

## HAYWARD QUADRANGLE: Groundwater Production by Aquifer

In the 56-square-mile area of the Hayward Quadrangle, groundwater is produced from metamorphic crystalline rocks of the Precambrian basement (in the western part) and several sedimentary formations composed of sandstone, limestone, and dolomite elsewhere. Of the latter, the Deadwood Formation, Pahasapa (Madison) Limestone, Minnelusa Formation, and Lakota and Fall River formations are dominant.

Information given in the following figures in regard to the volume of water produced, the depth of the wells, and the aquifer providing the water is taken from the website of the South Dakota Geological Survey <http://www.sdgs.usd.edu/>. The values are for private wells as reported in Well Drillers Reports of the South Dakota Water Rights Program and indicate the flow rates at the time of completion of the wells. Wells are drilled to depths of 1,000 feet (a single well reached 2,400 feet in the eastern part of the quadrangle) and water production varies from one to 600 gallons per minute.

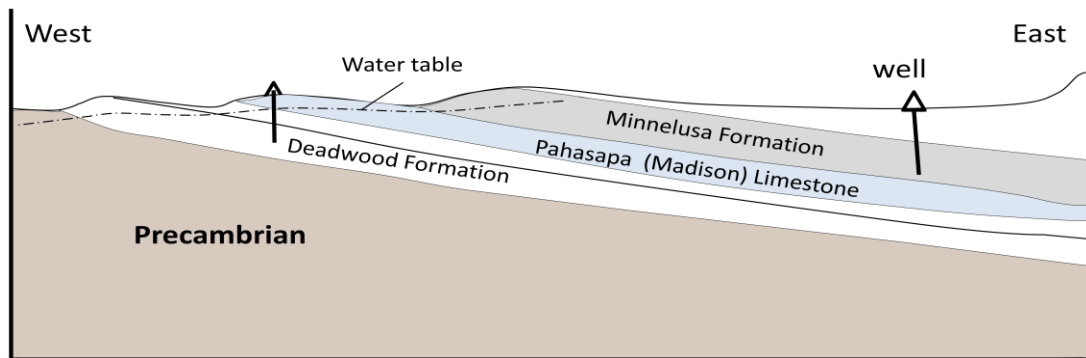


Figure 1. Diagrammatic cross section illustrating the relationships of aquifers in the Hayward Quadrangle. Note that drilling depths are greater within each aquifer to the east. Also, in the areas of outcrop of the formations (their western edges) the thickness of the water-bearing zone is less and may be absent.

### ***PRECAMBRIAN CRYSTALLINE AQUIFER (METAMORPHIC ROCKS)***

In the western part of the quadrangle, Precambrian metamorphic rocks are exposed at the surface and are, therefore, the source of most groundwater in that area (a few shallow wells might be completed in the alluvium along valley bottoms). For the several wells for which information is available (Figure 2), the drill depths range from 10 to 650 feet. Water production from these wells varies from one to 100 gallons per minute. Metamorphic rocks have no initial porosity to hold water. Therefore, cracks in the rocks (especially in quartz veins and granite) form the reservoir.

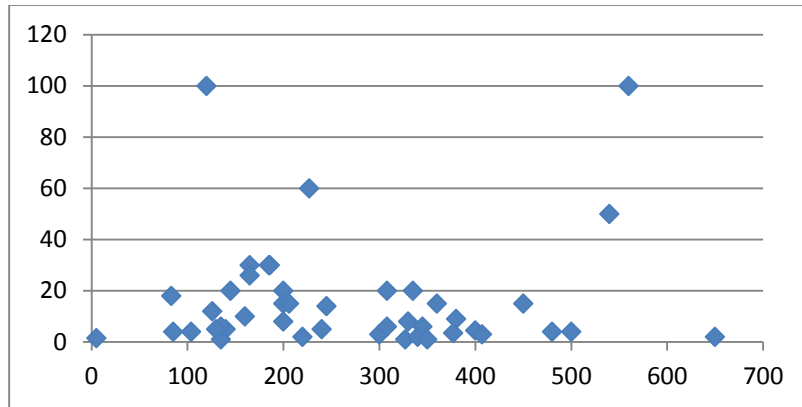


Figure 2. Water production rates for wells in the Precambrian crystalline basement, Hayward Quadrangle. The base line indicates the total depth of wells. The vertical shows gallons per minute initial water flow.

***DEADWOOD FORMATION***

Water production reported from the Cambrian-age Deadwood Formation varies from one to 100 gallons per minute (Figure 3). For the 16 wells producing from sandstone in the Deadwood aquifer more than half produce 30 gallons per minute or less.

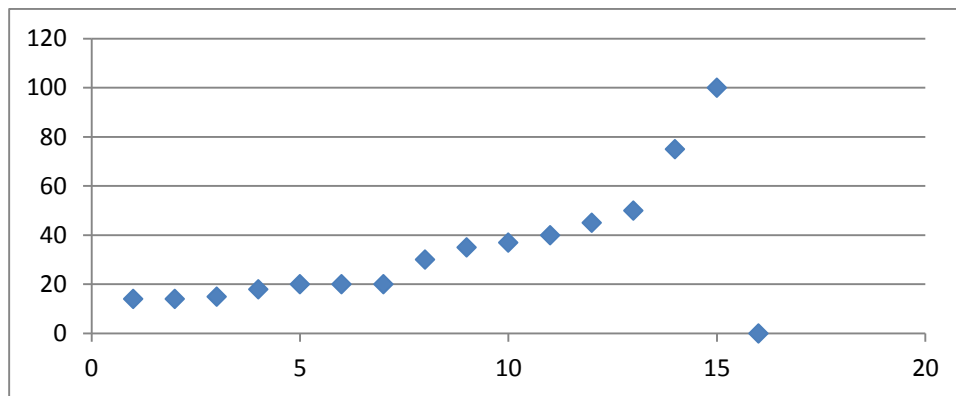


Figure 3. Water production rates from wells in the Deadwood Formation, Hayward Quadrangle. The vertical axis shows gallons per minute initial water flow. The horizontal axis shows that information was available from 16 wells. Note that most wells yielded less than 40 gallons per minute.

***PAHASAPA (MADISON) LIMESTONE***

Mississippian-age limestone and dolomite of the Madison aquifer is called the Pahasapa Limestone in the Black Hills. This formation is a major water-bearing unit, in part, because of

the caves and fissures (called karst) which formed from dissolution of the rock by flowing water in fractures.

In the western and central parts of the quadrangle, wells reach the Madison aquifer at depths of 100 to 700 feet. As shown in the graph of Figure 4, initial production from such wells varies between one and one-half and 200 gallons per minute. A single well drilled to a depth of 2,400 feet along the eastern edge of the quadrangle produced 600 gallons per minute.

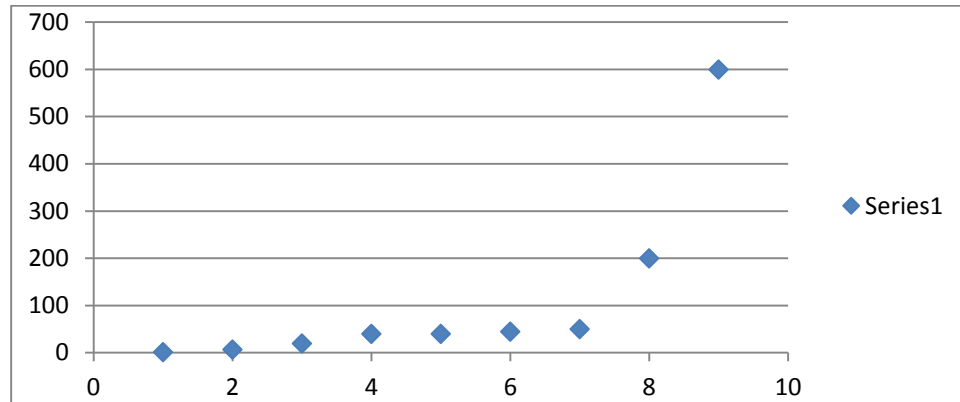


Figure 4. Water production from wells in the Pahasapa Limestone (Madison aquifer) Formation, Hayward Quadrangle. The vertical axis shows gallons per minute initial water flow. The horizontal axis shows that information was available from nine wells. Note that most wells yielded less than 50 gallons per minute.

### ***MINNELUSA FORMATION***

Pennsylvanian and Permian-age sandstone, limestone, and dolomite comprise the Minnelusa aquifer in the Black Hills. In the central and eastern parts of the quadrangle, wells reach the Minnelusa at depths of 100 to 1,250 feet. The graph of Figure 5 indicates initial water production from such wells at rates of one to 120 gallons per minute. For the 114 wells reported, two-thirds have flow rates of 30 gallons or less per minute and one-third are less than 20. The upper sandstone of the formation is the first productive aquifer reached by wells in the Red Valley along the eastern part of the quadrangle.

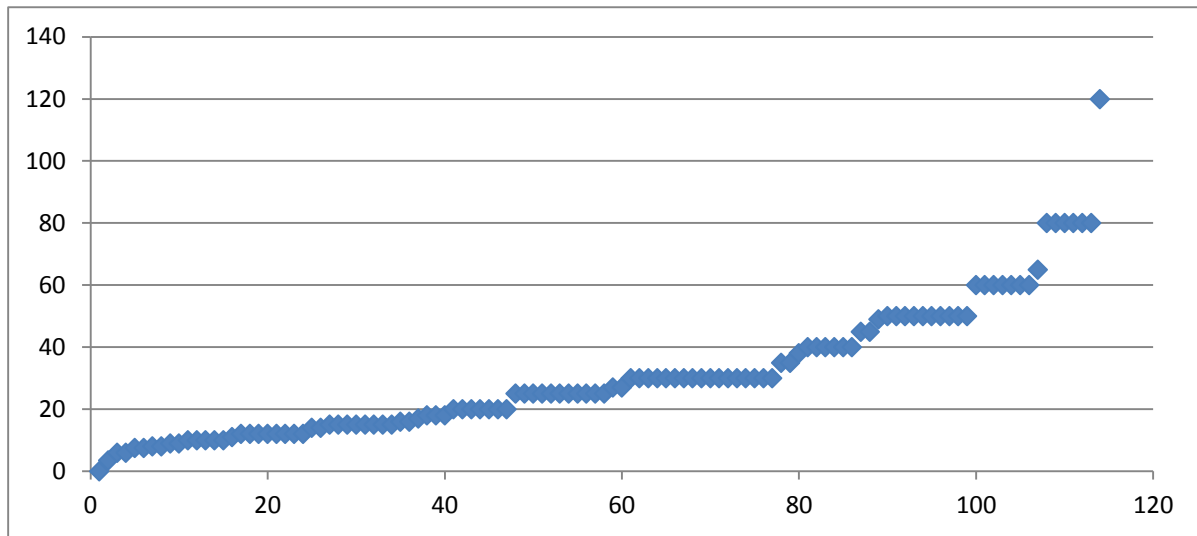


Figure 5. Water production from wells in the Minnelusa Formation, Hayward Quadrangle. The vertical axis shows gallons per minute initial water flow. The horizontal axis shows that information was available from 114 wells. Note that most wells yielded less than 40 gallons per minute.

**LAKOTA FORMATION/FALL RIVER FORMATION (INYAN KARA GROUP)**

Cretaceous sandstone and interbedded mudstone comprise the aquifer of the Lakota and Fall River formations in the Black Hills. The Lakota Formation underlies the Fall River Formation and is present as a reservoir further to the west.

*Fall River Formation:* In the southeastern part of the quadrangle the Fall River Formation is exposed at the surface, but producing wells range from 75 to 400 feet depth. As shown in the graph of Figure 6 (B), water production for the 10 reported wells is 18 gallons per minute or less.

*Lakota Formation:* Along the eastern margin of the quadrangle area the Lakota Formation (A, in Figure 6) produces water from depths of 50 to 425 feet. The initial rate of water production from 28 wells varied from five to 100 gallons per minute.

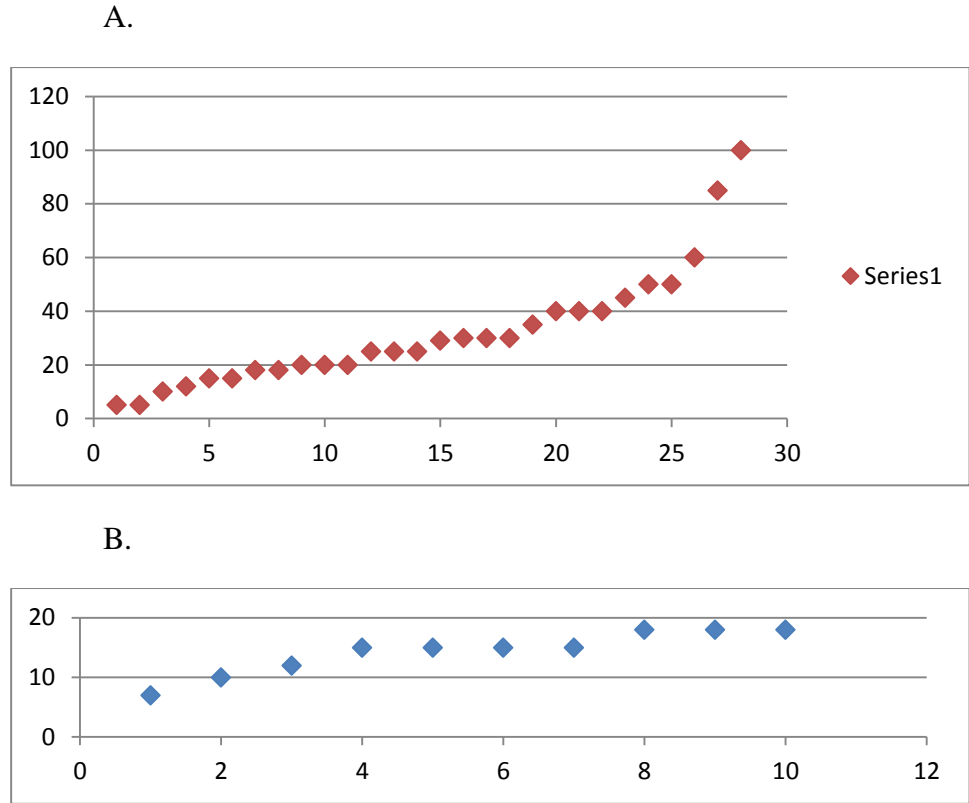


Figure 6. Water production from wells in the Lakota Formation (A) and Fall River Formation (B), Hayward Quadrangle. The vertical axis shows gallons per minute initial water flow. The horizontal axis shows that information was available from 16 wells. Note that most Lakota wells yielded less than 40 gallons per minute and that Fall River wells yielded less than 20 gallons per minute.

### OTHER AQUIFERS

A few wells within the quadrangle obtain water from other formations. For example, five wells produce from the Minnekahta Limestone at rates of eight to 150 gallons per minute, four from the Spearfish Formation had initial production of zero to 22 gallons per minute, and four from the Sundance Formation four to 20 gallons per minute. A single well in Quaternary alluvium produced 80 gallons per minute from a depth of 35 feet. Each of these formations lies above the aquifers described above and are at the surface in the eastern part of the quadrangle.