

# Prior USGS West Virginia District Karst Investigations in the Shenandoah Valley

- W.Va. Geological Survey Bulletin 21 – Paul P. Bieber
- W.Va. Geological Survey Economic Geology Bulletins 13 and 16 – W.A. Hobba
- U.S. Geological Survey Water Resources Investigations Reports 90-4118, 93-4073, and 00-4229 Kozar, Shultz, Mathes & others
- W.Va. University Thesis by Brad T. Zewe

# Major findings of 1961 Bieber Ground-Water Investigation

- Optimal well depths appear to average between 150 and 200 feet.
- Theorized that well depths greater than 500 feet were not economically practical.
- Total discharge for 44 of the largest springs in Berkeley and Jefferson Counties exceeded 100 million gallons per day.

# Major findings of 1976 Hobba Berkeley County Study

- Limestone aquifers can yield as much as 600,000 and shale aquifers as much as 100,000 gals/day of water per square mile.
- 85 % of all water in streams on limestone bedrock are derived from ground water.
- Hardness and nitrate were elevated in a few wells but were not prevalent contaminants.

# Major findings of 1981 Hobba Study

- Ground-water quality in Jefferson County is generally good except water is typically hard and nitrate is a common contaminant.
- 32 of 192 (17 %) wells sampled in 1974 had nitrate in excess of drinking water standards.

# Major findings of 1991 Kozar & others Jefferson County Study

- Ground-water flow is controlled by topography and geologic structure.
- Bedding planes act as barriers to down gradient flow causing lateral flow.
- Faults and joints in the rock serve as major routes for ground-water flow.

# Major Findings of 1991 Jefferson County Study - Continued

- There are two components of ground-water flow common in Jefferson/Berkeley County karst.
- The first component (diffuse flow), dominated by flow in fractured rock with little dissolution along fractures, varies in a range from 30 – 250 ft/d.
- The second component (conduit flow), characterized by flow along solution enlarged fractures, ranges from 250 to in excess of 1,500 ft/d.

# Major Findings of 1991 Jefferson County Study - Continued

- 70 % of sites sampled contained fecal streptococcus and 53 percent contained fecal coliform bacteria.
- 26 % of wells sampled in Jefferson County contained nitrate in excess of 10 mg/L.
- There was little change in nitrate concentrations from 1974 to 1988.

# Major Findings of 1995 Shultz & others Berkeley County Study

- Well yield decreases with well depth and yields are highest at depths less than 50 ft.
- Ground-water recharge in the limestone aquifer was estimated at 10 in/yr.
- 54 % of sites sampled contained fecal streptococcus bacteria and 24 percent contained fecal coliform bacteria.



# Major Findings of 2000 Mathes Berkeley County Study

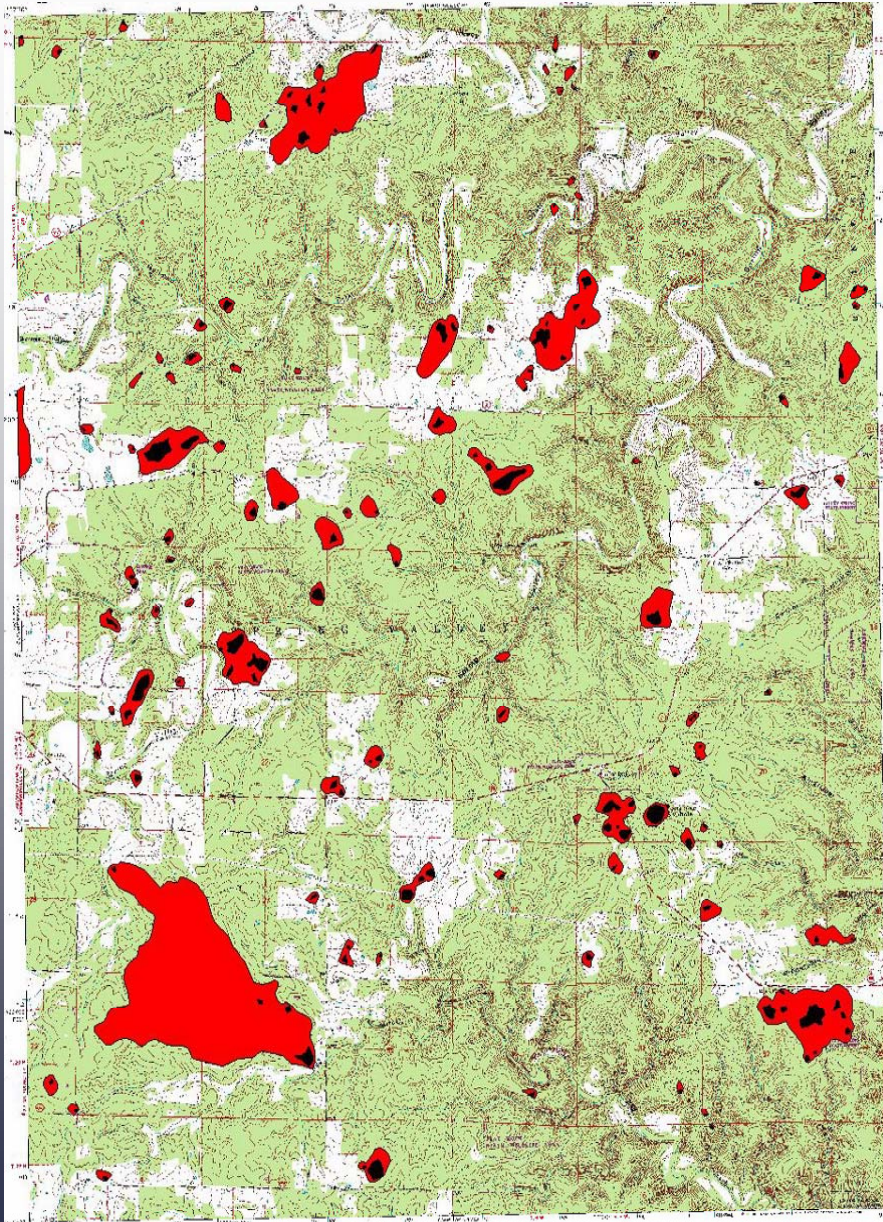
- Of 50 wells sampled, 30 % contained fecal coliform and 32 % contained *E. Coli* bacteria.
- There was no relation between septic density and bacteria concentrations in the 50 wells sampled.
- Deeper wells and wells with longer casings had lower concentrations of bacteria than shallower wells or wells with shorter casings.

# Major Findings of 1991 Zewe Berkeley/Jefferson County Study

- Median yield for wells in carbonate rocks is 15 gpm and wells < 200 ft deep have a median yield 2.5 times > than deeper wells.
- Wells in valleys in carbonate rocks have higher median well yields (25 gpm) than wells on hillsides (15 gpm) or hilltops (8 gpm) in similar carbonate terranes.

# Major Findings of 1991 Zewe Study Continued

- Wells  $< 200$  ft deep in carbonate terranes have a median yield of 20 gpm and wells  $\geq 200$  ft deep have a median yield of 8 gpm.
- Wells in carbonate rocks within .25 mi of a thrust fault have higher yields than wells greater than .25 mi of the fault.
- Wells near lineaments typically have higher yields than more distant wells.



**Sinkholes**

**(789,345 sq meters, 0.5% of area)**



**Area drained  
by sinkholes**

**(9,017,287 sq meters, 5.86% of area)**

# Topics Still Not Fully Understood

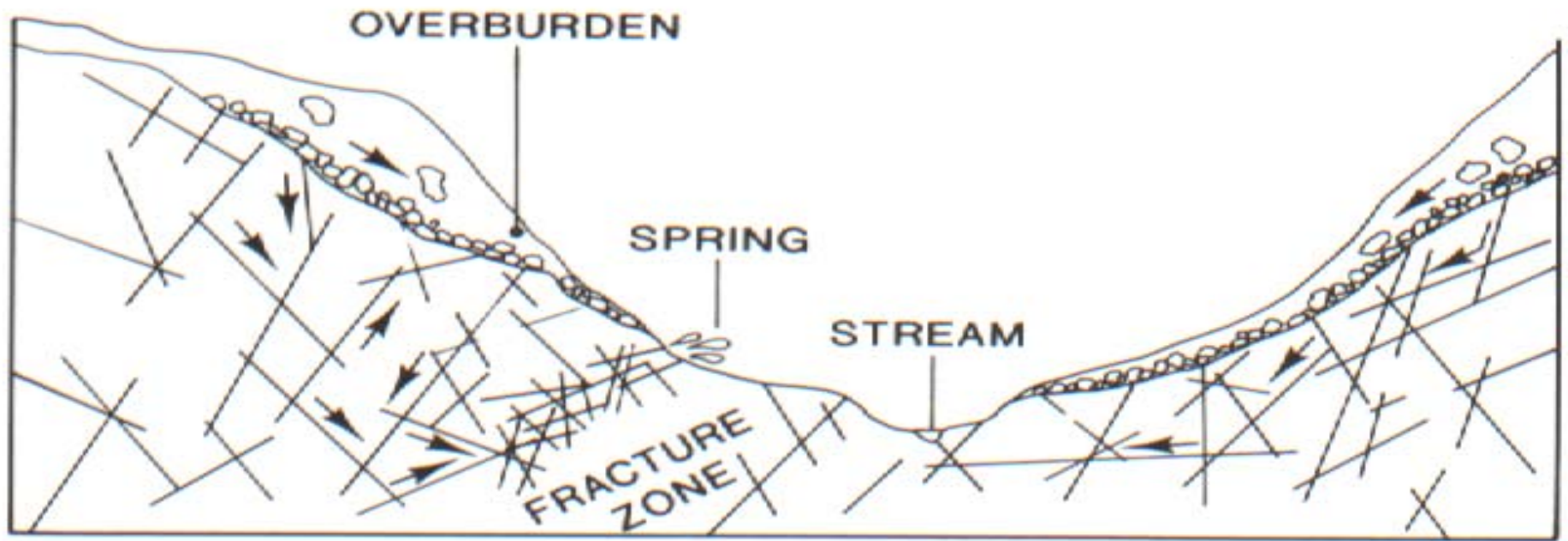
- The effect of grouting of well casings on the microbial quality of ground water in the region is still not fully understood.
- How much water can be developed from the karst aquifer also is not known.
- The source of bacteria within the karst aquifer of Jefferson and Berkeley Counties is not known.

# Current USGS West Virginia District Karst Investigations in the Shenandoah Valley

- Berkeley County Fracture Trace and Lineament Analysis Project
- Leetown Science Center Hydrogeologic Assessment
- Berkeley County Bacteria Source Tracking Project

# Berkeley County Fracture Trace and Lineament Analysis Project Objectives



- To identify areas within the karst aquifer of Berkeley County where higher than average fracturing of bedrock occurs
- To identify zones within the aquifer which may be especially susceptible to contamination by identifying high yield fracture trace zones
- To evaluate the water yielding capacity of fracture trace zones with respect to well yield and aquifer permeability



NOT TO SCALE

*modified from Wright (1990, p. 15)*

### EXPLANATION

-  Generalized ground-water flow path
-  Fractures in the rock

**Figure 4.** Generalized ground-water-flow patterns in non-carbonate rocks.



# Berkeley County Geohydrology

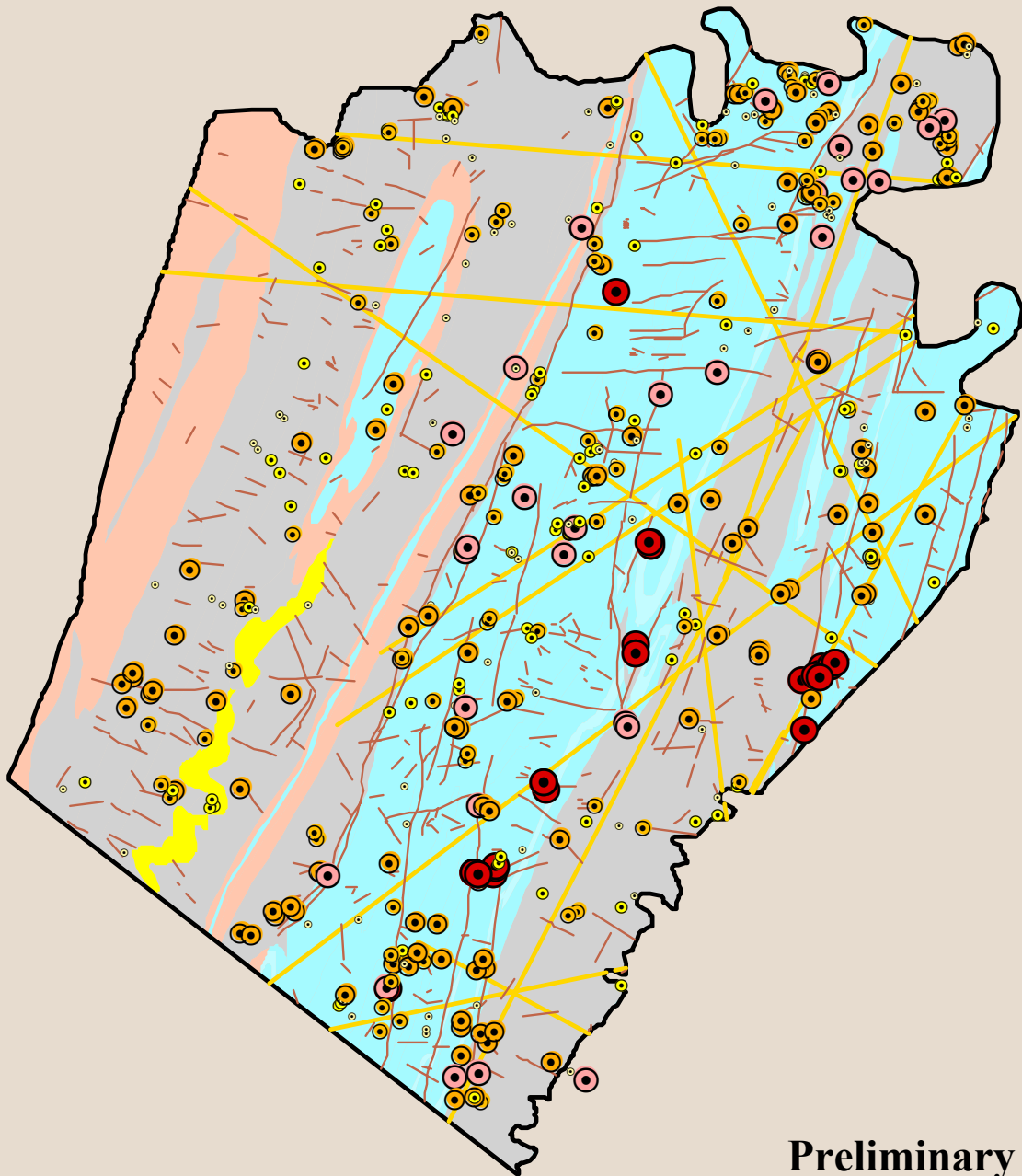
## Well Yield (gpm)

- 0-5
- 5-10
- 10-20
- 20-50
- 50-100
- 100-2000



 Lineament

 Fracture/Fault



Preliminary Data

# Ground Water Model of the Northern Shenandoah Valley

By

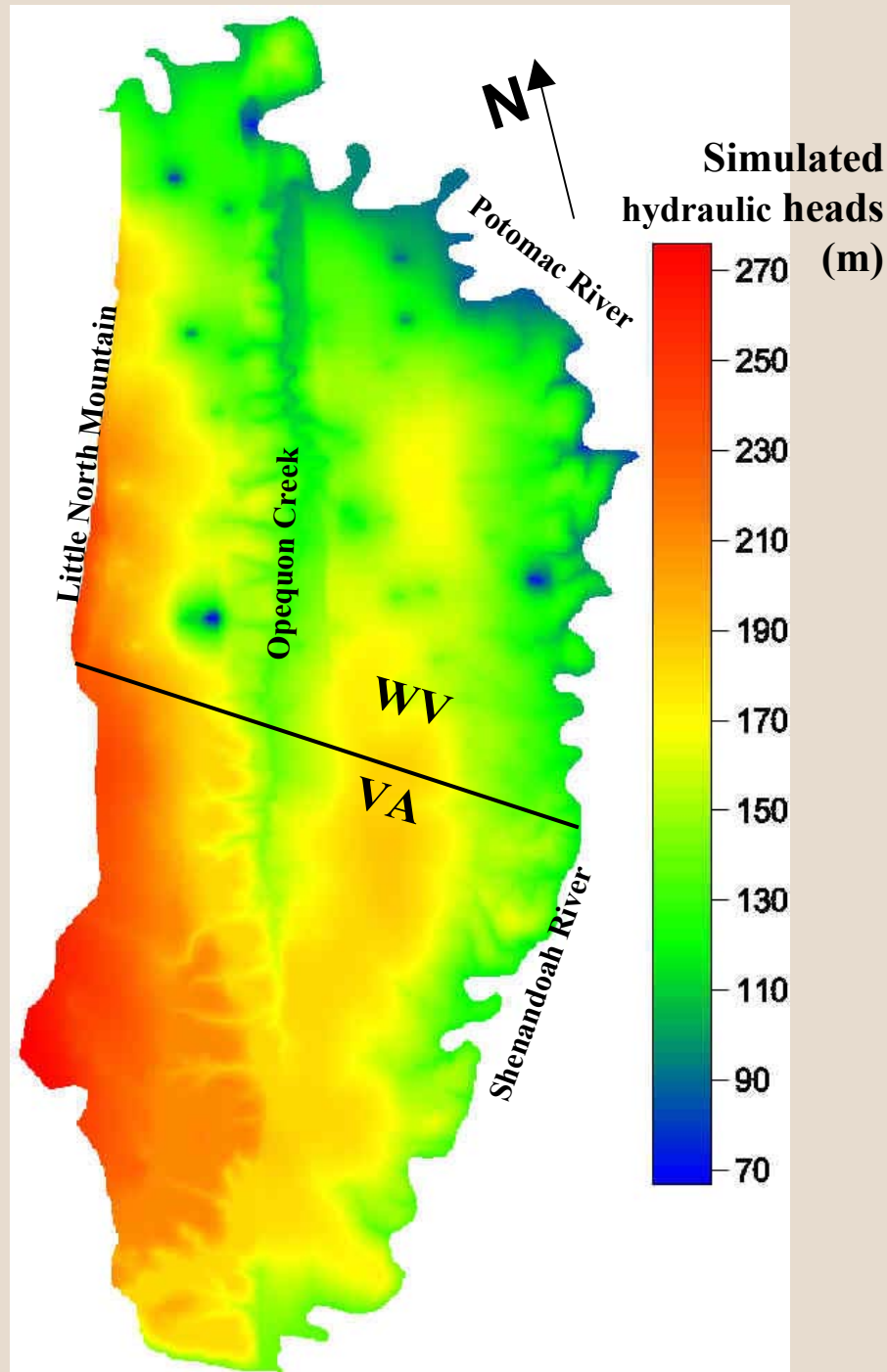
Jason S. Early & Joseph J. Donovan  
*West Virginia University*

Mark D. Kozar  
*U.S. Geological Survey*

## Study Objectives:

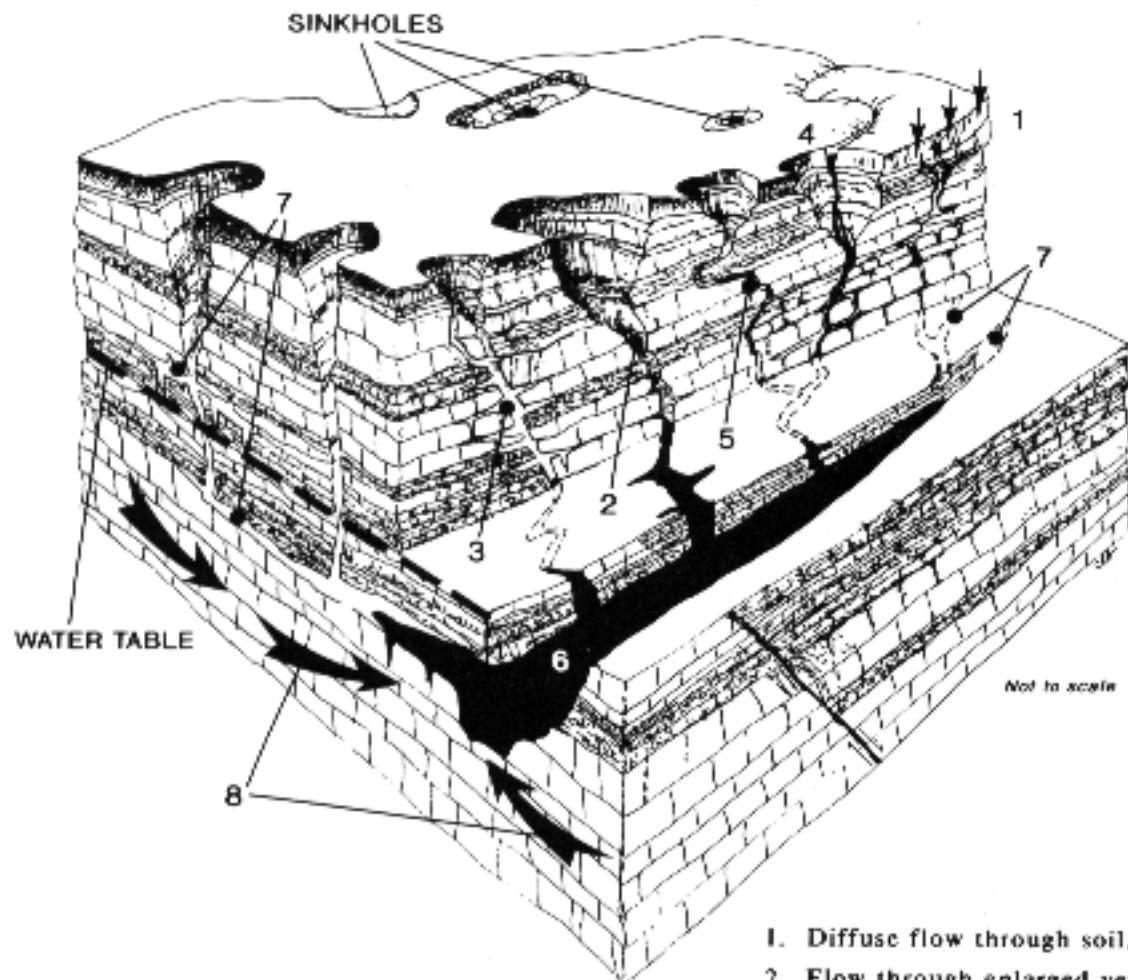
- Develop a regional ground-water flow model using MODFLOW
- Determine the steady-state water budget for the aquifer
- Provide a hydrogeologic framework upon which source water protection areas could be delineated\*

\*Study funded in part by a Source Water Assessment Program study by the West Virginia Bureau for Public Health



# Leetown Science Center Hydrogeologic Assessment Project Objectives

- To develop a thorough understanding of groundwater resources at the Leetown Science Center.
- To provide Leetown Science Center staff with data which will help them to better manage and plan long-term water use.
- To test and evaluate new technology for karst hydrology research which may then be applied to similar hydrogeologic settings throughout the region.



#### EXPLANATION

1. Diffuse flow through soil, residuum, or unconsolidated surficial material
2. Flow through enlarged vertical conduits
3. Diffuse flow through joints, fractures, faults, and bedding planes
4. Surface streams draining into sinkholes
5. Horizontal and vertical flow to master conduit
6. Water-filled master conduit
7. Air-filled conduit
8. Flow lines of diffuse ground-water flow

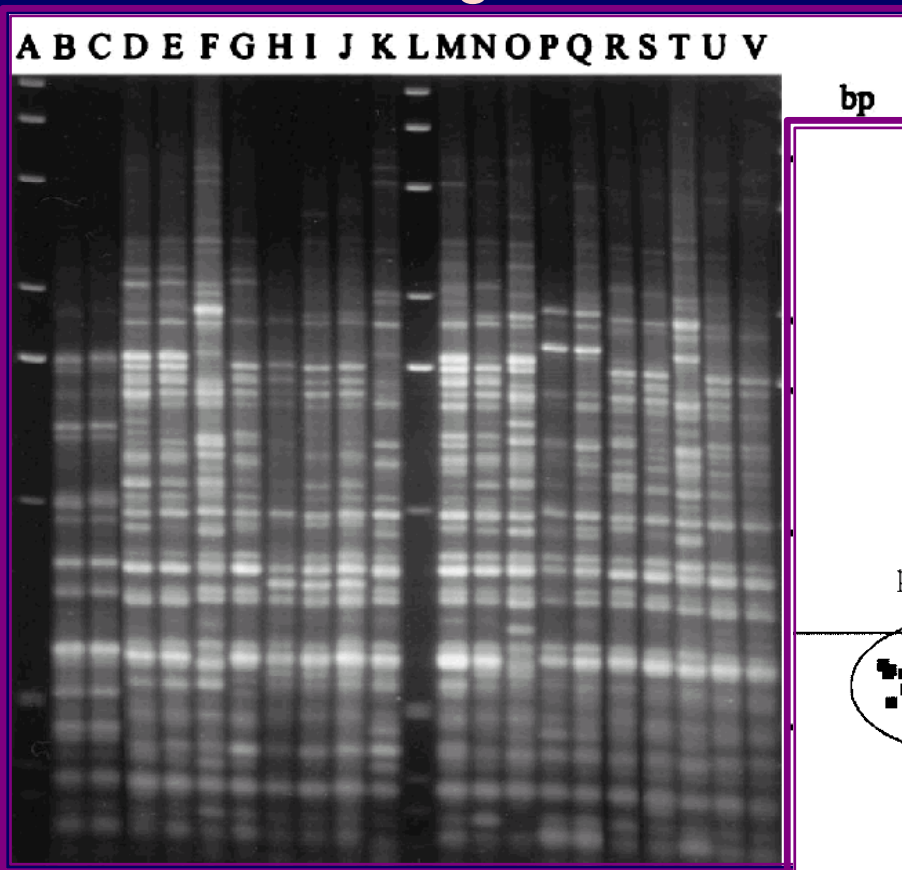
Modified by D.S.Mull and others, 1988

# Berkeley County Bacteria Source Tracking Project Objectives

- To compare the ability of seven methods of bacteria source tracking to associate fecal bacteria isolates with nine bacteria sources (includes human and eight common animal sources).
- To associate fecal bacteria from wells, springs, and stream in Berkeley County, WV to their source.

# Bacteria Source Tracking to Determine Animal Sources of *Escherichia coli*

From something like this ...



to something like this

