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Spring Meeting: April 30, 2021
Virtual Meeting

Opening Remarks at 9 AM
Program Speakers/Topics:

9:15 AM — **Allen Wehrmann, PE, PH;** Riverbank Filtration: A Path to a Sustainable Supply in a Shallow Alluvial Setting

9:45 AM — **M. Jim Hendry;** Using Environmental Isotopes to Understand the Hydrogeology of Aquitards in the Prairies

10:15 AM — **Megan Brown, Ph.D;** Groundwater Changes During Prairie Restoration

10:45 AM — *Break*

11:00 AM — **William W. Simpkins;** Till Aquitards and Sustainability of Confined Aquifers in Minnesota

11:45 AM — Closing discussions

12:30 PM — Meeting Adjourned

Riverbank Filtration: A Path to a Sustainable Supply in a Shallow Alluvial Setting

Allen Wehrmann, PE, PH, Sr. Groundwater Engineer, Champaign, IL
Rhett Moore, PE, PH, Principal Hydrologist, Bloomington, IN
Jack Wittman, PhD, PH, CGWP, Vice President, Bloomington, IN
INTERA Incorporated

Beyond the Mahomet Aquifer, sources of groundwater in south-central Illinois are often limited to relatively shallow, thin unconsolidated deposits. Production rates from wells in these settings are limited by available drawdown. In the right setting, radial collector wells can provide an efficient method for producing high quality groundwater from relatively thin sand and gravel deposits. This presentation describes the results of a study performed to collect the data needed to estimate capacity and, under a short deadline, develop a conceptual design for a radial collector well to be constructed in a shallow outwash aquifer.

To characterize the hydraulic properties of the aquifer and the bed of the adjacent river, we conducted a field investigation at the site. Based on the field results, we developed a regional, two-dimensional, steady-state groundwater flow model to evaluate the relative performance of collector well designs with varying lateral numbers, lengths, and orientations. Alternate designs were evaluated based on model estimates of capacity, production per unit length of screen, and the setback distance from the creek required to maximize log-removal credits.

Using Environmental Isotopes to Understand the Hydrogeology of Aquitards in the Prairies

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Stable isotope analyses of porewater samples (δ18O and δ2H) can provide knowledge of the controls on solute transport as well as the timing of hydrogeologic events. Difficulties in collecting porewater samples, especially in clay-rich aquitards, have limited the application of δ18O and δ2H to defining transport mechanisms and timing of events. The recent development of vapor equilibration techniques for core samples coupled with laser analytical methods to determine δ18O and δ2H have allowed us to generate high-resolution profiles of these isotopes through aquitards (and aquifers) in a cost-effective manner. This presentation reviews the sampling and analytical methods used to generate these high-resolution profiles and provides examples that highlight the value of applying high-resolution profiling of δ18O and δ2H in conjunction with numerical transport modeling to define groundwater flow and solute transport mechanisms at both large and small scales using data collected at many sites across the Canadian prairies.

At the large scale (100's of meters in thickness), 1-D numerical transport modeling of high-resolution δ18O (every meter) profiles provides insights into large-scale/long-term solute transport through thick Cretaceous shale in the Williston Basin and in clay till deposits. These studies show that despite the potential for significant advective migration during glaciations, molecular diffusion is a dominant solute transport mechanism through these shales and tills. In the case of the shale profiles, the dominant palaeo-event is the introduction of glaciogenic meteoric water into aquifers underlying the shale during the Pleistocene, likely along an aquifer outcrop area or through local vertical conduits. In the case of thick clay till deposits, studies show that vertical transport is dominated by molecular diffusion and that the δ18O profiles developed over the Holocene. At the small scale (less than 10's of meters thick sediments located near ground surface), 1-D numerical transport modeling conducted on high-resolution δ18O profiles (every 0.3 m) provide insights into small-scale/short-term solute transport. Based on δ18O profiles measured across sand layers in these units, transport in the sand layers is shown to be dominated by lateral advection while transport in the fine-textured sediments is dominated by diffusion. Both large- and small-scale profiles show the unique value of applying this cost-effective equilibration-laser method to generate high-resolution δ18O and δ2H profiles in a range in hydrogeologic environments.

Groundwater Changes During Prairie Restoration

Megan R.M. Brown[1,3], Melissa Lenczewski[1,3], Kayla Koenig[2],
Philip Carpenter[1,3], Holly P. Jones[2,3], Nicholas A. Barber[4]

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A prairie grassland biodiversity experiment to determine the impact of plant community assembly processes on ecosystem functions will be conducted at the Northern Illinois Center for Community Sustainability (NICCS) location on Northern Illinois University's campus. Analogous to grassland restoration projects, an unused parcel of land will have prairie plots of varying plant species and trait composition planted in spring 2021. While groundwater quality and regional groundwater flow in prairie grasslands have been studied, the changes in groundwater during restoration has not been thoroughly investigated.

To address this topic, we have installed five monitoring wells with continuous soil cores and plan to install at least two more. Water levels and groundwater quality data have been collected since October 2020 in order to have background site data prior to planting. The monitoring well soil cores indicate that the site is primarily composed of diamicton and Tiskilwa Till. However, the monitoring well in the center of the site has a section of sand from approximately 8-12 feet below ground surface. Groundwater levels in the center well are noticeably different than the rest of the site.

Geophysical investigations were conducted at the site during the Geophysical Field Methods graduate level course at NIU. A north-south trending low-conductivity zone was indicated with the EM-31 in vertical dipole mode; this is consistent with a sand channel. Resistivity sounding and profiles also indicate a possible sand channel.

The monitoring wells will continue to be monitored during planting and the restoration experiments for water levels and water quality. Water quality measurements include dissolved oxygen, oxidation-reduction potential, electrical conductivity, pH, and temperature. The additional wells will be installed to target the inferred sand channel. In addition to the NIU weather station's one-second precipitation dataset, irrigation of the prairie plots will be measured to be included in the groundwater analysis.

Till Aquitards and Sustainability of Confined Aquifers in Minnesota

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Multiple glaciation events formed complex sequences of aquifers (e.g., outwash sand and gravel) and aquitards (e.g., till, lake sediment, and loess) in the Midwest. Many isolated confined aquifers in glacial terrain rely on a vertical flux of water (leakage) through overlying aquitards to maintain their sustainability; however, the process is poorly quantified. Through funding from the Legislative-Citizen Commission on Minnesota Resources in 2014, personnel from the U.S. Geological Survey, Iowa State University, Minnesota Geological Survey, and Minnesota Department of Health joined forces to investigate the variability of vertical groundwater flow through till aquitards and till hydraulic properties at five sites in Minnesota. Sites included till stratigraphic units within the late Wisconsin Des Moines (Litchfield sites [2]; New Ulm Fm.), Superior (Cromwell site; Aitkin and Cromwell Fms.), and Wadena (HFC site; Hewitt Fm.) glacial lobes, and a Pre-Illinoian unit (Olivia site; Good Thunder Fm.).

Till thickness ranged from 60 to 166 ft and core was obtained and described at each site by the Minnesota Geological Survey. Thirty-one small-diameter piezometers were installed in five nests, with screens set in surficial aquifers, till aquitards, and underlying confined aquifers. Downward hydraulic gradients of 0.04 to 0.56 were observed in till at four sites; one site showed a slight upward gradient. Till K values were estimated from slug tests (K_h) and aquifer tests in the confined aquifer (K_v). Geometric mean K_h ranged from 0.0002 to 0.07 ft/d – both values occurring in the New Ulm Fm till at the Litchfield sites, ½-mile apart. K_v from aquifer tests were within an order of magnitude of K_h. Vertical travel times through the till ranged from one to 913 years and Darcy calculations suggest vertical flux could sustain the aquifer at only one of the five sites. The till response to pumping the underlying aquifer varied among the sites. At three sites, water levels in the till declined with pumping in the aquifer, suggesting good vertical connectivity upward into the till, although the upward extent varied from 45 to 122 ft. Till at another site (Litchfield 2) showed no response to aquifer pumping. A poroelastic response, shown by brief, reverse water-level fluctuations (Noordbergum and Rhade), was observed in the till at three sites, one of which was entirely dominated by this response.

The results of this study suggest that till aquitards: (1) are heterogeneous with respect to hydraulic properties/responses, and (2) are leaky and affect the sustainability of confined aquifers. However, caution is advised when extrapolating these site-specific data to other sites.