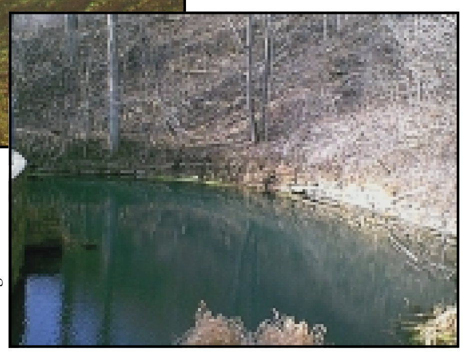
IOWA'S WATER
Ambient Monitoring Program

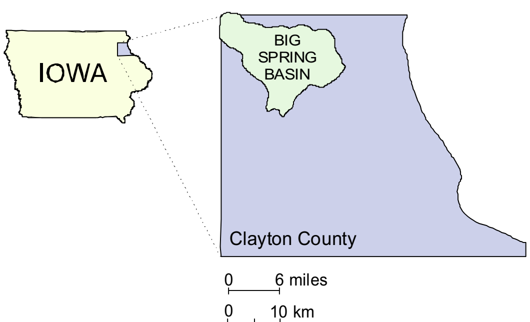
Big Spring Retrospective

Aimee Donnelly



Rick Langel

Figure 1. *Big Spring is located in Clayton County. Approximately 97 percent of the Big Spring watershed is in agricultural production.*



"How is the water quality today different from years past and will it be better in the future?" This question presents many challenges for scientists. Long-term monitoring projects are rare, primarily because of the lack of continued funding, and also because the goals of government administrations do not always remain the same over time. Results for successful long-term projects can be difficult to understand given the competing influences of changing climate, land use and management practices. Predicting future water quality at a particular location requires sound knowledge of the forces that are shaping our water quality today. Changes in water quality can happen very rapidly in response to a spill or a management activity (e.g., creation of a dam) but generally occur over a much longer period of time. This period, called a "lag" is typical of a complex environmental system that resists change – often because they can absorb stressors more easily. Short-term monitoring projects often fail to reveal the "lag-time" or delay in the impact of a management action that may be revealed in a long-term project.

Physical Setting

Big Spring is Iowa's largest spring and is located in Clayton County (Figure 1). The spring was formed where rocks from the Galena Aquifer, exposed at the ground's surface in the

Art Bettis

Figure 2. *Measurements are made of a newly formed sinkhole, caused by collapse of soil and shallow rock into a subterranean cavern.*

Turkey River valley, discharge water. The Galena Aquifer is important to the region because it is the primary drinking-water source for rural residents. However, the unique geology of the area makes groundwater vulnerable to contamination from activities at the surface (Figure 3). Unlike many areas of Iowa, there is only a thin covering of glacially deposited materials – tills and loess – on the bedrock, which usually provide a barrier to the downward movement of water and therefore restrict the movement of contaminants at the surface. Where the covering of glacial materials is thin, there is little protection for the underlying groundwater. In addition, the Big Spring basin has naturally occurring sinkholes and fractures that provide a direct route for the movement of surface contaminants to the aquifer below (Figure 2).

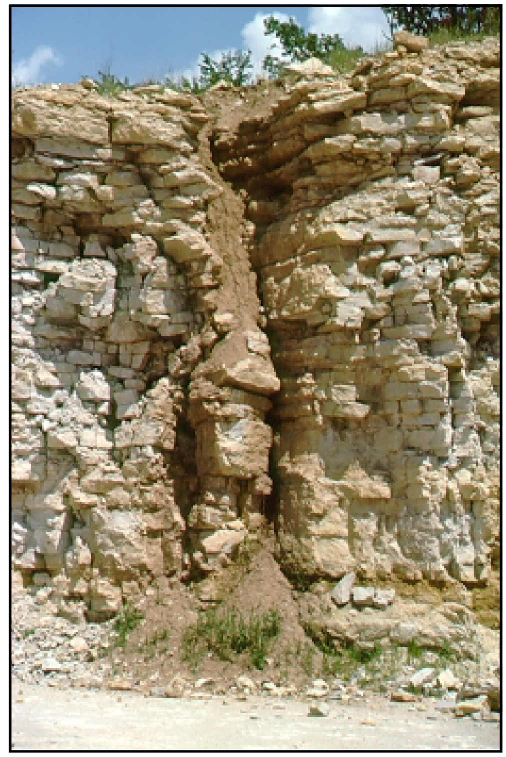
History of the Big Spring Project

One of the longest-running groundwater monitoring projects in Iowa – or the United States – is the Big Spring Basin Water Quality Monitoring Program. This project was initiated in 1981 in response to concerns that the Galena Aquifer was being impacted by activities at the land surface. Data collected from the 1950s and 60s showed an average annual nitrate-N concentration of 3 mg/L (nitrate expressed as nitrogen only). In the 1980s, the average annual nitrate-N concentration had increased to 9 mg/L, a three-fold increase in groundwater nitrate concentrations in a 30-year time span. The increase in average nitrate concentrations during this time span also mirrors the increases in nitrogen fertilizer use in the Big Spring Basin (Figure 4). Roughly 97 percent of the land use in the basin is agricultural: 50 percent in corn, 35-40 percent in alfalfa and 10 percent in pasture. Small dairy and hog operations are common, but there are no significant urban or industrial sources in the area.

The main purpose of the monitoring project was to understand the hydrology of the spring, document changes in water quality related to factors such as climate, land-use changes and, ultimately, to improve the system through the adoption of best management practices (BMPs). The Big Spring Demonstration Project (1986-1992) used on-farm demonstrations along with public education programs to show the economic and environmental benefits of enhanced chemical management.

Water-Quality Trends

The steady increase in groundwater nitrate levels in the Big Spring area from 1950-1980 seems to indicate a fairly rapid response to increased use of commercial fertilizer (Figure 4). However, monitoring during this time was infrequent, and does not detail the week-to-week, month-to-month, or even year-to-year differences the more recent monitoring efforts show. Given the historical increases in nitrate, the obvious question is whether declines in fertilizer use would result in similar declines in groundwater nitrate. In 1983, the national Payment-in-Kind (PIK) program led to a 40-percent decline in nitrogen applications in the basin for just that one year. A dramatic drop in groundwater nitrate was observed two years later, suggesting a two-year lag time in the response to decreased inputs.



Lynette Seigley

Figure 3. *Fractured dolomite of the Galena aquifer underlies most of the Big Spring basin landscape.*

Fertilizer use rebounded to previous levels after the PIK year. In 1986, new BMPs were implemented as part of the Big Spring Demonstration Project (a cooperative effort between local, state and federal agencies and basin farmers); these BMPs were aimed at improving both the timing and application rates for farm chemicals in order to reduce impacts on the groundwater. As a result of the project, the average nitrogen fertilizer use on corn declined by 34 percent from 1981 (174 lbs/acre) to 1993 (115 lbs/acre), with little or no effect on corn yields in the basin. However, the effect of this gentle decline in nitrogen input on water quality has largely been overshadowed by the more dominating influence of climate. During dry periods, movement of nitrate through soil and into the groundwater is slowed. Conversely, in wetter times, nitrate seeps more rapidly from the soil to underlying aquifers. The effect of the statewide drought of 1988-89 on water quality can be seen in the sharp decline of nitrate-N concentrations in 1990, which rebounded to record levels when the rains returned in the early 1990s. Despite lowered inputs of nitrogen to the agricultural system throughout the prior decade, the 1990s experienced consistently high levels of groundwater nitrate with most of the average annual values exceeding the U.S. Environmental Protection Agency's drinking water standard of 10 mg/L.

The tracking of chemical use in the basin, including fertilizer and manure, ended in 1994. Statewide trends would suggest a possible upswing in fertilizer use in the second half of the 1990s, but this probably does not account for the sharp increase in nitrate for 1998. Instead, the current amount of nitrogen discharged from Big Spring appears to largely be

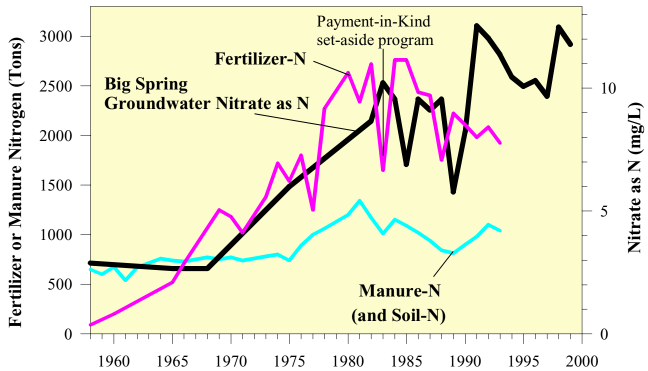


Figure 4. *Annual nitrate concentrations (expressed in mg/L) for Big Spring in comparison to the inputs from nitrogen fertilizer and manure (expressed in tons) from 1958-2000.*

driven by the amount of water moving through the groundwater system. Long-term nitrogen losses average approximately 40 percent of the fertilizer applied, but vary from as little as five percent in dry years to as much as 80 percent in wetter years.

The lessons learned from 20 years of monitoring indicate that time lags in groundwater response, coupled with wide variations in climatic conditions, make it difficult to tie year-to-year changes in land-use management to improvements in water quality. This project further suggests caution when applying short-term monitoring results to decision-making, without the context of a longer time frame to understand the variability of the system. The bottom line? We don't have all the answers yet, and changes happen slowly. To find out more information on this project, please visit the Geological Survey Bureau Web site at **www.igsb.uiowa.edu/inforsch/bigsprng/bigsprng.htm.**

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Water Monitoring Program Web Site – www.igsb.uiowa.edu/water

Prepared by
Iowa Department of Natural Resources, Geological Survey Bureau
109 Trowbridge Hall, Iowa City, IA 52242-1319