Report for 2004NE73B: Investigation of Groundwater Interactions with Surface Hydrologic Systems in River Valleys -- Using Modeling and Field Approaches

- Articles in Refereed Scientific Journals:
  - Chen, X.H., Y. Yin, J.W. Goeke, and R.F. Diffendal, Jr. 2005. Vertical movement of water in a high plains aquifer induced by a pumping well. Environmental Geology 47(7): 931-941 (DOI: 10.1007/s00254-005-1223-4).
  - Chen, X. H., 2005. Statistical and geostatistical features of streambed hydraulic conductivities in the Platte River, Nebraska. Environmental Geology (accepted for publication).
- unclassified:
  - Wen, F. J. and X. H. Chen, 2004. Evaluation of the impact of groundwater irrigation on streamflow depletion in Nebraska. Journal of Hydrology (in review).

Report Follows

COVERAGE

Project Number:	2004NE73B
Funding Period:	March 1, 2004 – February 28, 2005
Title:	Investigation of Groundwater Interactions with Surface Hydrologic Systems in River Valleys – Using Modeling and Field Approaches
PI:	Xun-Hong Chen
CO-PI:	James Goeke and Robert Caldwell

RESEARCH SYNOPSIS

Title: Investigation of Groundwater Interactions with Surface Hydrologic Systems in River Valleys – Using Modeling and Field Approaches

Project Number: 2004NE73B

Start Date: 03/01/2004

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Congressional District: NE 1

Research Category: Groundwater flow and transport

Focus Categories: GW, HYDROL, MOD

Descriptors: Streambed hydraulic conductivity, Evapotranspiration, Groundwater modeling, Diurnal fluctuation of the water table, Parameter Estimation

Primary PI: Xun-Hong Chen

Other PIs: James Goeke and Robert Caldwell

Project Class: Research

Summary

This project is part of an on-going water resources investigation in Nebraska with a current focus on the interaction of groundwater with surface water. Surface water and groundwater are recognized to be hydrologicaly connected in Nebraska, and thus efficient management of surface water and groundwater requires a better understanding of their hydrologic relations. The goal of this project is to determine the groundwater evapotranspiration rate in riparian zones of selected river valleys of Nebraska, which is a key parameter in the development of water resources management tools

Objectives

This project has three specific objectives: 1) Install groundwater observation wells in the Platte River valley to observe groundwater level fluctuations in response to evapotranspiration and changes in stream stages; 2) Develop a cross-sectional numerical model for simulation of groundwater interactions with surface hydrologic components; 3) Develop an inverse method that calculates the rate of groundwater evapotranspiration, as well as streambed conductance, using the observed water level data.

Results

Objective 1 – The Platte River valley between Grand Island and Kearney was selected as the study area for this project. Two groundwater wells were constructed. One is co-located with the USGS stream gauge on the Platte River near Kearney; the other is co-located with a weather station of the High Plains Regional Climate Center (HPRCC) at the Kearney Airport. Hourly groundwater level and temperatures have been collected from the two wells since May 2004. In the study area, we also constructed several groundwater monitoring wells from previous projects and we collaborated with the Central Platte Natural Resources District for long-term groundwater monitoring from additional seven wells. One of these wells is co-located with the USGS stream gauge on the Platte River near Grand Island; several other wells are under trees in the riparian zone. Nine groundwater wells, three weather stations (HPRCC), and two streamflow and two rain gauges (USGS) form a monitoring system of surface water and groundwater within the study area.

Long-term groundwater monitoring data from the Republican River valley were analyzed to determine the evapotranspiration rate. Figure 1 shows the diurnal fluctuations of the water table from two observation wells. Figure 2 shows daily evapotranspiration rate of groundwater at the two observation locations.

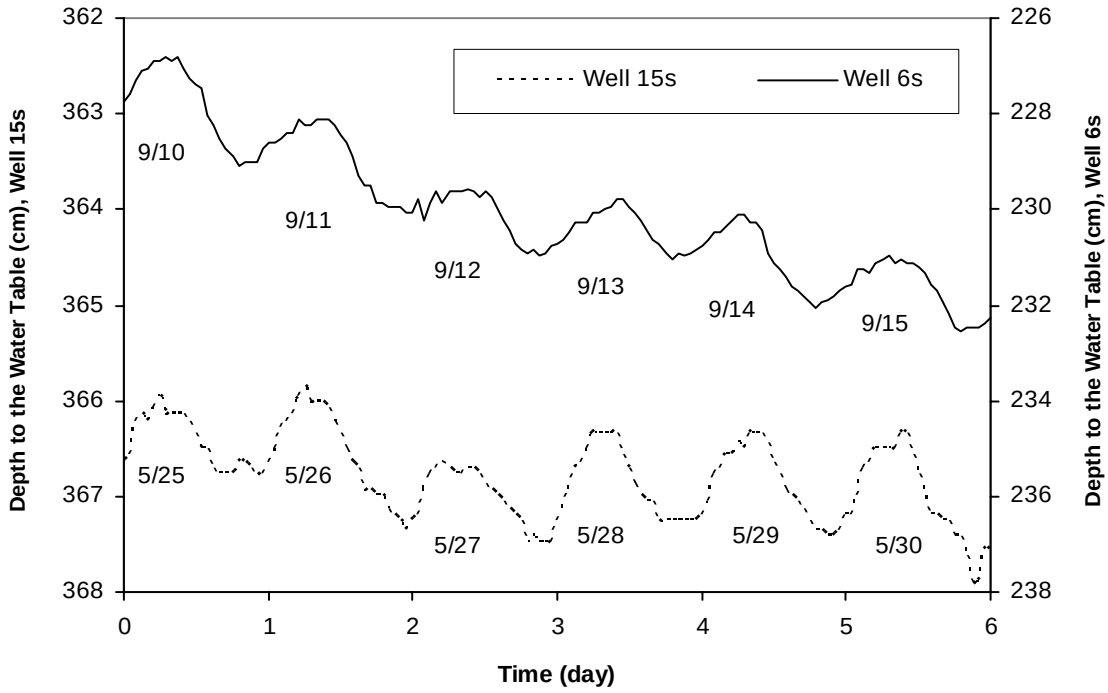

Fig. 1. Diurnal fluctuation of the water table (depth below the ground surface) with time (1999) observed at well 6s near the Republican River, Nebraska, USA and at well 15s near the Red Willow Creek, a tributary of the Republican River.

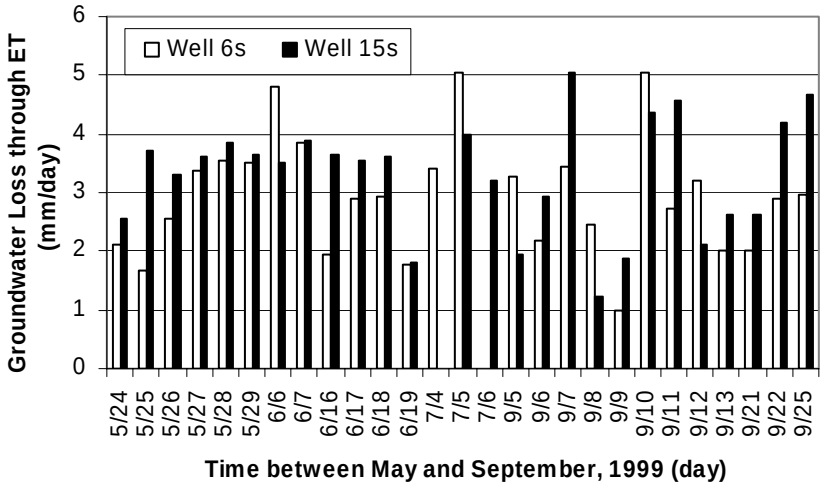

Fig. 2. Daily groundwater loss through evapotranspiration (ET) of the riparian vegetation in the Red Willow Creek and the Republican River valley, Nebraska.

Diurnal fluctuation of the water table was also observed from two monitoring wells in the riparian zone of the Platte River. The evapotranspiration rate was also estimated for the two locations.

Objective 2 – A groundwater flow model was developed to simulate the interactions between groundwater and surface water (stream stage, ET, and recharge). The model was developed based on the Garlerkin finite-element method and is able to model detailed flow systems over a vertical profile. This model has been used to simulate the stream-aquifer interactions based on the long-term monitoring data of groundwater levels and stream stages at the USGS gauge station near Kearney (station number 06770200) and Grand Island (station number 06770500).

Objective 3 – The cross-sectional groundwater model was coupled with the least squares methods for inverse calculation of aquifer and streambed hydraulic parameters. This method uses both stream stage and groundwater level data and inversely calculates several hydraulic parameters: vertical and horizontal hydraulic conductivities in the nearby aquifer, specific yield, and vertical hydraulic conductivity of streambed. We also conducted permeameter tests to determine vertical hydraulic conductivity of the shallow part of the channel sediments on the Platte River. The tests were conducted along two transects across the Platte River, one near Kearney and the other near Grand Island. The values of vertical hydraulic conductivity range from about 8 to 136 m/d across the river channel.

Student support

The grant has supported one Ph.D. student in hydrogeology.