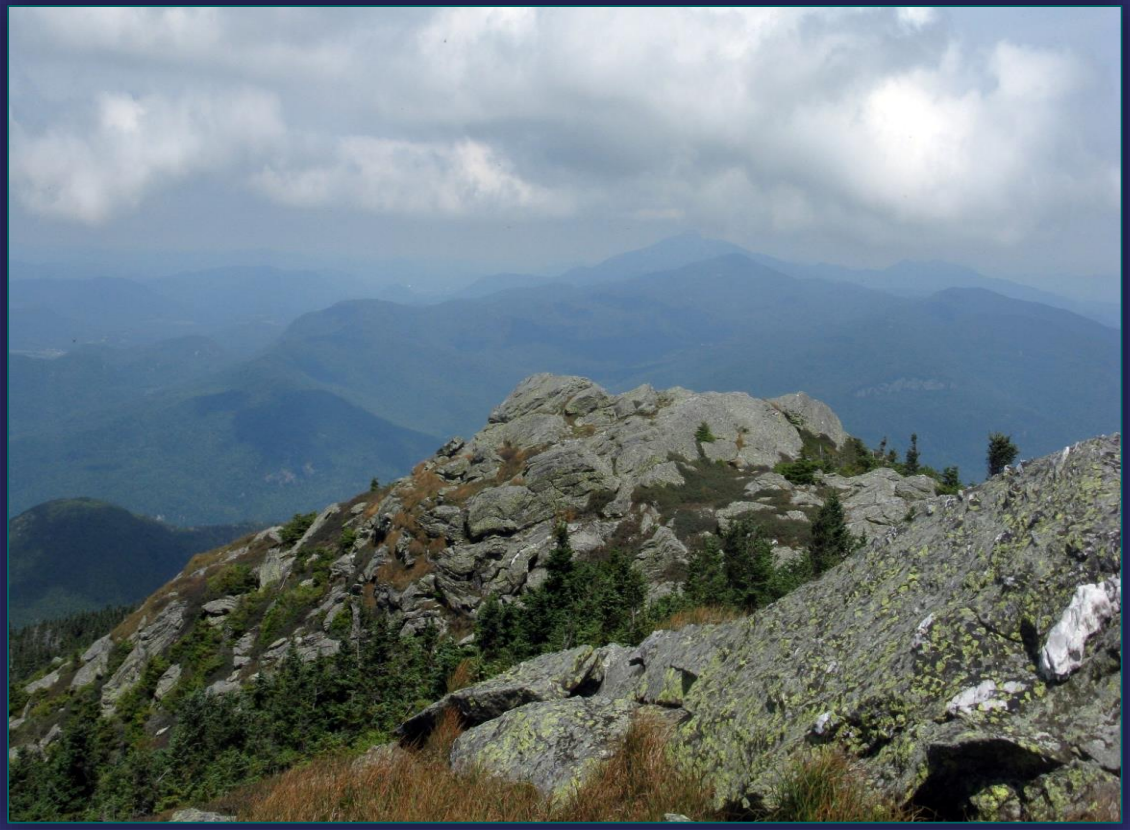


Looking north from Camels Hump

Overflowing well, Hinesburg

# Geology and Groundwater

Marjorie Gale, Vermont State Geologist
Department of Environmental Conservation
Montpelier, VT

Define terms

View the system from above

View the system from below

Properties of surficial materials

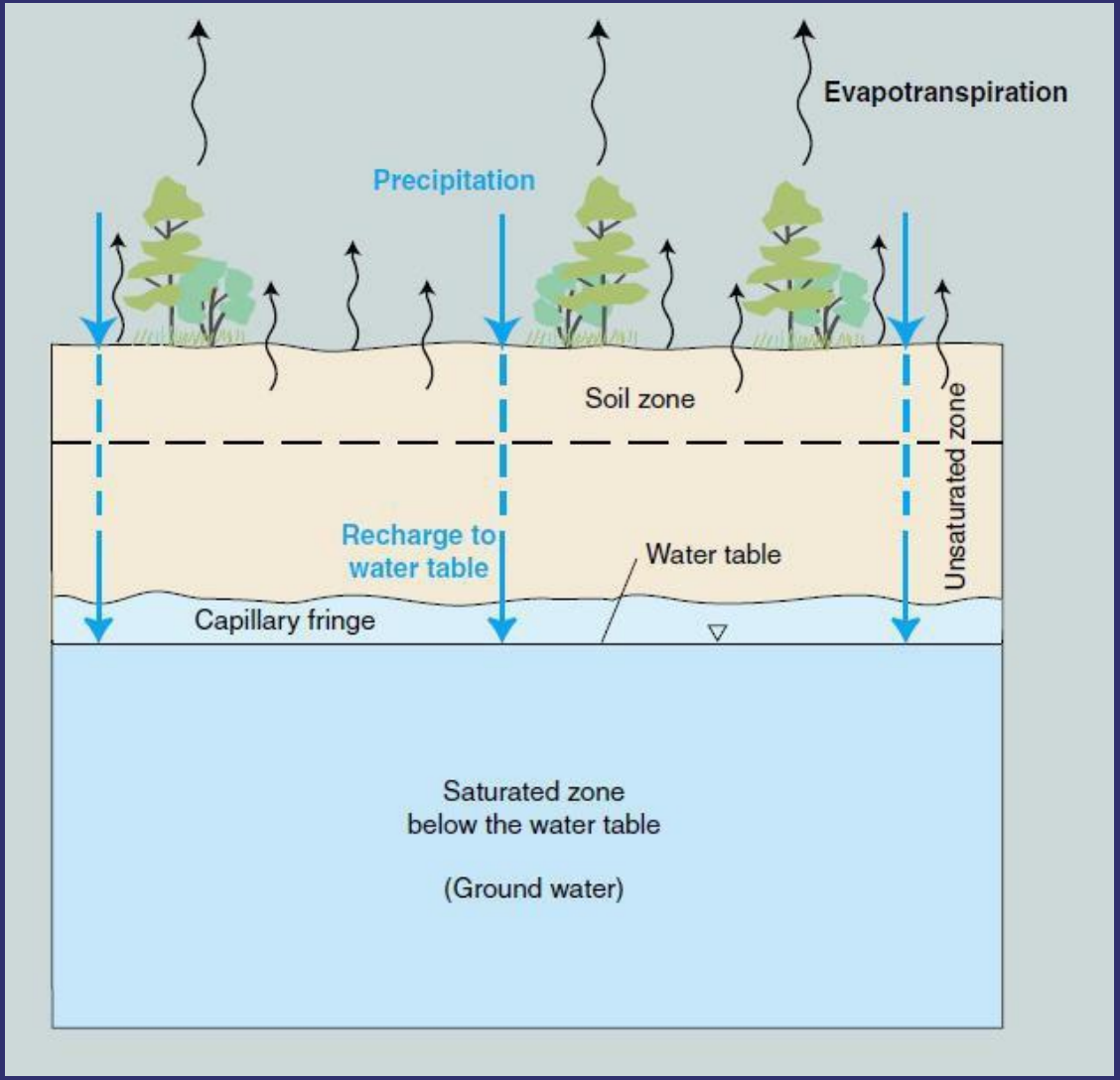
Secondary porosity in bedrock

Interpreting groundwater flow

**Groundwater** is water that flows or seeps downward and saturates soil or rock, supplying springs and wells.

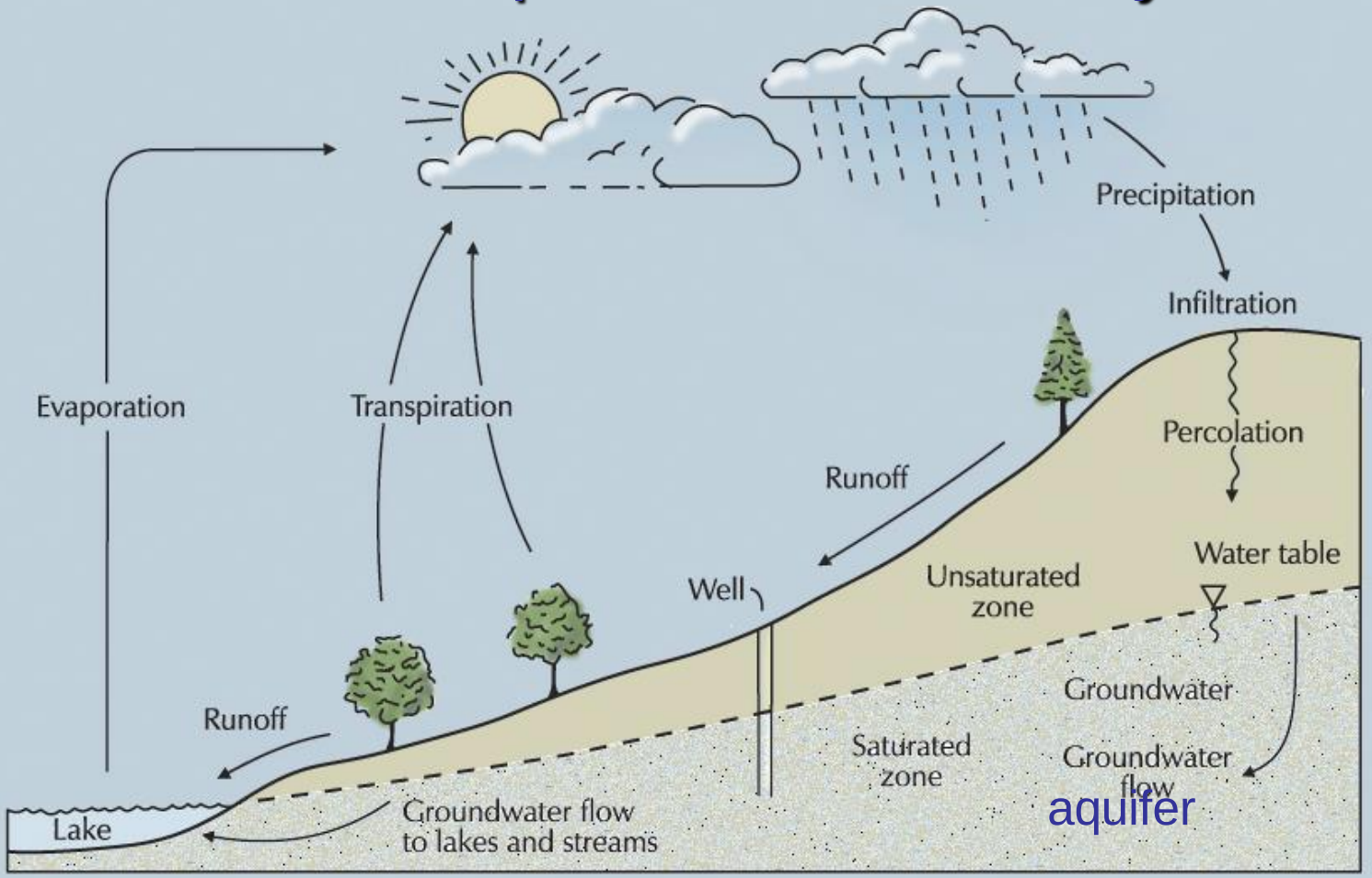
The *water table* is the top of the saturated zone. Below the water table all pores are completely filled with water.

Above the water table, in the *unsaturated zone*, pores are partly or completely filled with air.

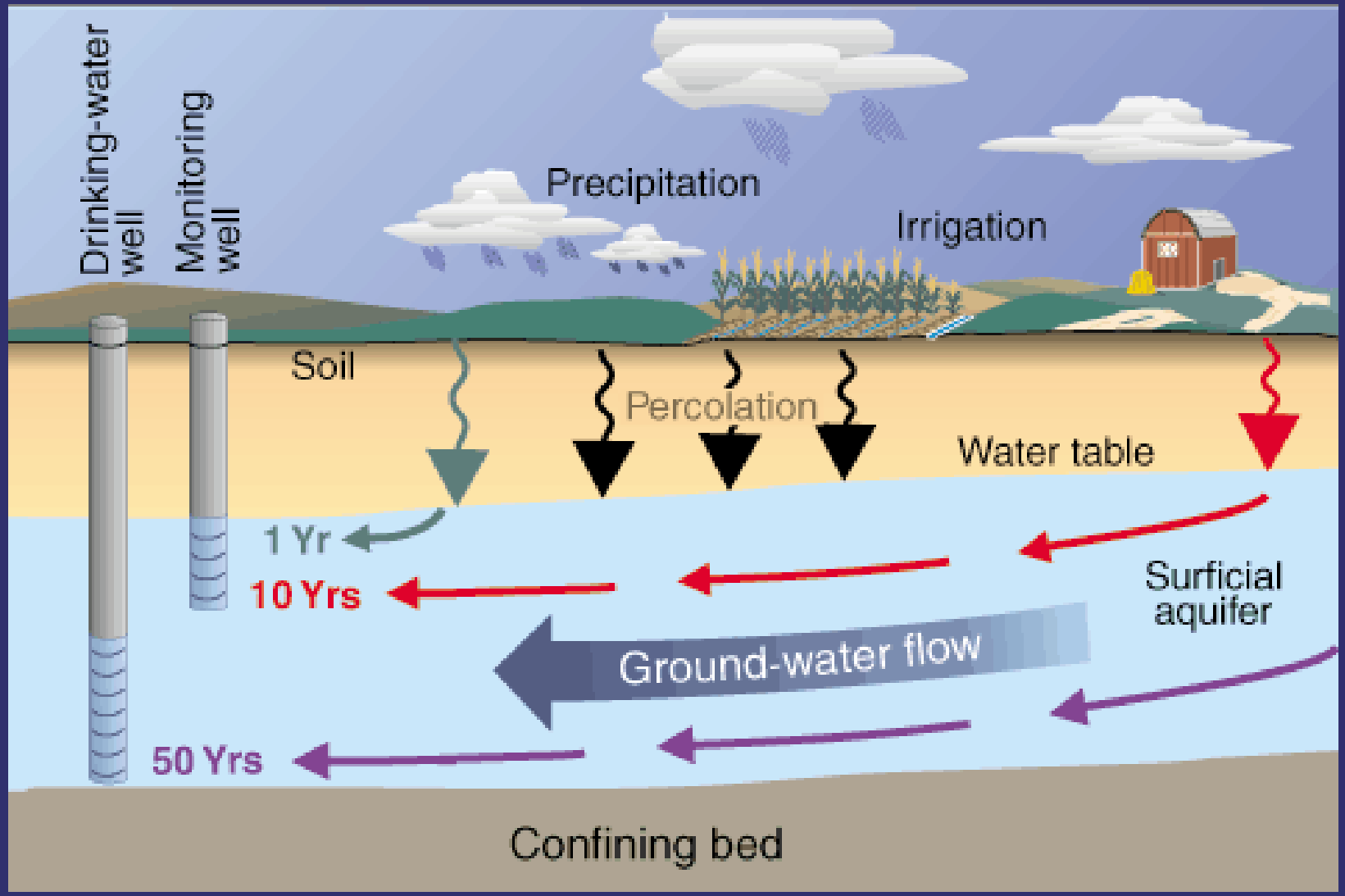



source: K. Bradbury (Wisconsin GS) and USGS

# All water is part of the water cycle…



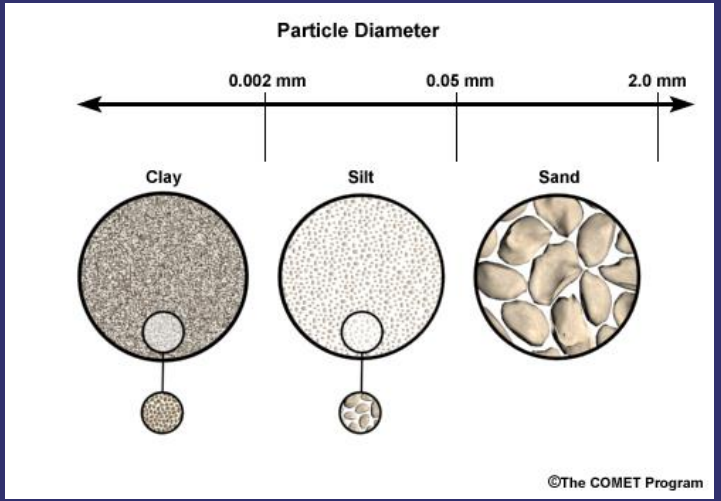

Aquifers are geologic units (sand and gravel, sandstone, etc) that can store and transmit significant quantities of groundwater




Lag time – The effects of land-use practices may take time to become apparent in groundwater. GW generally moves more quickly through porous media. (USGS)

# Surficial materials influence the rate of movement through materials (hydraulic conductivity) and infiltration

| Depositional Environment | Material | Horizontal Hydraulic Conductivity |
|---|---|---|
| Lake-bottom and deltaic (coarse) | | |
| | Gravel | 150 - >250 feet/day |
| | Coarse sand | 60 – 200 feet/day |
| | Medium to coarse sand | 15.9 feet/day |
| | Medium sand | 60 – 175 feet/day |
| | Fine sand | 1 – 30 feet/day |
| | Sand and silt (deltaic) | 1.1 – 56.7 feet/day |
| Lake Bottom | | |
| | Fine to very fine silty sand | 0.2 – 9 feet/day |
| | Fine sand to silt | 0.165 – 5.29 feet/day |
| | Fine sand, silty sand, silt, minor clay | 0.01 – 1.13 feet/day |
| Lake Bottom (fine) | | |
| | Lacustrine silt to clay | 0.002 – 0.029 feet/day |
| Mixed | | |
| | Lacustrine sand and ablation till | 135 feet/day |
| Till | | |
| | Sandy ablation till | 22 feet/day |
| | Till | 1 foot/day |
| | Hardpan | 0.3 feet/day |




Porosity (open space)

Permeability (connected spaces)

Secondary porosity – bedrock structures

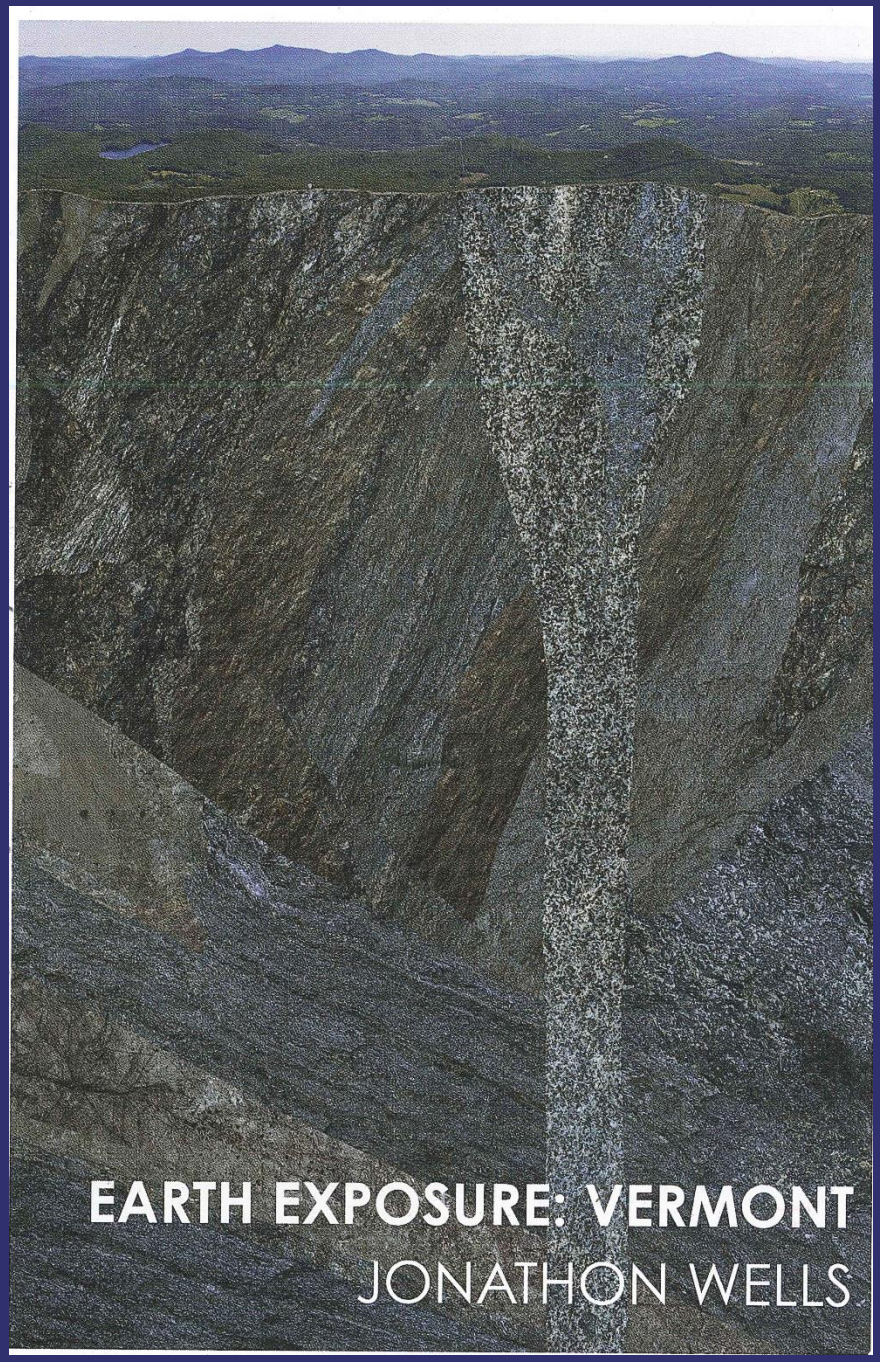
# *The system from above…..*

Photo credit: Vermont Yankee CSM Review, 4/27/2011

Groundwater flow generally mimics surface water flow –

Recharges in the uplands and discharges to rivers

# *The System From Below*




~1000 feet

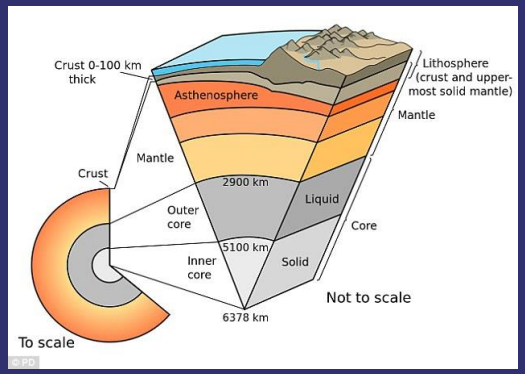
~1 mile

7 km
4.4 miles

~ 36” - Soils
Thin to thick surficial materials (most <50’)
Av drinking water well in VT ~290’

GW generally <3000’

Saline water (?)



# Surficial Materials – fill, alluvium, soils, glacial lake deposits, glacial deposits

Porous, permeable sand deposits, may not be **homogeneous**

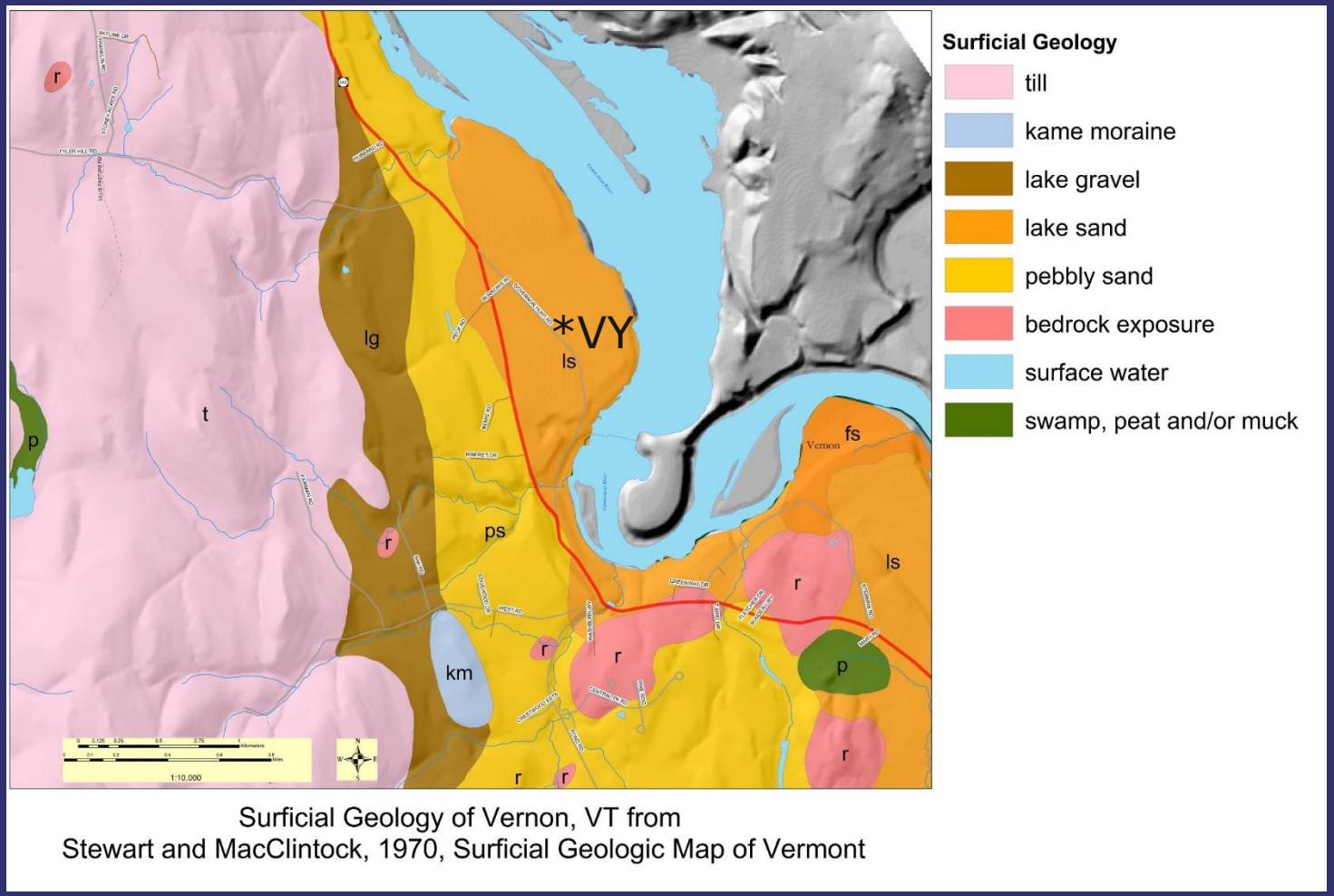
Fluvial gravel over lacustrine sand

Lacustrine sand with calcite-cemented concretions

Less permeable - Silt and clay

Piping – in more porous silts/sands

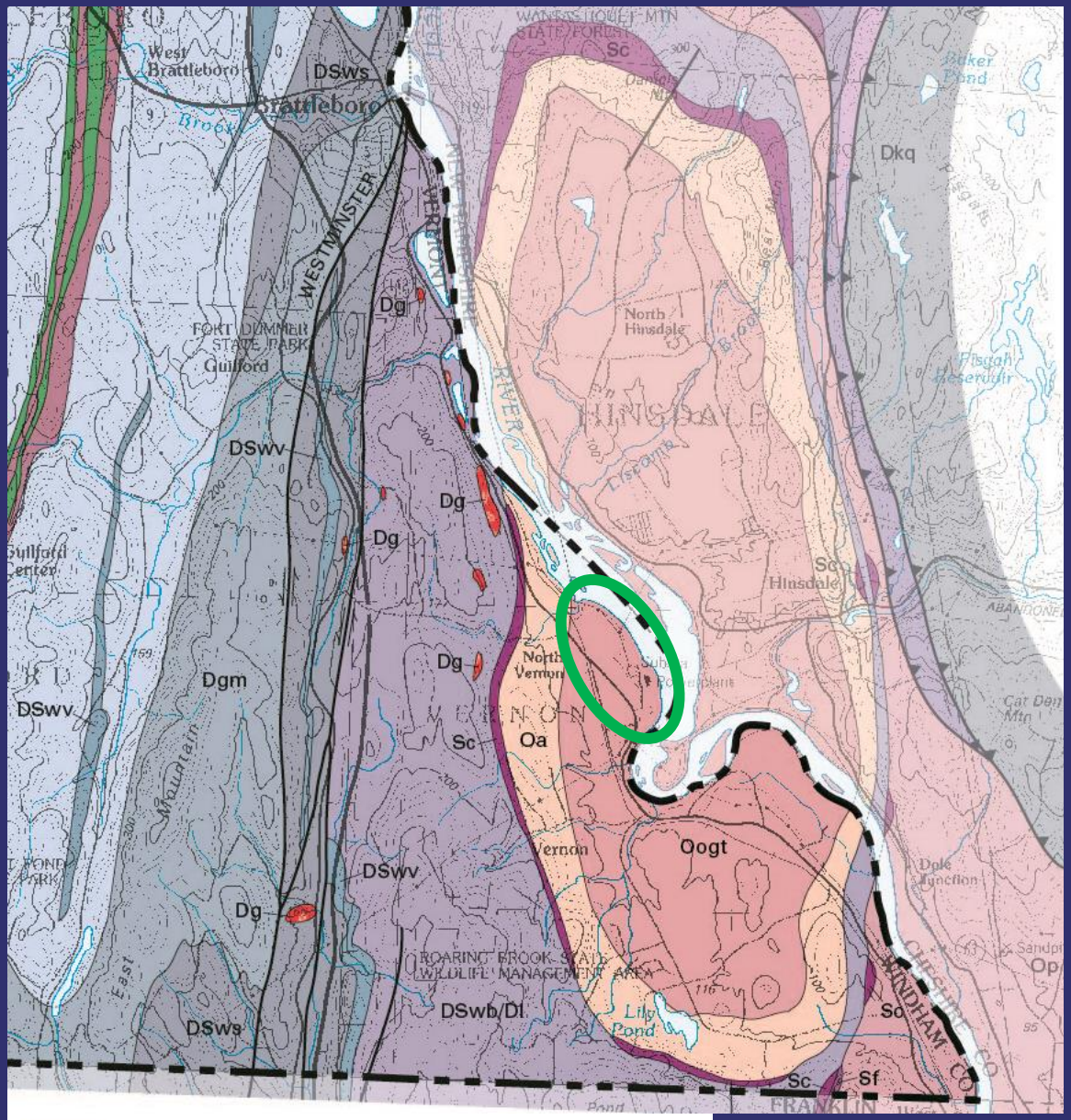
Dense, compacted glacial till




Surficial Geology of Vernon, VT from
Stewart and MacClintock, 1970, Surficial Geologic Map of Vermont

Site has ~ 30’-70’ of surficial materials underlain by fractured bedrock.

Groundwater flow in the glacial-deposit aquifers is primarily local, from recharge areas near valley walls to discharge in the streams.

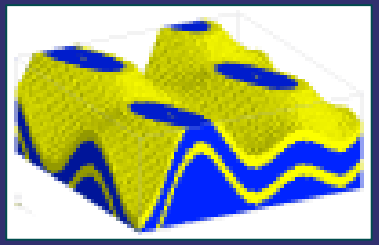



Bronson Hill Anticlinorium

Vernon Dome

Amonoosuc Volcanics

Oliverian Plutonic Suite
444 +/-8 my



Dome and basin

Gneiss, Lebanon Dome

**Crystalline bedrock aquifers** – interlocking minerals, minimal inter-granular porosity, only permeable where they are fractured or have secondary porosity.

# Secondary porosity in bedrock may allow water to infiltrate–

Fractures vary – orientation, length, aperture, intersections, depth, rock type; Hydraulic conductivity in rock is generally much less than in surficial deposits

## Methods for detailed subsurface properties and connectivity –

Maps and cross-sections – delineate topography, materials, watersheds

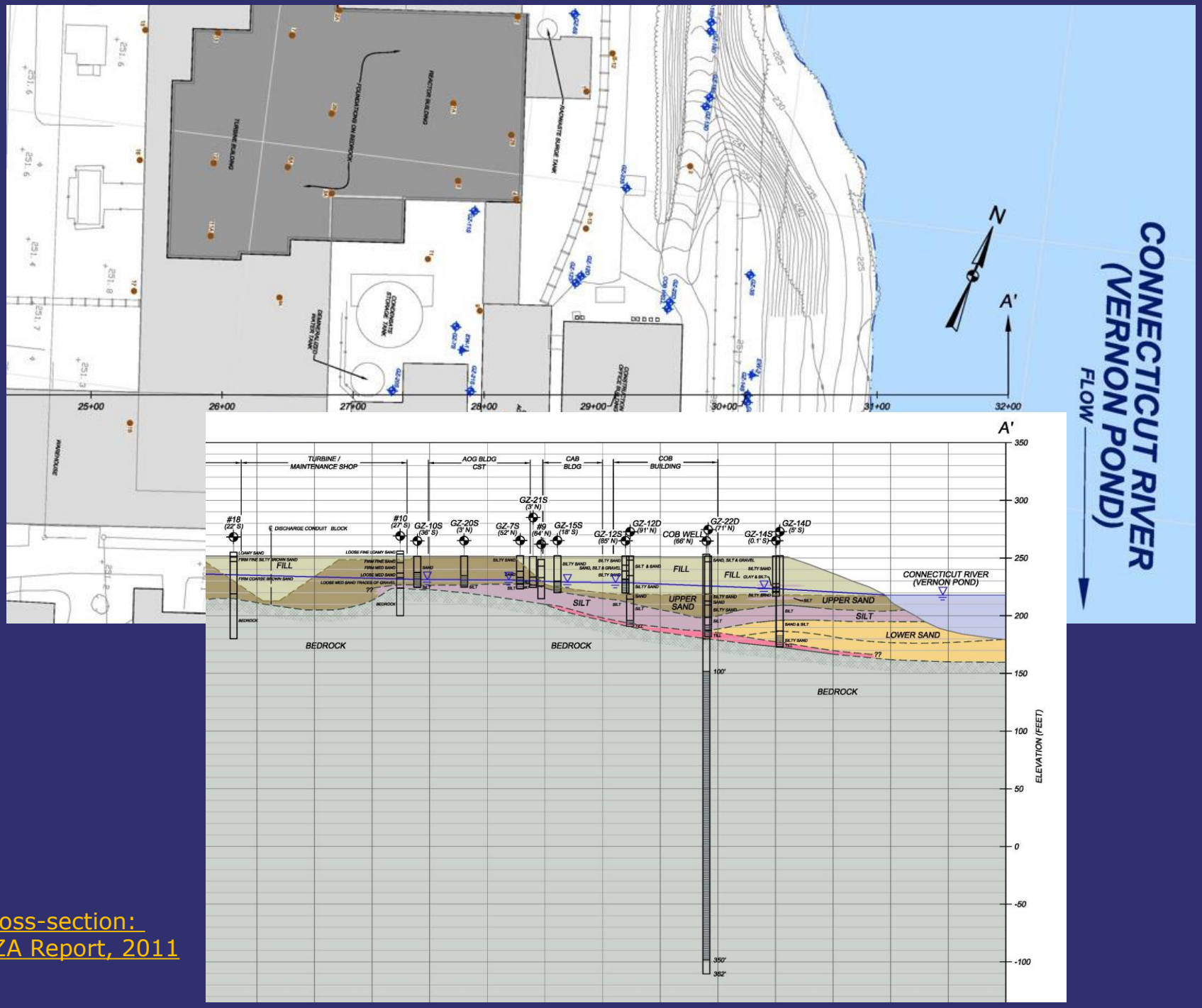
Cores/borings – add detailed depth information

Monitoring Wells – add hydrologic information

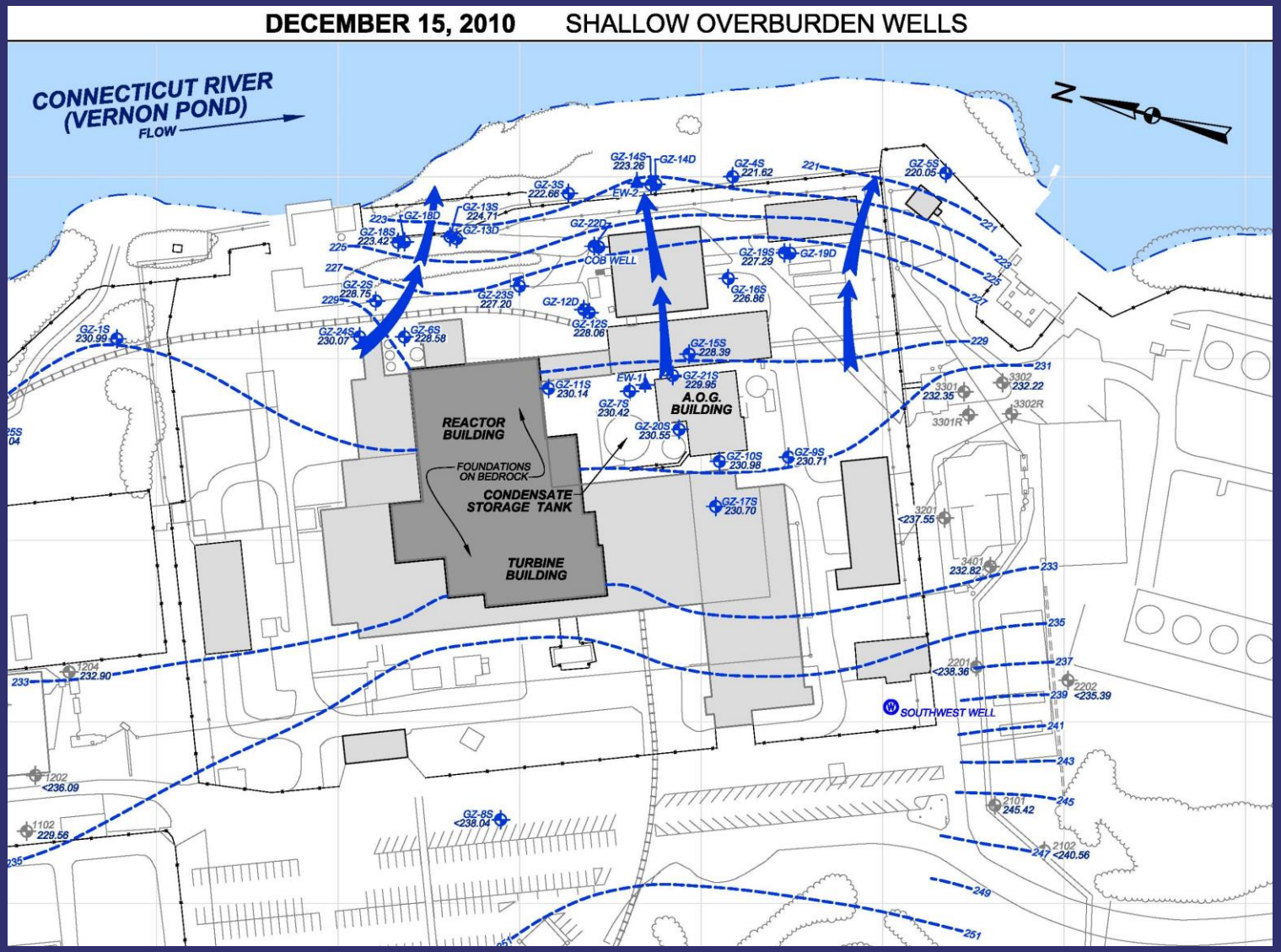
Pump tests – determine connectivity between boring sites and through materials

Down-hole Geophysical Logging

- Caliper Probe
- Fluid Temperature/Resistivity Probe
- Acoustic Televiewer (ATV) Probe
- Heat-Pulse-Flow-Meter (HPFM) Probe
- Dual-View Borehole Camera




[Cross-section: GZA Report, 2011]




Water table elevations and groundwater flow, GZA, 2011

Photo credit: Paul Franz