



United States Department of the Interior

U.S. GEOLOGICAL SURVEY

October 10, 2003

Joe Hankins, Chairman
Jefferson County Water Advisory Committee
c/o The Conservation Fund
Freshwater Institute
P.O. Box 1889
Shepherdstown, WV 25443

Subject: Proposal to Evaluate Ground-Water Resources in the Karst Aquifer of Jefferson County, WV

Dear ^{Joe}~~Chairman Hankins~~:

The United States Geological Survey (USGS) is conducting a multi-disciplinary regional Program to assess water and associated geological and biological resources in the northern Shenandoah Valley; an area that is underlain by karst and fractured-rock aquifer systems. The present scope of the Program is discussed at the following web site:

<http://va.water.usgs.gov/GreatValley/Index.htm>

The Program's geographic focus is on the I-81 corridor where significant, sustained population growth is occurring in former predominantly agricultural communities. As urbanization continues, water-use and water-quality patterns are impacting the available water resources. The end objective of the assessment is to develop data throughout the study area that can be input into a regionalized ground-water model simulating flow in the regional karst and fractured-rock aquifer systems.

In addition to the considerable Federal resources that have been dedicated to the effort, success of this regional assessment is enhanced by cooperative studies funded by a number of local entities in Virginia and West Virginia. Each of the local studies, while providing understanding of the ground-water system at a local scale, also provides input into the regional model. USGS advocates the regional-scale study because the ground-water flow systems transcend political boundaries.

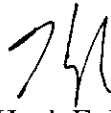
In West Virginia's Eastern Panhandle, cooperative partners have been identified in Berkeley and Morgan Counties and on and near the Leetown Science Center in Jefferson County. Neighboring Frederick, Warren, and Clarke Counties in Virginia are similarly being assessed.

The USGS invites Jefferson County to participate in this cooperative effort as outlined in the attached proposal. The proposed investigation is for that part of Jefferson County not included in the Leetown study. The key benefits that the County would receive include:

- County-wide characterization of aquifer hydraulic properties.
- Correlation of major lineament features with identified zones of aquifer yield.
- County-wide characterization of geochemical and water-quality conditions.

USGS representatives, Carol Boughton at (304) 724-4576, Mark Kozar at (304) 347-5130 ext. 228, or myself at (304) 347-5130 ext. 223, will be happy to provide further details of this proposal and near-by related water resource assessments.

Sincerely,

A handwritten signature in black ink, appearing to read 'H. Bevens', written in a cursive style.

Hugh E. Bevens
West Virginia District Chief

Attachment

Use of Fracture Trace Analysis for Evaluation of Ground-Water Resources in a Karst Aquifer, Jefferson County, West Virginia

*Prepared by
U.S. Geological Survey, Geologic Division)
Reston, VA
U.S. Geological Survey, Water Resources Division
West Virginia District
Charleston, WV*

Problem: The karst limestone and dolomite aquifer on which Jefferson County depends as the primary source of water for many residential homeowners and several large public supplies is highly susceptible to contamination. Sources such as runoff from agricultural fields and feedlots, septic systems, lawn maintenance, and highway runoff to name just a few, pose significant threats to the quality of water within the aquifer. The majority of potential sources of contamination are related to land use. Certain areas of the karst aquifer are more susceptible to contamination than are others due to the higher proportion of solutionally enlarged fractures in the more conduit dominated portions of the aquifer. Knowing where the conduit dominated portions of the aquifer occur will help county and local planners identify potentially susceptible karst areas and help them to better manage the land use within the recharge areas to these sensitive areas.

In addition to the susceptibility of the aquifer to contamination, the area also recently endured a severe drought which lasted for more than two years and has experienced similar severe droughts in the past. The droughts left spring and stream flows within the county much lower than average and also reduced water levels in quarries. Lower ground-water levels within the aquifer resulted in water shortages and forced homeowners, farmers, and businesses to curtail water use and also forced many individuals to search for alternate sources of water. In addition, continuing economic expansion in the area has led to increased population and ever increasing demands on available sources of water. The areas that are highly susceptible to contamination are the same areas where large quantities of water are likely to be available to augment already dwindling supplies of ground water. A combined land- and water-use management plan would provide county planners with information to help them better protect and manage the karst aquifer on which they depend as their primary source of water.

Background: Natural linear features observed on aerial photographs and satellite imagery have been correlated to zones of fracturing in bedrock and termed fracture traces (Lattman, 1958). Fracture traces are changes in soil, alignments of vegetation, topographic sags and stream valleys, alignment of gaps in ridges and other features that may reflect zones of increased permeability, weathering and solution. Water wells drilled along, adjacent to, and at intersections of fracture traces in carbonate rock terrain have been known to produce between 10 to 100 times more water than wells drilled away from these features (Lattman and Parizek, 1964).

Objective: The primary objective of this project is to locate areas within the karst aquifer of Jefferson County where higher than average fracturing of bedrock occurs based on fracture traces identified by analyses of satellite imagery, aerial photographs, and other methods. Once the aquifer has been delineated with respect to fracture traces, an additional objective is to identify zones within the aquifer which may be especially susceptible to contamination by identifying fracture trace zones with higher than average permeability. Finally, a third objective is to evaluate the water yielding capacity of fracture trace zones with respect to well yield and aquifer permeability.

Approach: Geologists from the Geologic Discipline (GD) will obtain aerial photographs, satellite imagery, and digital orthophoto quadrangles that cover the karst portion of Jefferson County in the area west of the Blue Ridge and east of the Martinsburg Shale.

Linear features that appear on the imagery will be evaluated and the data entered into a Geographic Information System (GIS). The collected data will then be field checked to assure that the features are naturally occurring fracture traces as opposed to man-made objects such as fence lines and pipe lines. The geologists will produce a geologic map and a fracture trace map in both printed and digital form to be used by hydrologists for evaluating the hydraulic properties of zones where high concentrations of fracture traces occur (fracture trace zones).

Although fracture traces are an important tool for potentially locating alternate sources of ground water, other geologic and hydrologic information must also be incorporated into the study. Various lithologies and geologic formations may differ in fracture trace density. Geologic structures such as faults, bedding planes, and anticlines may increase fracture permeability. Potentiometric surface maps available for the county may be used to show approximate depths to water. All of these variables will be analyzed with respect to the fracture trace data to identify whether these factors are related to the occurrence or distribution of significant fracture trace zones within the aquifer.

Once the fracture trace maps and analyses have been completed, Hydrologists from the Water Resources Discipline (WRD) will evaluate the permeability of fracture trace zones by conducting detailed well inventories on as many as 200 wells. The well inventories will obtain data related to well depth, length of casing, well yield, grouting criteria, geologic formation, and water level. In addition, the wells will be hydraulically tested by conducting specific capacity and/or aquifer tests on as many of the inventoried wells as possible.

Personnel: Personnel needed for completion of this project will include two GD Geologists, one WRD Hydrologist, and one WRD Hydrologic Technician.

Benefit Statement/Federal Role: There are several benefits which will likely result from this research. First, this project will yield data and knowledge which local, county, and state planners may use to help better understand and protect sensitive karst aquifers not only in West Virginia's Eastern Panhandle, but also in neighboring areas with similar

hydrogeologic settings in Pennsylvania, Maryland, and Virginia. Such information could easily be used in helping planners to better understand optimal land use scenarios within their county or region. Finally, the same data may be used to help identify potential sources of ground water. Continued economic expansion in the region will continue to tax the available water resources. The data and knowledge gained by conducting this study will help local water managers to locate and explore for new public supply water wells.

The federal role in this project includes developing a technique for assessing the vulnerability of karst aquifers in the Great Valley of Pennsylvania, Maryland, Virginia and West Virginia to contamination and to develop techniques which may be used by local water management agencies in developing and managing ground-water resources within the region. The USGS Water Resources and Geologic Disciplines are working jointly on this effort and are assessing methods and techniques in Virginia and West Virginia with the intent to transfer the technology to hydrogeologically similar areas within the region.

Workplan: This project will be completed over a two year period. Collection and analysis of fracture trace data will occur in the first twelve months of the project. A report will be written analyzing all data collected during the project and will be completed by the end of the second year.

Budget and Tasks:

Tasks to be Performed by the USGS Geologic Division

- Obtain aerial/satellite imagery
- Analyze aerial/satellite imagery for fracture traces
- Analyze geologic data
- Field verify fracture traces
- Prepare fracture trace maps
- Prepare final report to Jefferson County, WV

Tasks to be Performed by the USGS Water Resources Division

- Analyze fracture trace data
- Conduct well inventories
- Conduct specific capacity or aquifer tests
- Prepare final report to Jefferson County, WV

Project Costs

FY 2004

USGS Geologic Division FY 2004 Costs	\$ 27,000
USGS Water Resources Division 2004 Costs	<u>\$ 91,000</u>
Total FY 2004 Cost	\$118,000

FY 2005

USGS Geologic Discipline FY 2005 Costs	\$ 3,000
USGS Water Resources Discipline 2005 Costs	<u>\$ 91,000</u>
Total FY 2005 Costs	\$ 94,000

Total Project costs **\$212,000**

Project Funding

FY 2004

Jefferson County	\$ 72,500
USGS	<u>\$ 45,500</u>
Total FY 2004 Funding	\$118,000

FY 2005

Jefferson County	\$ 48,500
USGS	<u>\$ 45,500</u>
Total FY 2005 Funding	\$ 94,000

Total Project Funding **\$212,000**

Summary of USGS Cooperative Proposal to evaluate the ground-water resources in the karst aquifer of Jefferson County, West Virginia

What the study will do-- Characterize the karst aquifer in Jefferson County to determine zones of high permeability that may be

- 1) Zones of large ground-water productivity, or
- 2) Zones which may require protection to avoid aquifer contamination.

Products from the study—

- 1) Electronic database will be developed for 200 wells in the county. This electronic database will include the following and can be used by the county for future applications
 - a) GPS well locations
 - b) Well construction, depth, length of casing
 - c) Hydrogeologic data including water level and aquifer permeability
- 2) Well location data table provided in electronic file and geographic information system (GIS) format that the county can use to help build future electronic mapping capabilities
- 3) GIS map showing detailed geologic lineament features expressed at surface
- 4) Hydrogeologic data maintained long-term by USGS in publicly accessible data base
- 5) Peer-reviewed report interpreting data (available in printed and electronic format)

Cost Advantages--

40% of cost will be provided by USGS.

Additional Opportunity-

Dr. Peter Vila of Shepherd College may collaborate to provide anion chemistry and bacterial analyses at all of a subset of well sites, deepening our understanding of groundwater quality.

Opportunity to create library of stored water samples for additional analyses.

Opportunity to utilize this investment as a matching effort against other grant funded opportunities in the region.