THE REGIONAL GROUND WATER FLOW SYSTEM IN SOUTHEASTERN WISCONSIN

BASED ON THE FINDINGS OF THE UNITED STATES GEOLOGICAL SURVEY: GROUND WATER IN THE GREAT LAKES BASIN: THE CASE OF SOUTHEASTERN WISCONSIN

Prepared by:

Jeffrey Edstrom
William Ward

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GEOSYNTEC CONSULTANTS

55 West Wacker Drive, Suite 1100
Chicago, IL • USA
Tel. (312) 658-0500 • Fax (312) 658-0576

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Summary: Waukesha's Existing Source of Water is Groundwater within the Great Lakes Basin and Ceasing Use of that Source would have Significant Environmental Benefits.

This document is an analysis of the United States Geological Survey (USGS) and Wisconsin Geologic Natural History Survey (WGNHS) and summarizes the findings regarding the regional groundwater system in southeastern Wisconsin and, in particular, Waukesha's use of water from that system in its web-based report, "Groundwater in the Great Lakes Basin: The Case of Southeastern Wisconsin."[1] The USGS is within the U.S. Department of the Interior and is "the primary source of data on the Nation's surface-water and ground-water resources."[2]

Our analysis of the work completed by USGS and WGNHS report shows that:

1) Waukesha draws its water supply from the portion of the deep sandstone aquifer that flowed naturally toward Lake Michigan (See Figure 1) and is within the historic Lake Michigan groundwatershed.

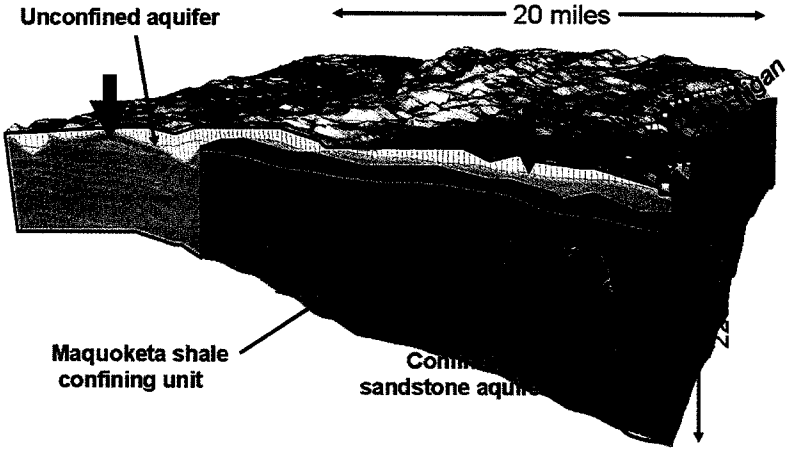

Figure 1. Hydrogeology of Southeastern Wisconsin. The confined aquifer in the graphic is the deep Aquifer. The blue arrows indicate direction of flow. The Maquoketa shale confines ground water below it and is a barrier to the flow of water to and from the surface. The dotted line is the surface water divide.
Source: USGS, adapted by Southeastern Wisconsin Regional Planning Commission (unconfined aquifer layer and arrows added)

2) The water that Waukesha currently pumps for its public water supply was tributary groundwater under pre-pumping conditions.

3) The surface water divide for the Lake Michigan watershed is not the same as the watershed's groundwater divide.

4) While the City of Waukesha is located outside of the surface water divide, which defines the locations of streams flowing to Lake Michigan and the Mississippi River, Waukesha has always been located over a portion of the deep sandstone aquifer that naturally flowed toward Lake Michigan under pre-pumping conditions. Thus, Waukesha is within the historic Lake Michigan groundwatershed.

5) Pumping over the last 100 years by municipalities in southeastern Wisconsin has drawn down the water level in the deep aquifer by more than 600 feet and has resulted in the movement of the divide that defines the flow of ground water toward Lake Michigan or the Mississippi River further to the west.

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[1] United States Geological Survey, "Groundwater in the Great Lakes Basin: The Case of Southeastern Wisconsin," http://wi.water.usgs.gov/glpf/index.htm, (Page viewed March 10, 2006).
[2] United States Geological Survey, Mission Statement, Wisconsin Water Science Center, http://wi.water.usgs.gov/overview/mission1.html (Page viewed March 15, 2006).

6) This pumping has altered the natural hydrogeology so that the groundwater, which once fed Lake Michigan, now receives water from Lake Michigan.

7) Ceasing all pumping from the deep aquifer will allow the water level to recover by 50% within 7 years and by 90% in 70 years.[3] Ceasing ground water pumping would restore natural hydrogeologic conditions and allow the ground water divide to move back to its historic location and dramatically reduce the negative impacts of the drawdown on surface streams and wetlands.

Waukesha's Water Supply Source is Groundwater that is Part of the Great Lakes Basin.

Waukesha's existing deep wells have a pumping capacity of 24 million gallons per day.[4] Wells 1 through 10 pump water from depths of between 1650 and 2266 feet. These wells are located in the east central portion of Waukesha County within Waukesha City limits.

These wells draw water from the deep sandstone aquifer. The aquifer is located beneath southeastern Wisconsin and serves as a water source for many local communities. It once served the City of Milwaukee before the city switched to a Lake Michigan surface water supply.

The groundwater divide is partly defined and influenced by a layer of Maquoketa shale under the surface of southeastern Wisconsin that runs from Lake Michigan in the east to approximately the Waukesha County-Jefferson County line (See Figure 2). This shale significantly reduces the ability of water to infiltrate from surface to the deep sandstone aquifer. As a result, the deep aquifer is "confined" below the Maquoketa shale but is "unconfined" further to the west. Just to the west of the shale, water flows to the aquifer in two different directions (east and west) based on topography, soil type, and other hydrogeologic factors (See Figure 3).

Because of the confinement layer in much of southeastern Wisconsin, the primary infiltration/recharge area for the deep sandstone aquifer is generally influenced by the western portion of Waukesha County the Maquoketa shale. This is in the Kettle Moraine area in western Waukesha County where the type of soil deposits allows the highest infiltration rate in all of southeastern Wisconsin. It is located to the west of both the surface water divide that defines the surface watersheds of the Lake Michigan and Mississippi River basins and the groundwater divide for the basins. Because the shale largely acts as a barrier to water entering the aquifer within the Lake Michigan

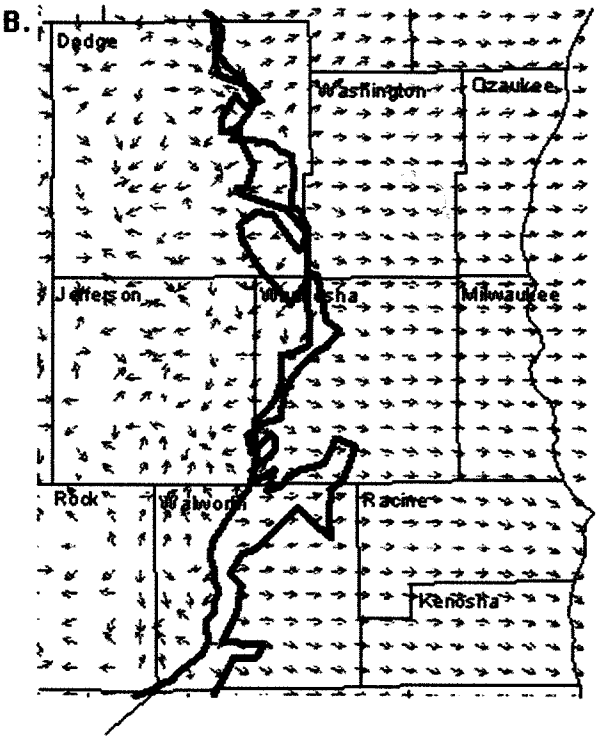

Figure 2. The St, Peter Aquifer groundwater divide (red line) under prepumping conditions relative to the western extent of the Maquoteka shale (black line) and flow of water in the aquifer (red – upward flow and blue – downward flow – arrows. Source: United States Geological Survey

[3] United States Geological Survey, "Groundwater in the Great Lakes Basin: The Case of Southeastern Wisconsin," http://wi.water.usgs.gov/glpf/cs_pmp_src.htm, (Page viewed March 10, 2006).
[4] Waukesha Water Utility.

basin, water flows from the west into the ground and follows a natural path down and to the east to the deep aquifer and then toward Lake Michigan (See Figures 3 and 4).

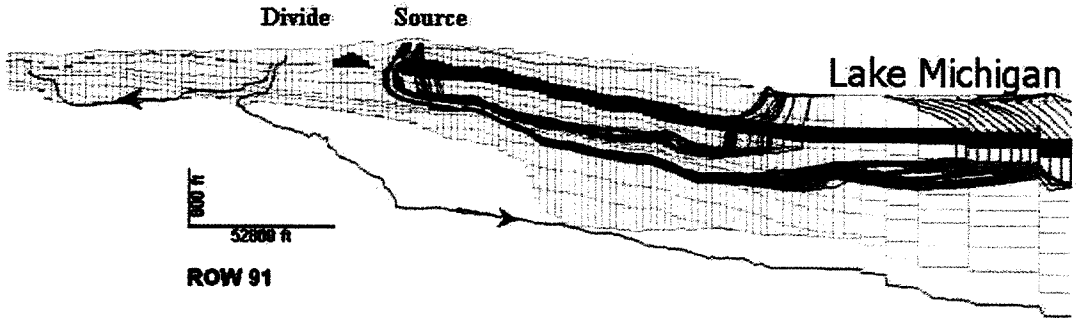

Figure 3. "USGS Model output: West-to-east sections showing locations and regional ground-water flow lines to Lake. Blue formation is Maquoketa shale. Yellow formation is St. Peter sandstone. East of divide all flow lines go from water table toward Lake Michigan."
Source: D.T. Feinstein, U.S. Geological Survey, http://wi.water.usgs.gov/glpf/cs_nt_lk.htm

This flow from the Mississippi River basin through the deep aquifer system to the Lake Michigan basin is neither accidental nor man-made. It is a natural flow of surface water into an aquifer that is tributary to Lake Michigan and has occurred since the glaciers that formed the Great Lakes retreated.

Currently, the USGS model indicates that approximately "71% of the water that replenishes discharge from deep wells in southeastern Wisconsin is ground water that flows from surface water streams (captured base flow) within the Mississippi River (surface water) Basin"[5] near where the shale layer ends. As this surface water infiltrates, some of it remains in shallow aquifers located in the Mississippi River basin, but the remainder percolates further through the soil to the deep sandstone aquifer. Once settling in the deep aquifer, the direction of flow of this water is easterly toward the cone of depression.

Other sources of ground water recharge to the deep aquifer system are from the Lake Michigan basin including captured flow from streams in the Lake Michigan surface water Basin (6%), inland storage release (3%), storage release below Lake Michigan (8%), water that once flowed toward rocks under Lake Michigan (8%), and water flowing out of Lake Michigan itself (4%).[6]

A Reduction of Pumping from the Deep Sandstone Aquifer will Result in a Dramatic Recovery from Groundwater Drawdown Effects.

Waukesha has always been within the Lake Michigan groundwater basin. Under pre-pumping conditions, the ground water flow beneath Waukesha was uninterrupted to Lake Michigan (See Figure 4). The effect of pumping over the last 100 years has been dramatic. It has created a large cone of depression that has lowered the aquifer level by approximately 600 feet. This has created a sharper incline of the aquifer level that has increased the rate of flow from the west and moved the boundary of the groundwater divide further westward (See Figures 5 and 6). It also draws water away from surface streams, reducing baseflow and leading to negative impacts on the local environment.

[5] http://wi.water.usgs.gov/glpf/im.html, (Page viewed March 8, 2006).
[6] http://wi.water.usgs.gov/glpf/im.html, (Page viewed March 8, 2006).

Ceasing water pumping from the deep aquifer in southeastern Wisconsin would allow the water level to recover by 50% within 7 years and by 90% in 70 years[7] and allow the ground water divide to move back to its historic location. This will also reduce the negative impacts on surface streams and wetlands.

Conclusion

Based on the facts presented above, we conclude the source of water for the Waukesha Water Utility is, and has always been, drawn from a portion of the deep sandstone aquifer that the USGS has identified as part of the historic Lake Michigan groundwater basin, not the Mississippi River basin. The flow of water from the aquifer under pre--pumping conditions has always been eastward toward Lake Michigan. The water currently being pumped by the Utility was within the historic Lake Michigan groundwater basin and should be considered tributary to Lake Michigan. The water entering from the Mississippi River basin will take hundreds of years to enter the Waukesha Water system.

Defining the deep groundwater divide as being the same as the surface water divide is contrary to scientific evidence. The surface water divide is defined by the surface topography of the area. In contrast, the groundwater divide in southeastern Wisconsin has historically been influenced by the western extent of the layer of Maquoketa shale, although it has been affected by pumping from the aquifer over the last 100 years.

The effect of 100 years of water withdrawal from the deep aquifer system in southeastern Wisconsin has moved the deep ground water divide between the Lake Michigan and the Mississippi River basins further to the west and has drawn down base flow from local streams. Ceasing pumping from this aquifer will allow it to recover over time and allow the groundwater divide to move back to its historic location and reduce the impacts on surface streams and wetlands. It will thus restore the historic flow to Lake Michigan.

[7] United States Geological Survey, "Groundwater in the Great Lakes Basin: The Case of Southeastern Wisconsin," http://wi.water.usgs.gov/glpf/cs_pmp_src.htm, (Page viewed March 10, 2006)