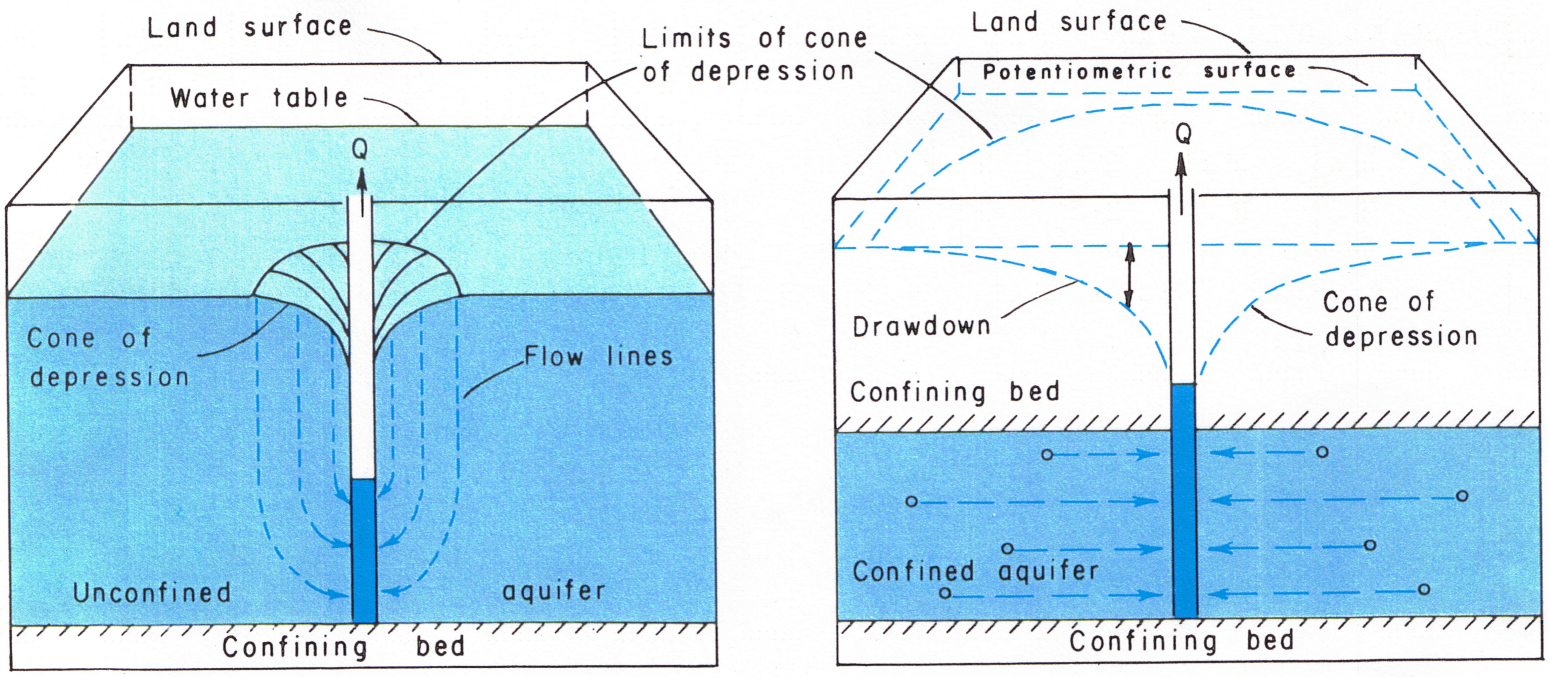
Percentage of housing units served by wells in Orange County, N.C., 1990

EXPLANATION

PERCENTAGE OF HOUSING UNITS SERVED BY WELLS, BY CENSUS BLOCK GROUP, 1990

- 0 - 10
- 10.1 - 20
- 20.1 - 30
- 30.1 - 40
- 40.1 - 50
- 50.1 - 60
- 60.1 - 70
- 70.1 - 80
- 80.1 - 90
- 90.1 - 100

CONE OF DEPRESSION



Unconfined Aquifer

Confined Aquifer

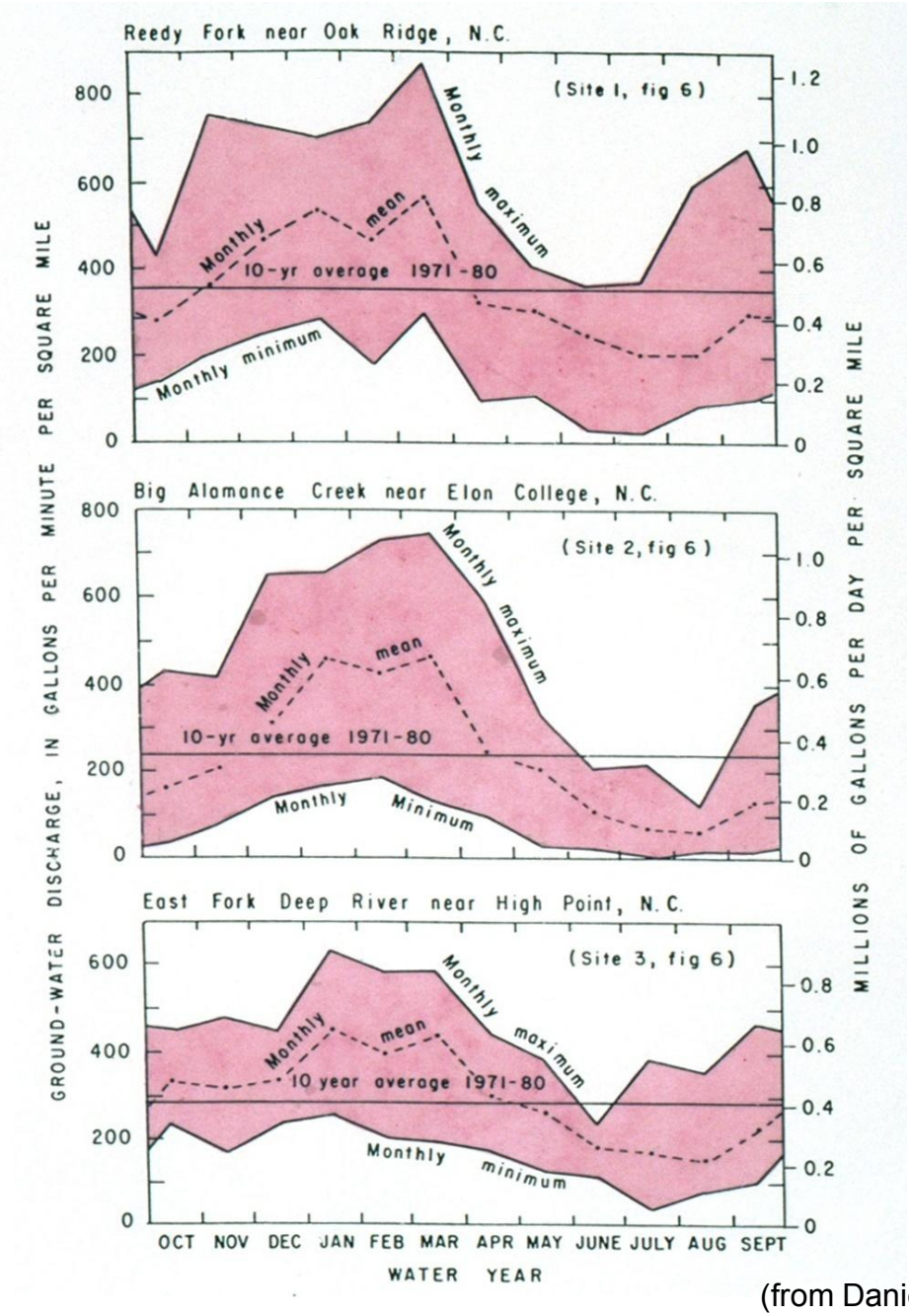
The movement of water from an aquifer into a well results in the formation of a cone of depression. The cone of depression expands very slowly in an unconfined aquifer.

Withdrawal of water from the regolith-fractured rock aquifer system may produce drawdowns that combine characteristics of unconfined and confined aquifers, depending on properties of the regolith. Often the regolith-fractured rock aquifer system behaves as a semi-confined aquifer with water derived from storage in the confining unit.

AIR ROTARY DRILLING — Testing yield and drawdown

Drilling of test well Gu-383 at the Greensboro-High Point Regional Airport research site, 1983. Yield at time of photograph approximately 50 gal/min.

A 62-hour pumping test of this well was conducted in May 1983. The average pumping rate for the test was 38.5 gal/min and the total amount of water pumped during the 62-hour test was 143,200 gallons. By the time pumping stopped, drawdown effects extended over an area somewhat greater than 3.7 acres (from Daniel and Sharpless, 1983).

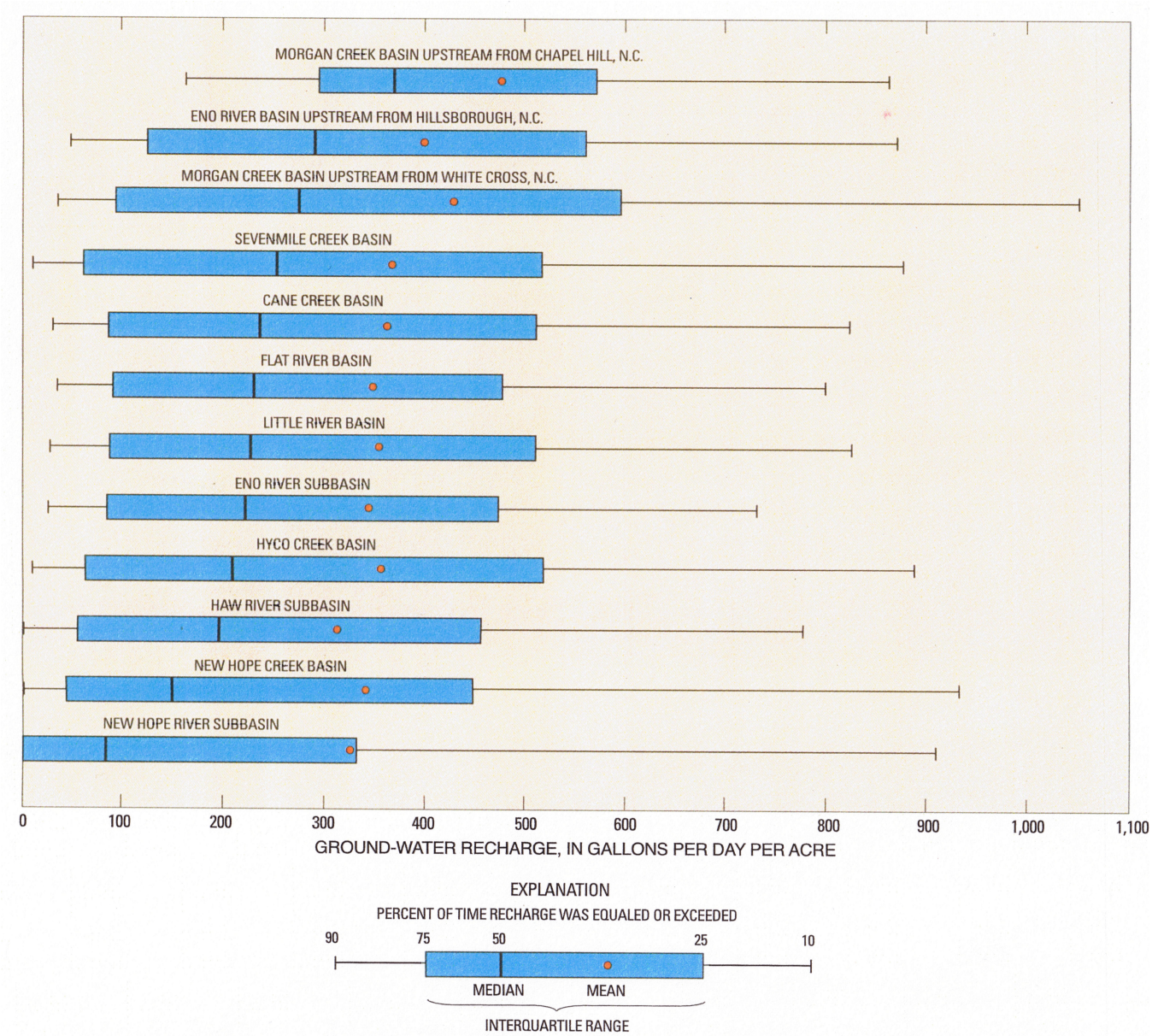


VARIATION OF MONTHLY MEAN GROUND-WATER RECHARGE--

Examples from the upper Cape Fear River Basin

There is a pronounced seasonality with highest rates of recharge typically occurring in the late fall and winter and lowest rates in late spring and summer.

(from Daniel and Sharpless, 1983)



GROUND-WATER RECHARGE

The average recharge for the 12 basins is 365 (gal/day)/acre.

Ground-water recharge duration characteristics and mean recharge in 12 basins and subbasins in Orange County, N.C. (from Daniel, 1996)

SUMMARY

1. Ground water is the most abundant available fresh water resource
2. Ground-water systems store water and transmit water. Thus, a ground-water system serves both as reservoir and conduit.
3. The aquifer system in Orange County is a two-part system composed of fractured bedrock overlain nearly everywhere by regolith.
4. Most ground water in the County is stored in the regolith. The average saturated thickness of regolith is about 27 ft. On average, available water in storage in the regolith is slightly less than 1 million gal/acre.
5. The saturated thickness of regolith varies with topographic setting and hydrogeologic unit.
6. Ground water is less affected by drought than surface water.
7. Ground water is recharged by the infiltration of precipitation in upland recharge areas. Mean ground-water recharge in Orange County, based on data from 12 drainage basins, is 365 (gal/day)/acre.
8. Recharge varies seasonally with precipitation and evapotranspiration.
9. Ground water in Orange county is obtained primarily from wells.
10. The average well yield in Orange County is 17.6 gal/min. 90 percent of all wells yield more than 2 gal/min, and half of all wells yield more than 10 gal/min.
11. Two areas in the County contain wells with maximum yields ranging from 25 gal/min to more than 100 gal/min. These areas are in the northwestern and southwestern parts of the County.