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Impact of the 1998-2002 Drought on the Karst Aquifers of Clarke County in the Shenandoah Valley of Virginia

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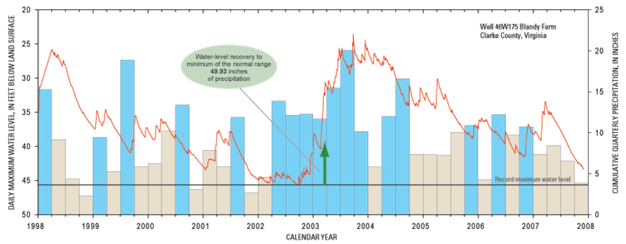
Abstract

The prolonged drought between 1998 and 2002 focused attention on the quantity and sustainability of the ground-water resources of Clarke County, Virginia. The County is underlain by complexly folded and faulted Paleozoic and Precambrian rocks with a majority of the area characterized by karst aquifers. During this drought, over 20 wells and numerous springs and stream segments went dry. Above normal precipitation in the fall of 2002 and winter of 2003 brought an end to this drought. The magnitude of the recovery varied between the Opequon Creek and Shenandoah River watersheds. Ground-water levels in the Opequon Creek watershed recovered between 30 and 50 feet within a 6-month period; whereas levels in the Shenandoah River watershed generally recovered less than 10 feet. During this same period, flow in streams and springs returned after several dry years. In one case, spring 46XS 8 that had been dry for several years began to flow at a rate of 1,000 gallons per minute. Results from hydrograph separation indicate that the ground-water component accounts for more than 80 percent of the streamflow during both dry and wet periods. Generally, the majority of this ground-water component is derived from the discrete discharge of springs.

Effect of Precipitation



Above normal precipitation, especially snowfall, for seven quarters in 2002 and 2003 caused water-levels in well 46W175 to rise from record lows to record highs for the period of record since 1987. Gaging stations (for example gage 01616100 Dry Marsh Run) were not established until August, 2002; however, large increases in streamflow were recorded over the same period of recovery shown in well 46W175. Ground-water discharge is a major component of the mean streamflow throughout the County. (See stacked bar graph to the right for gage 01616100.)

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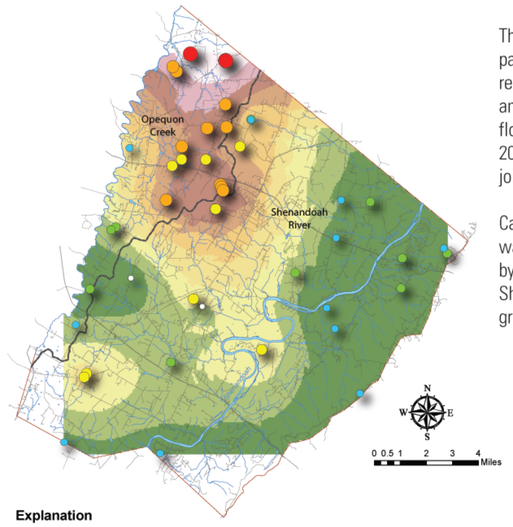
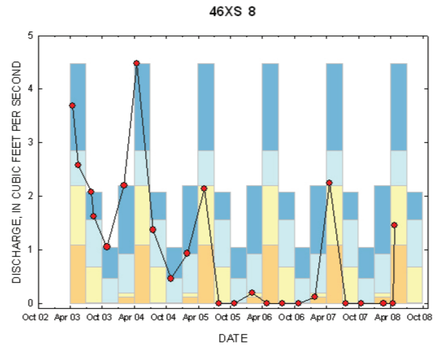
Net Water-Level Change



The carbonate area with the largest recorded recovery was in the northwest part of Clarke County within the Opequon Creek watershed. Water levels recovered more than 30 feet between October, 2002 and April, 2003. Springs and streams that had been dry through most of the drought returned to flowing conditions. A majority of the recovery occurred between December, 2002 and January, 2003. Numerous faults, steeply dipping bedding and joints, and a high density of sinkholes are characteristic of this area.

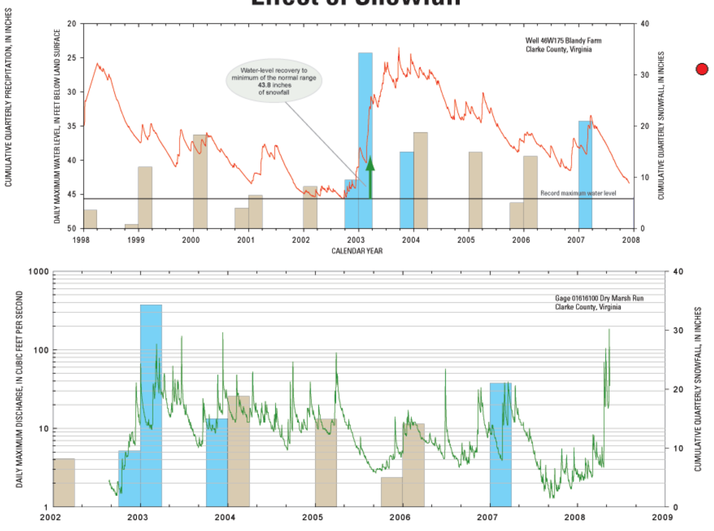
Carbonate areas within the Shenandoah River watershed generally had water-level recovery of less than 20 feet. This part of the County is underlain by older carbonate units that are believed to be less soluble. In addition, the Shenandoah River may act as a regional sink that tends to stabilize ground-water fluctuations.



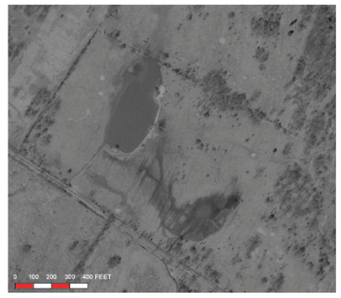
Quarterly spring-discharge statistics--In cubic feet per second
High
75th
50th
25th
Low
Percentile

Quarterly spring-discharge measurement--In cubic feet per second. One cubic foot per second equals 448.8 gallons per minute.

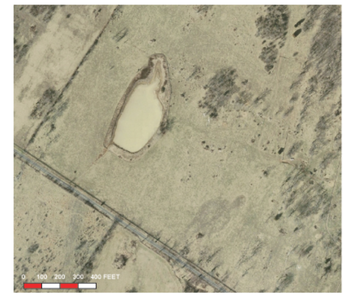
Effect of Snowfall



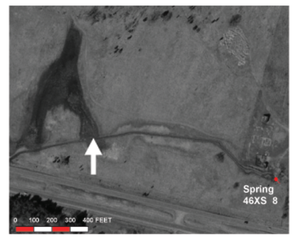
Wet Conditions



Drought Conditions



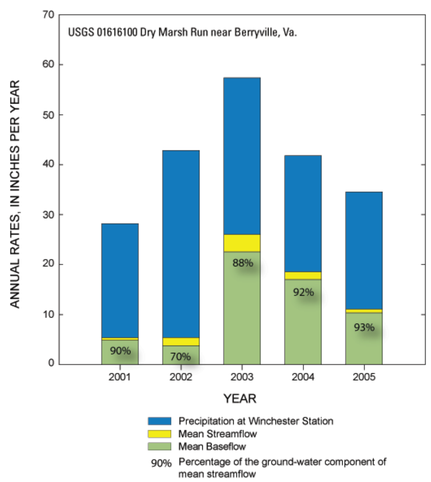
Area along Rt. 620 where ground water overflows along bedding and joints (darker tones) in the carbonate rock in 1996 (wet) and 2002 (drought). Strike of the bedding is to the northeast. North is top of photograph.



Area along Rt. 7 and west of Berryville where Dry Marsh Run flows from spring 46XS 8 (red dot) during wet conditions into a swallet hole (arrow) and wetland area (darker tones) shaped like a wishbone to the north of the arrow. During dry or drought conditions spring 46XS 8 is frequently dry. During wet conditions, flows range from less than 1 cfs to 4.5 cfs. North is top of photographs.

Cessation of flow from springs, like spring 46XS 8, causes stream segments for miles downstream to become dry, which illustrates the importance springs have on streamflow in these carbonate areas. The aerial photograph of a portion of the northwest part of the County shows the extent of dry stream segments. Notice that the difference in altitude between spring 46XS 8 (dry) and gage 01616100 (flowing) is similar to the range of ground-water level fluctuations.

Ground-Water Discharge



Dry Stream Segments