Title: **Groundwater Pumping Effects on Groundwater Levels, Lake Levels, and Streamflows in the Wisconsin Central Sands**

Project I.D.: DNR project # 202

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Background/Need: The study summarized here examined the impacts of groundwater pumping on Wisconsin Central Sands water resources. Prominent hydrologic studies in the 1960s and 1970s warned that the growth in groundwater pumping for agricultural irrigation in the region could substantially lower water levels and streamflows. Irrigation pumping nonetheless grew unchecked in succeeding decades, and presently encompasses some 2,300 high capacity wells that service 200,000 acres.

Since 2000, Central Sands water levels and stream discharges have been notably stressed, at least in areas that contain large densities of high capacity wells. These stresses have included the drying of streams and lakes. Questions exist as to the causes of stressed conditions, and the relative role of weather and pumping.

Objectives: The purpose of this study was to determine the impacts of groundwater pumping on Central Sands water resources. Specific objectives were to:

1. Assemble available lake level, groundwater level, and stream baseflow data.
2. Collect new stream baseflow data.
3. Evaluate assembled stream, lake, and groundwater level data for indications of pumping impacts.
4. Expand and improve upon an existing groundwater flow model for the region.
5. Use the improved flow model to evaluate potential impacts of groundwater pumping on lake levels, groundwater levels, and stream baseflows.

Methods: Statistical analyses were employed to evaluate: (1) whether recent weather was unusually dry; (2) whether water levels in "reference" streams, lakes, and monitoring wells were unusually low ("reference" means locations that are unlikely to be greatly impacted by groundwater pumping); and (3) the magnitude of water level declines not attributable to weather conditions. Groundwater flow modeling was used to: (1) validate statistical inferences about water level declines not attributable to weather; (2) map water level declines given anticipated amounts of evapotranspiration on irrigated crops compared with the nonirrigated perennial landscape; and (3) estimate pumping induced baseflow reductions in streams.

Results and Discussion: Central Sands precipitation in 2000 to 2004 was mostly average to above average while in 2005 to 2008 was slightly below to slightly above average. Post-1970 precipitation increased by 0.7 to 2.8 in compared with 1940-1970 precipitation.

Reference streams revealed significant lows over the past 90 years, especially 1931 to 1934, 1948-9, 1957-9, 1964, 1977, and 1988. In contrast, reference stream discharges in 2000-2004 were about average for the long term, 8-18 percentiles in 2005-2007, and in 2008 were a more robust 25-50 percentile.

Groundwater and lake levels in areas with few high capacity wells were slightly below to slightly above average in 2000-2005, and in 2006-8 were lower than average, 11 to 16 percentile, but not at rare nor record lows. The available groundwater and lake level record (1950s to present), for areas with few high capacity wells, was generally coincident with stream discharge records, and exhibited 50 year lows in 1958-9.

Hence neither weather conditions nor hydrologic conditions in areas with few high capacity wells suggest that weather conditions are responsible for stresses in areas with many high capacity wells.

Groundwater levels in areas with many high capacity wells experienced record lows in 2000-2008, in sharp contrast to areas with few high capacity wells. Groundwater level declines beyond that which may be accounted for by weather ranged from about one to three feet, depending on landscape position. Decline estimates are probably underestimated by about 0.4 to 0.76 feet**.**

Lakes levels in areas with many high capacity wells showed substantial declines that cannot be accounted for by weather, in the range of 1.5 and 3.6 feet, depending on the lake's location. These declines represent an average for the 1990s to 2007, do not capture potential peak amounts of missing water, and due to methodology may be underestimated by about 0.4 to 0.76 feet**.**

Flow modeling indicates irrigation pumping may cause groundwater and lake level declines up to four feet or more where in reality lakes are highly water level stressed. Modeled headwater stream discharge reductions are commonly 20-50%.

Conclusions/ Implications/ Recommendations: We conclude that weather conditions in 2000-2008 are alone unable to account for the severely depressed water levels and streamflows in areas of the Central Sands that contain high densities of high capacity wells. Declines of around four feet or more in water levels by pumping are possible. Pumping impacts on streamflows are most severe in stream headwaters, where common flow reductions of 20-50% are possible.

Related Publications: Report from DNR project #196

Key Words: Groundwater pumping, stream depletion, irrigation impacts

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Final Report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.