

Changing Groundwater Levels in the Cambrian-Ordovician Sandstone Aquifers of Northern Illinois, 1980-2014

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Introduction

The St. Peter and Ironton-Galesville Sandstones, the principal bedrock units that comprise the Cambrian-Ordovician sandstone aquifers in northern Illinois, are a primary source of water for many municipalities and industries. Due to continued groundwater pumping, water levels in Cambrian-Ordovician sandstone wells have dropped by as much as 800 feet in the Chicagoland area since the first wells were drilled in 1864. Many communities in the Chicagoland area switched from groundwater to Lake Michigan water starting in 1980 due to economic factors and water quality concerns (Sasman et al., 1986). However, urbanization and population growth in the southwestern and westernmost suburbs of Chicago has

led to an increase in withdrawals from the sandstone aquifers since 1980. In northwestern and central Illinois, the sandstone aquifers are often the most productive source of water for communities and continue to satisfy municipal and industrial water needs.

To understand the impact of continued use and changing water demand, the Illinois State Water Survey (ISWS) conducted their largest synoptic measurement of water levels in Cambrian-Ordovician sandstone wells since 1980. A total of 576 water level measurements were made in 33 counties between July 2014 and February 2015 (Figure 1). For more details about this study's methodology and results see Abrams et al., 2015.

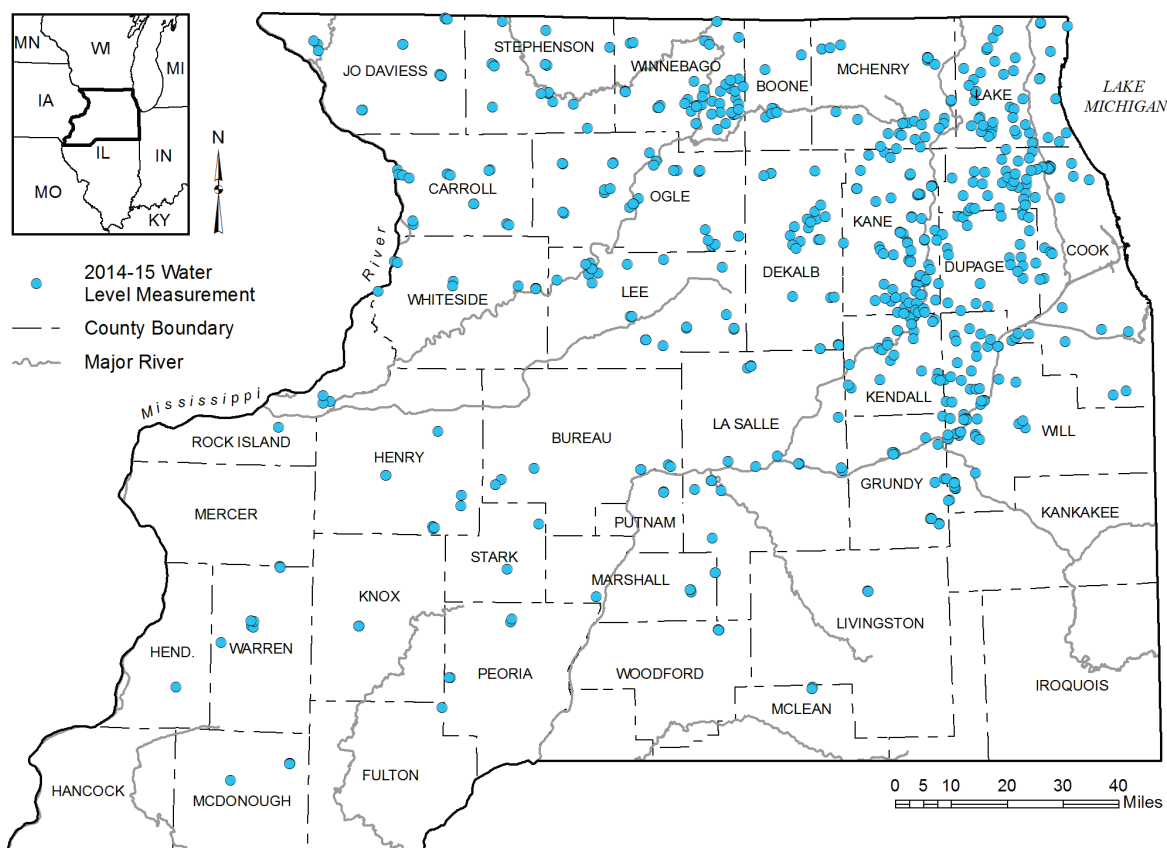


Figure 1. Map of the study area and locations of water level measurements obtained for wells open to the Cambrian-Ordovician sandstones.

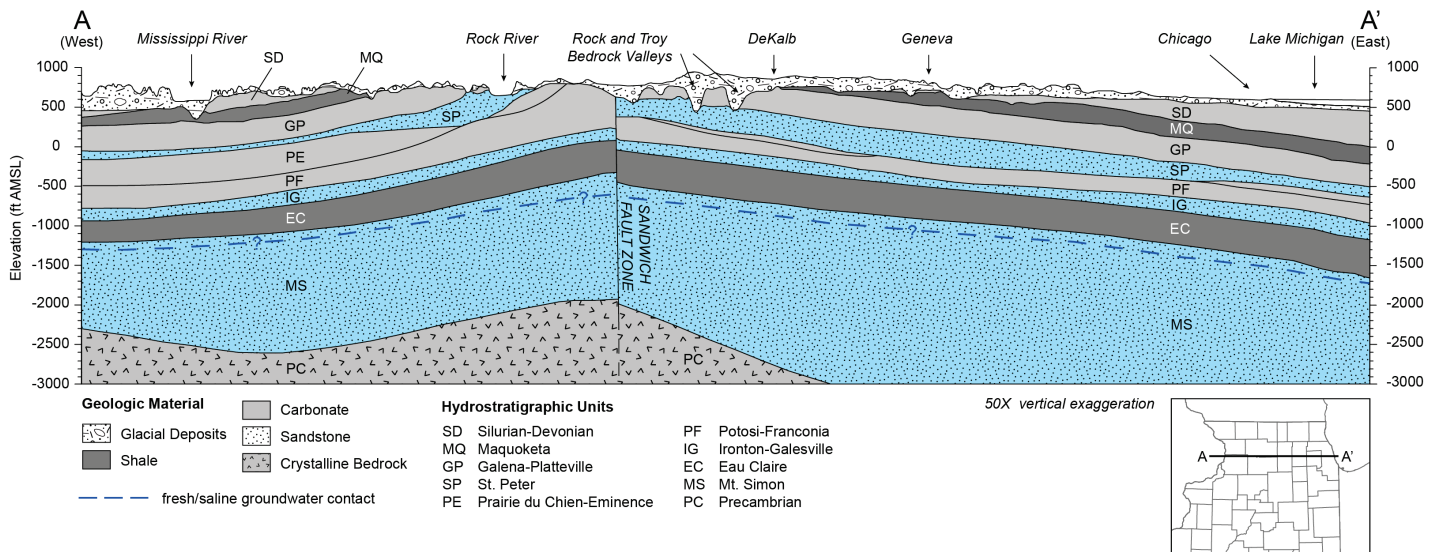


Figure 2. West-to-east cross section across northern Illinois showing the St. Peter and Ironton-Galesville Sandstones bounded by carbonate and shale bedrock aquitards. The St. Peter Sandstone and older bedrock layers are at land surface in north-central Illinois, with layers dipping to the west and east. Note the Sandwich Fault Zone, which offsets bedrock layers.

Hydrogeology and Water Use

The St. Peter and Ironton-Galesville Sandstones are composed mostly of fine to medium grained, well rounded, exceptionally pure quartz sand (Willman et al., 1975). The St. Peter Sandstone is Ordovician in age and is generally 100-200 feet thick. It is present at land surface along the Rock River in north-central Illinois but is buried as it dips west towards the Mississippi River and east towards Lake Michigan (Figure 2). In northwestern and northeastern Illinois, the St. Peter is overlain by Silurian Dolomite, Maquoketa Shale, and Galena-Platteville Dolomite. These units generally have low permeability and act as aquitards, preventing vertical infiltration of groundwater to the St. Peter. The deeper Ironton-Galesville Sandstone is Cambrian in age, is generally 150-200 feet thick, and is usually more productive than the St. Peter. It is separated from the St. Peter Sandstone by several formations that act as

aquitards (Figure 2). The Mt. Simon Sandstone, which underlies the Ironton-Galesville, is not typically a viable source of groundwater in northern Illinois due to its high salinity.

Withdrawal rates by municipal and industrial facilities from the Cambrian-Ordovician sandstones declined from 263 million gallons per day (Mgd) in 1980 to 165 Mgd in 2012 due to many communities in northeastern Illinois switching to Lake Michigan water (Figure 3). However, northeastern Illinois withdrawal rates steadily increased from 75 Mgd in 1993 to 97 Mgd in 2012. Withdrawal rates in northwestern Illinois and the rest of the study area have declined slightly overall.

Methods

Groundwater levels (also referred to as heads) were measured at public water supply wells and industrial facilities by ISWS staff using a combination of airline, dropline, and steel tape methods. Wells were turned off for at least 30 minutes to let water levels recover. 546 out of the 576 water levels were used to make a potentiometric surface for the Cambrian-Ordovician sandstones using a groundwater flow model. A potentiometric surface is made by contouring heads and represents the height that water will rise to in tightly cased wells. Potentiometric surfaces can be used to determine 1) areas of recharge, 2) the direction of groundwater flow, and 3) where cones of depression are forming in response to pumping. The 2014 potentiometric surface (Figure 4A) was compared to 1980 to determine how water levels in wells have changed over 34 years (Figure 4B).

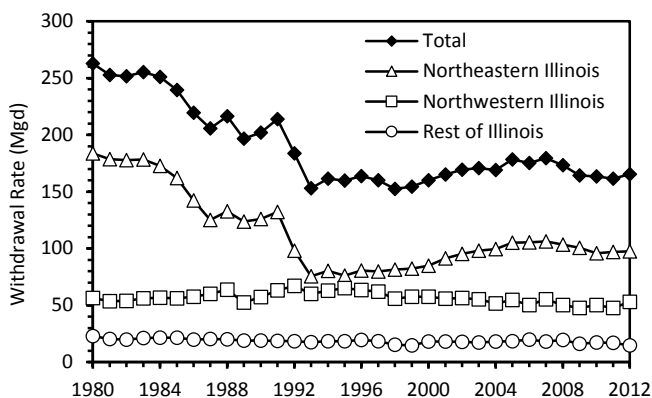


Figure 3. Graph of withdrawal rates for the Cambrian-Ordovician sandstones in Illinois in millions of gallons per day (Mgd)

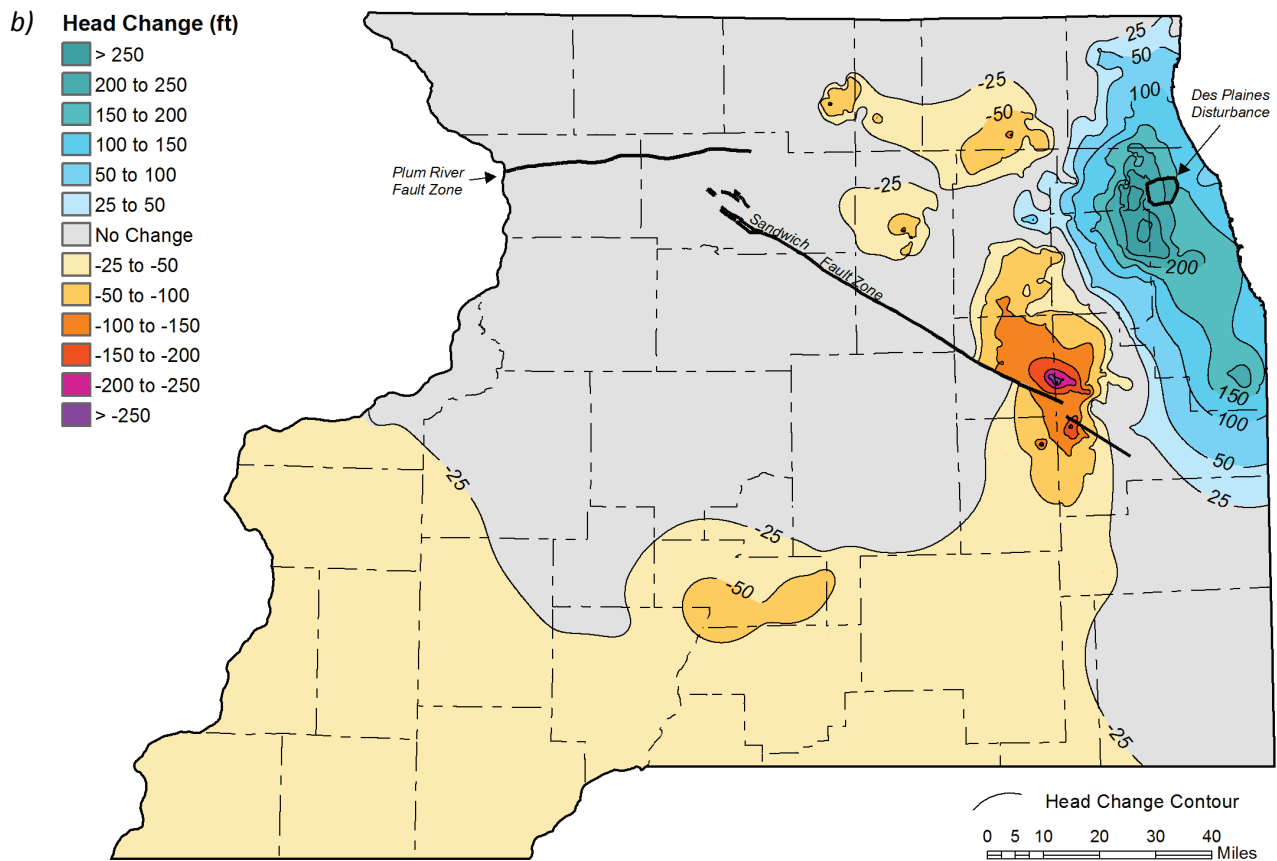
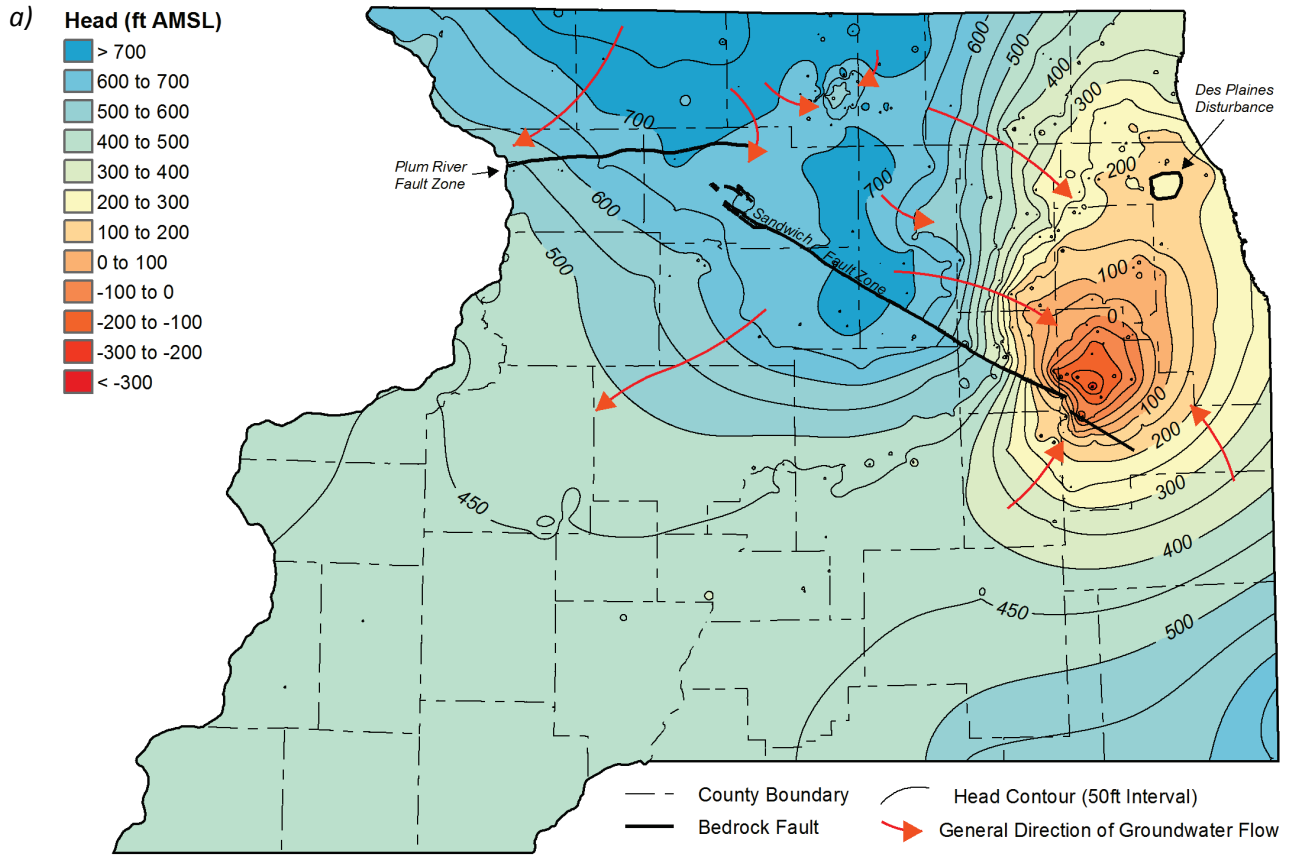


Figure 4. (a) Potentiometric surface for the Cambrian-Ordovician sandstones in 2014 in feet above mean seal level (ft AMSL) and (b) Head change in Cambrian-Ordovician sandstone wells between 1980 and 2014

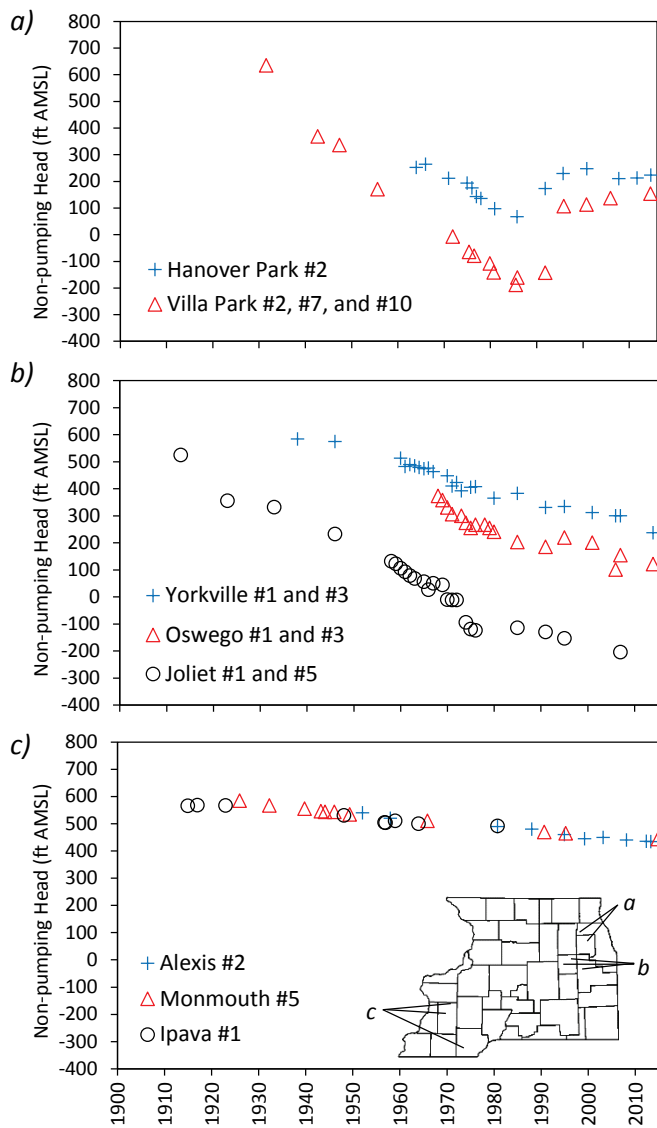


Figure 5. Long term hydrographs representative of (a) water level decline and subsequent recovery in Lake, DuPage, and Cook Counties, (b) rapid water level decline in Kendall and Will Counties, and (c) the steady decline in water levels in western and central Illinois.

Results and Discussion

Heads in the Cambrian-Ordovician sandstones are highest in northeastern Jo Daviess, Stephenson, and northwestern Winnebago Counties (Figure 4A). Groundwater flows southwest towards the Mississippi River or southeast towards the Rock River, where the St. Peter Sandstone is at or near land surface. Heads are above 700 feet in eastern Ogle, eastern Lee, and western DeKalb Counties. This area of high heads is likely due to a hydraulic connection between the shallow glacial aquifers and deeper sandstone aquifers within the Troy and Rock Bedrock Valleys (Figure 2) and is an important area of recharge to northeastern Illinois. In general, groundwater flows east and southeast from DeKalb and Boone Counties towards

the area of lowest heads in Will and DuPage Counties. Heads in northern Will County are as low as 300 feet below sea level, resulting in a steep hydraulic gradient across Kane and northern Kendall Counties.

Water levels in Cambrian-Ordovician sandstone wells have recovered substantially in Cook, Lake, and DuPage counties since 1980 due to the majority of communities switching to Lake Michigan water (Figure 4B). Heads recovered by 25-150 feet in Lake County and by as much as 350 feet in northern DuPage and northern Cook Counties (Figure 5A). However, heads are still 500-600 feet lower than predevelopment conditions and head recovery in this region is slowing.

Water levels continue to decline in western Will, Kendall, and southern Kane Counties (Figure 4B). Heads have decreased by 100-300 feet in the Joliet region since 1980 (Figure 5B). Head decline in this region is exacerbated by the presence of the Sandwich Fault Zone, which can act as a flow barrier to limit groundwater recharge from the southwest. Smaller head declines are present around the pumping centers of Rockford in Winnebago County, Huntley and Crystal Lake in southern McHenry County, and DeKalb and Sycamore in DeKalb County. Heads in these areas have declined by 50-150 feet since 1980.

Water levels have not declined significantly in northwestern Illinois. This is a result of small demand and relatively high recharge rates found throughout the area. These high recharge rates are due to surface water connections with the St. Peter and the absence of the Maquoketa Shale to impede vertical infiltration. In central and western Illinois, heads have declined by 25-50 feet since 1980, despite the small withdrawal rates. This continues the trend of slowly declining water levels in this region (Figure 5C). The presence of several shale units overlying this area prevents vertical infiltration and allows little to no recharge. Additional study is needed to determine if the northeastern Illinois cone of depression is influencing this decline.

References

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