Title: Water Balance Modeling for Irrigated and Natural Landscapes in Central Wisconsin

Project I.D.: DNR project # 201

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Background/Need:
Significant decline in the water table in the Wisconsin Central Sand Plain (WCSP) has caused concern over the increase in land area devoted to irrigated agricultural crop production.

Objectives:
(1) Conduct a survey of Wisconsin Sand Plains (WSP) crop growers' current cropping and irrigation practices. (2) Develop a soil-specific determination of "field capacity" water content for a range of soil types in WSP. (3) Measure storm-based groundwater recharge rates under four vegetation types (various irrigated crops, deciduous forest, pine plantation, and natural grasslands) in WSP, by direct observation of water table changes. (4) Modify and apply a one-dimensional soil-plant-atmosphere model to estimate evapotranspiration and groundwater recharge under different vegetation types, using results from objectives 1-3.

Methods:
This study was conducted in Waushara County at the Univ. of Wisconsin-Madison Hancock Agricultural Research Station and on privately owned farmland near Hancock, WI, and in Adams County on privately owned land near Grand Marsh, WI. This area is known as the Wisconsin Central Sand Plain (WCSP) and consists of thick, uniform sand deposits that were formed in the bed of Glacial Lake Wisconsin. Soil parent material consists of glacial till overlain by glacial outwash. Groundwater is 1.2 to 9.1 m below the surface throughout the region in unconfined sand and gravel aquifers. Eight groundwater monitoring well sites were established and the wells were equipped with pressure transducers and dataloggers, rain gauges, and 30-cm long time domain reflectometry soil water content probes. The dataloggers were programmed to make measurements of water table elevation, soil water content, and precipitation every 15 minutes.

Results and Discussion:
This study was conducted to investigate the fate of groundwater in WCSP by collecting continuous water table elevation data from eight different sites. The principal objective was to quantify interactions between vegetation (irrigated agricultural crops, prairie, and forest) and depth to groundwater. Our data show that groundwater recharge patterns varied by vegetation type, season, and according to location in the groundwatershed. During the growing season, interception of precipitation by plant leaf canopy and soil surface residue for some vegetation ecosystems (namely pine plantation) reduced recharge to the water table after precipitation events as compared to sites where the vegetation and residue intercepted a minimal amount of the precipitation. In the pine plantation, precipitation events from July 2008 to February 2009 yielded little to no recharge to the water table. Precipitation events during the growing season resulted in 1.4

cm greater water table rise under prairie than agricultural fields. After snowmelt events in winter 2008-2009, prairie vegetation yielded a 7.5 cm greater water table rise than agricultural fields. The lack of plant residue on agricultural fields lead to a continuous soil frost layer that extended to about 1 m. Cemented frost in the soil profile inhibited snowmelt water from infiltrating and recharging the groundwater. Increased residue on the surface of agricultural fields may enhance recharge to the water table in this region. Water tables responded to precipitation events differently based on their position in the groundwatershed and depth to the water table. Water tables in the discharge area of the groundwatershed (Grand Marsh area) responded quickly to precipitation events and the amount of rise increased linearly with precipitation. While agricultural crops used groundwater through irrigation, natural vegetation relied on the water table for daily transpiration needs in shallow groundwater areas. Where groundwater was further from the soil surface, in the groundwatershed recharge area (Hancock area), responses to precipitation events were buffered by the greater depth of soil above the water table. There were limited noticeable responses of the water table to rain events less than 0.4 cm, and we do not anticipate that natural vegetation will use water directly from deep groundwater. Thus, the only use of groundwater directly is by irrigation in the recharge area of the groundwatershed. We conclude that increase in irrigated agricultural lands in the WCSP alters groundwater recharge characteristics during frozen and non-frozen ground periods. Similar to measured results, data were obtained from two computer simulation models, the rather large and complex Integrated Biosphere Simulator (IBIS) and a simpler model Soil Water Balance (SWB) recently developed by Bill Bland.

Conclusions/Implications/Recommendations:

The most noticeable difference in groundwater recharge from field and natural vegetation has been the lack of recharge beneath a pine plantation. Recharge under this vegetation did not take place except for snowmelt and rain events greater than 3 cm. There was limited recharge during rain events or snow melt in midwinter under agricultural fields, but significant recharge from prairies. Differences in groundwater recharge in winter were attributed to differences in frost depth and the degree of pores filled with ice/water between the prairies and agricultural fields. The fields had a solid frost layer, suggesting that most of the soil pores were filled with ice, to a depth of 1 m or more while the prairies had a discontinuous frost layer, suggesting that soil pores were not filled with ice. Future policy should recognize the importance of various land covers on groundwater recharge in the WCPS.

Related Publications:

Bland, W.L. 2007. Research agenda for irrigation quantity issues. Proc. Wis. Annual Potato Mtg. 20:43-45.

Lowery, B., G.J. Kraft, W.L. Bland, A.M. Weisenberger, and P.E. Speth. 2008. Trends in groundwater levels in Central Wisconsin. Proc. 2008 Wis. Annual Potato Mtg. 21:33-38, Madison, WI.

Weisenberger, A., B. Lowery, and W.L. Bland. 2008. Trends in groundwater levels in central Wisconsin. In Agronomy abstracts (CD-ROM). ASA, Madison, WI.

Weisenberger, A., B. Lowery, and W. Bland. 2009. Trends in Groundwater Levels in Central Wisconsin. Proc. 2009 AWRA-Wis. Section Annual Mtg. 33:56, Stevens Point, WI.

Weisenberger, A., B. Lowery, and W. Bland. 2009. Groundwater recharge under selected vegetation in Central Wisconsin. Proc. 2009 Wis. Annual Potato Mtg. 22:121-127, Madison, WI.

Key Words: Groundwater, soil water content, drainage, groundwater recharge, water table elevation

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Final Report: A final report containing more detailed information on this project is available for loan at the Water Resources Institute Library, Univ. of Wisconsin-Madison, 1975 Willow Dr., Madison, WI 53706, 608-262-3069.