

Shallow Ground-Water Flow and Mass Flux of Nitrogen and Phosphorus in the Big Ditch Watershed

Project Description

The objective is to estimate the amount of nitrogen (N) and phosphorus (P) contributed to Big Ditch, a tributary of the Sangamon River, by ground water. The surficial geology of the watershed was characterized by studying available literature and analyzing soil cores collected for the project. Monitoring wells were designed to sample shallow ground water near the top of the water table and ground water from deeper sand layers. Water levels in the wells are measured periodically and a ground-water flow model is being developed. Ground-water samples are being collected periodically and analyzed for N species and total P. The fluxes of N and P will be estimated by multiplying flow rates by N and P concentrations.

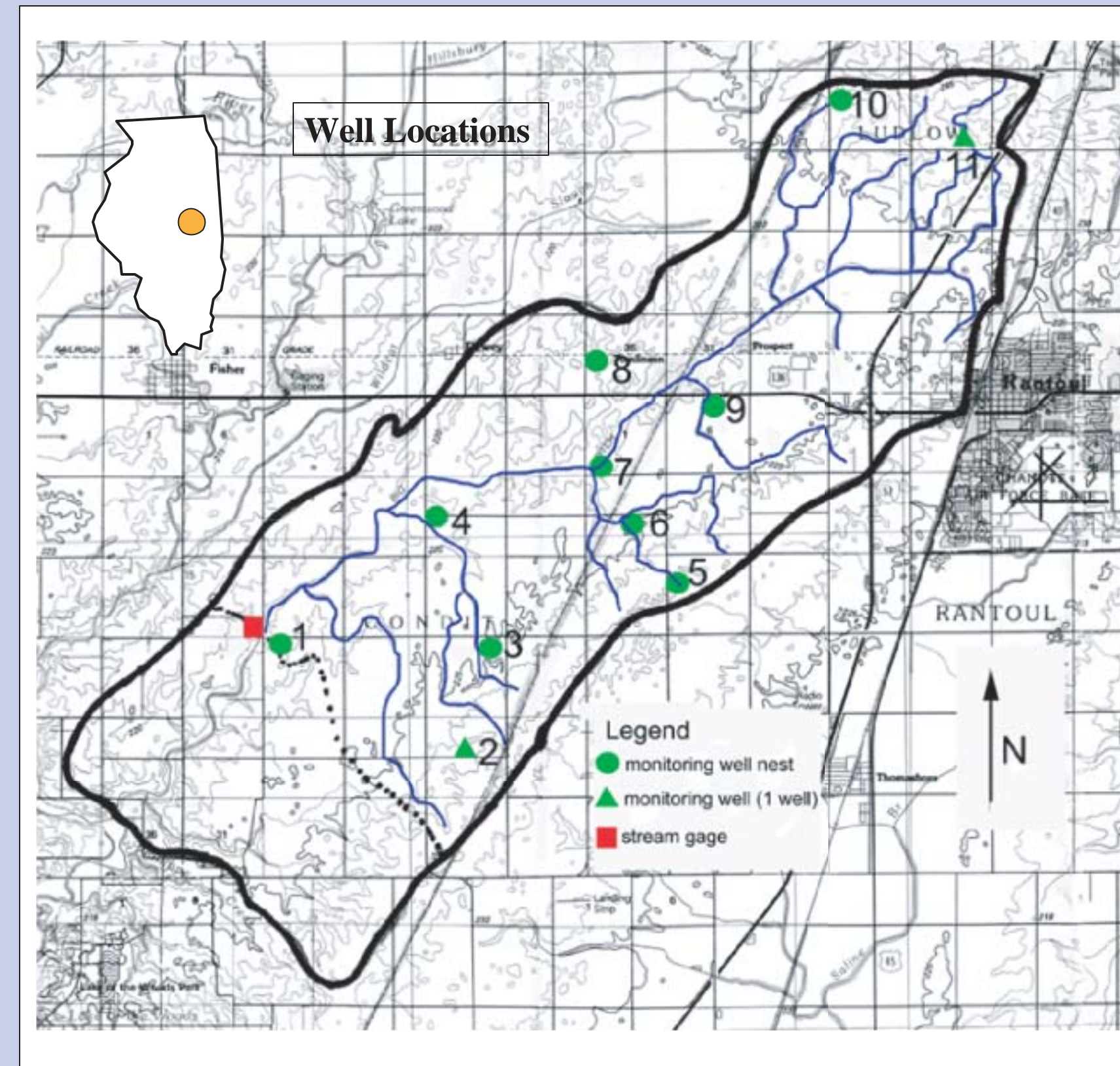
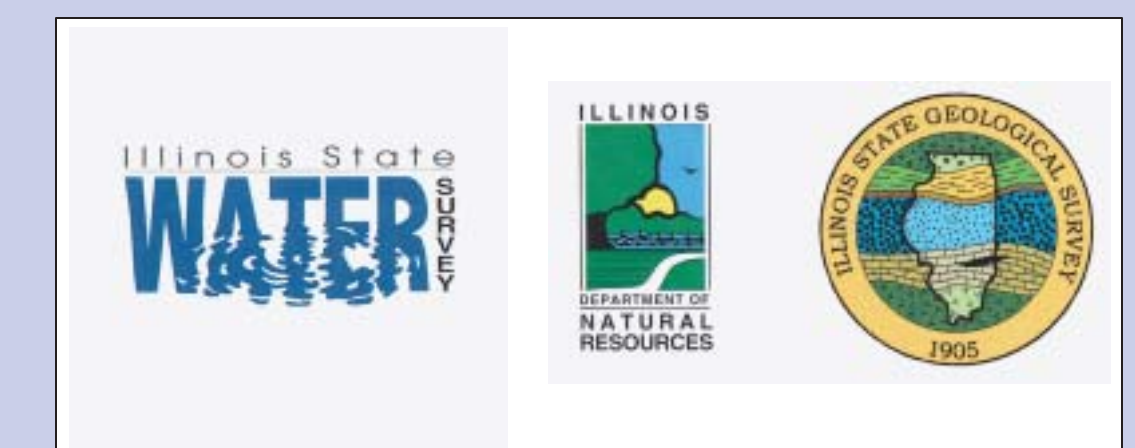
Description of the Study Area

The study area covers approximately 40 square miles and consists of the Big Ditch watershed east of CR700E, where the ISWS operates a stream gauge. Land use is predominantly agricultural (corn and soybeans) with some rural residences and industry. Soil associations are mapped as, from the southwest to the northeast, Elliott-Ashkum, Drummer-Raub, Dana-Par-Drummer, Drummer-Elburn-Brenton, and Varna-Elliott-Ashkum. The soils are mapped as silt loam, silty clay loam, and clay loam. Most farm fields in the watershed are tile drained. The tile drains contribute most of the water flow to Big Ditch.



Big Ditch at Site 9. A tile drain is shown in the lower-middle part of the picture. The picture was taken in mid-summer when there was little drainage from the tiles.

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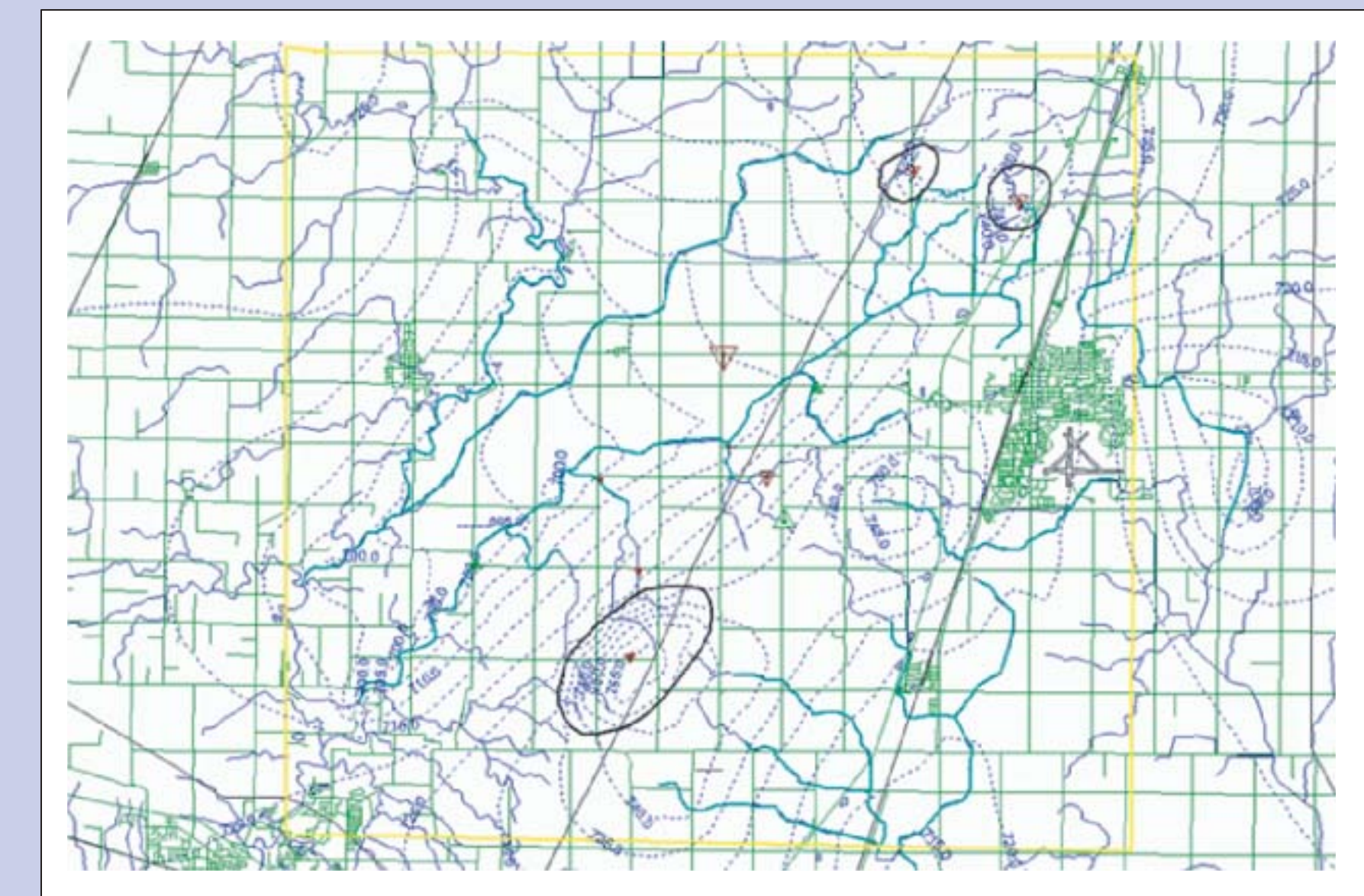
Preliminary Ground-Water Model

Shallow groundwater flow in the Big Ditch watershed was modeled using GFLOW 2000 (Haitjema, 1995). By including areas of lower K (areas outlined in black), we were able to improve the match between modeled and observed heads. The differences in heads are represented by triangles. Larger triangles represent larger differences. Upward triangles indicate that the modeled heads are higher than the observed heads.

The hydraulic conductivity estimated by modeling was 350 ft/day or 0.12 cm/sec, which greatly exceeds the maximum K (4.4×10^{-3} cm/sec) determined by slug tests. This difference likely reflects the presence of tile drains used to drain agricultural soils.

Case 2, Inhomogenities included The parameters employed above are:

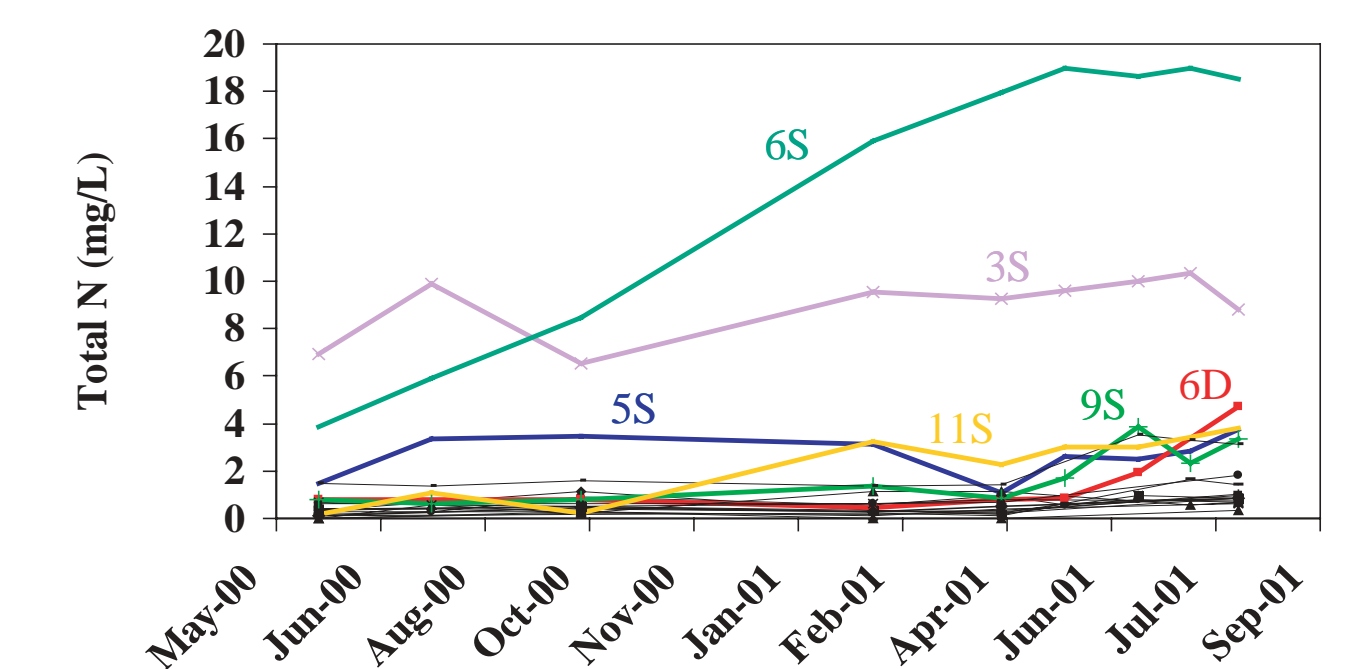
Aquifer type	semiconfined
Aquifer thickness	15 ft
Base elevation	695 ft
Hydraulic Conductivity	350 ft/day
Porosity	0.2
Recharge rate	0.0007 ft/day (2.628 in/yr)



METHODS

Twenty monitoring wells have been installed at eleven sites across the watershed, including 11 shallow wells to monitor the water table (~12 feet below surface), and 9 wells to monitor the ground water of deeper sand and gravel layers (up to 50 feet). Water levels are measured at regular intervals, at least once every 2 weeks. Continuous water-level recorders have been installed in 8 wells. Slug tests will be conducted to determine aquifer properties. Ground-water/surface water interactions of the Big Ditch will be characterized by baseflow separation calculations and by field experiments such as determining hydraulic gradients with a potentiometer. A ground-water flow model is being developed.

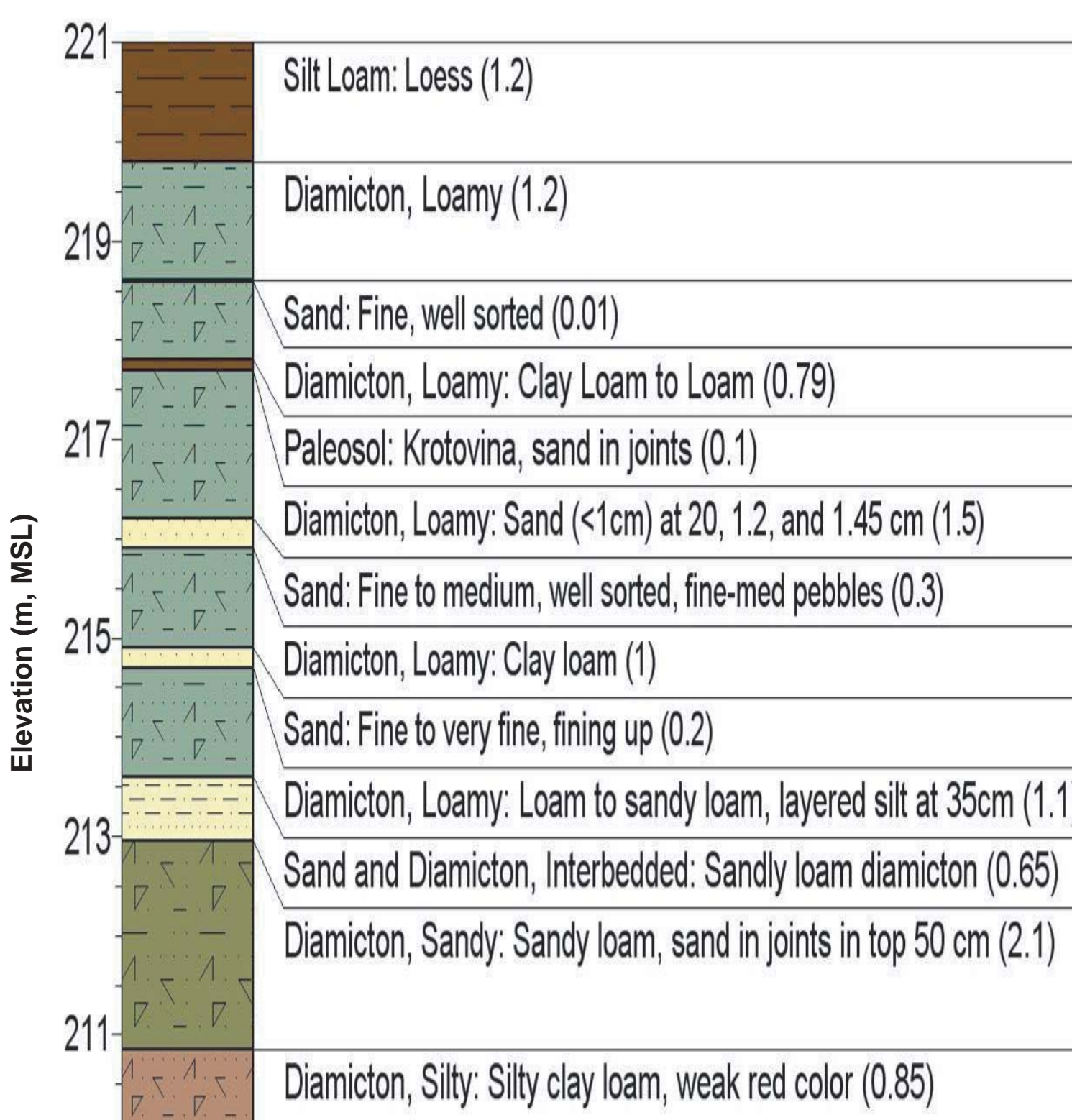
Water samples are being collected from the wells and analyzed for nitrate, ammonia, total Kjeldahl nitrogen, total phosphorus, and nonvolatile organic carbon. Temperature, pH, conductivity, and dissolved oxygen are determined when samples are collected. The analytical results will be combined with the flow model to estimate the fluxes of N and P from the shallow aquifer system to the Big Ditch.



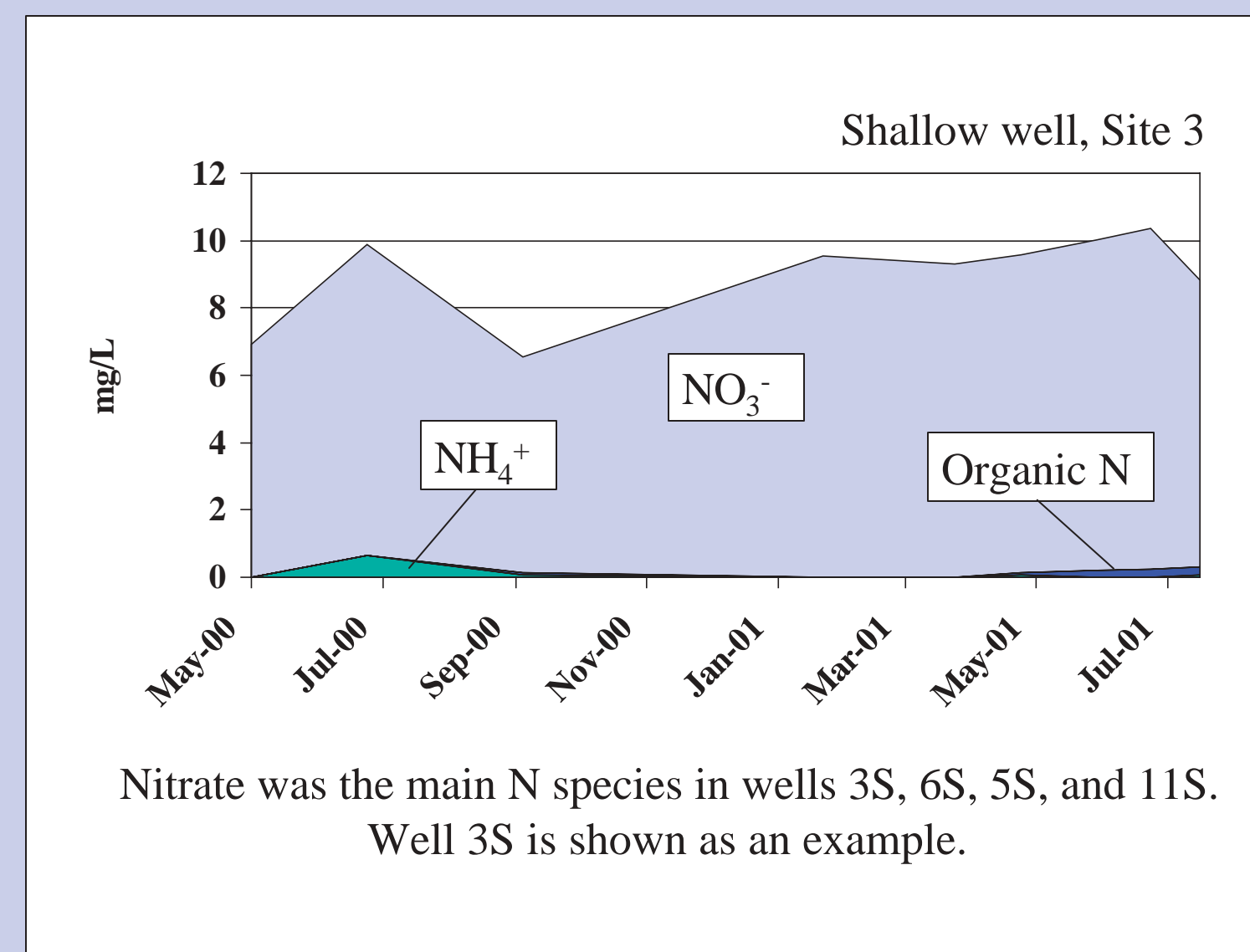
Total N was less than 1 mg/L in most of the wells. It was between 4 and 19 mg/L in two wells and between 2 and 4 mg/L in two others. (S = shallow, D = deep)

Geologic Setting of the Big Ditch Watershed

- Watershed is predominantly intermorainal landscape, but includes portions of the Rantoul moraine to the S-SE and the Illiana morainic system to the NE.
- The intermorainal area of the watershed ranges in elevation between 212 and 223 meters MSL. The Illiana morainic system within the watershed is typically about 235 meters MSL. In the northern-most end of the watershed, the land surface elevation peaks at nearly 250 meters MSL. The crest of the Rantoul moraine is typically between 235 and 240 meters MSL.
- Four different glacial tills were identified in the shallow subsurface. Jointing and fracturing of the tills was commonly observed and will likely have a large impact on ground-water flow and chemical transport.
- Sands and silty sediments were typically encountered in 1.0-1.6 meter zones with thin interbeds of glacial till. The average grain size and degree of sorting within these sands was highly variable.
- The shallow ground-water flow system will be significantly affected by the lateral continuity and uniformity of texture in these shallow sand deposits, and by joints and fractures in the fine-grained sediments.
- A buried soil (paleosol) was encountered in the upper 3.1 meters of several boreholes. The relatively high organic matter content of this horizon, compared to the bounding glacial deposits, may lead to increased denitrification. Local variability in the presence and thickness of this paleosol and the presence and magnitude of preferential flow through any fractures it might contain will affect the fate of nitrate within this horizon.



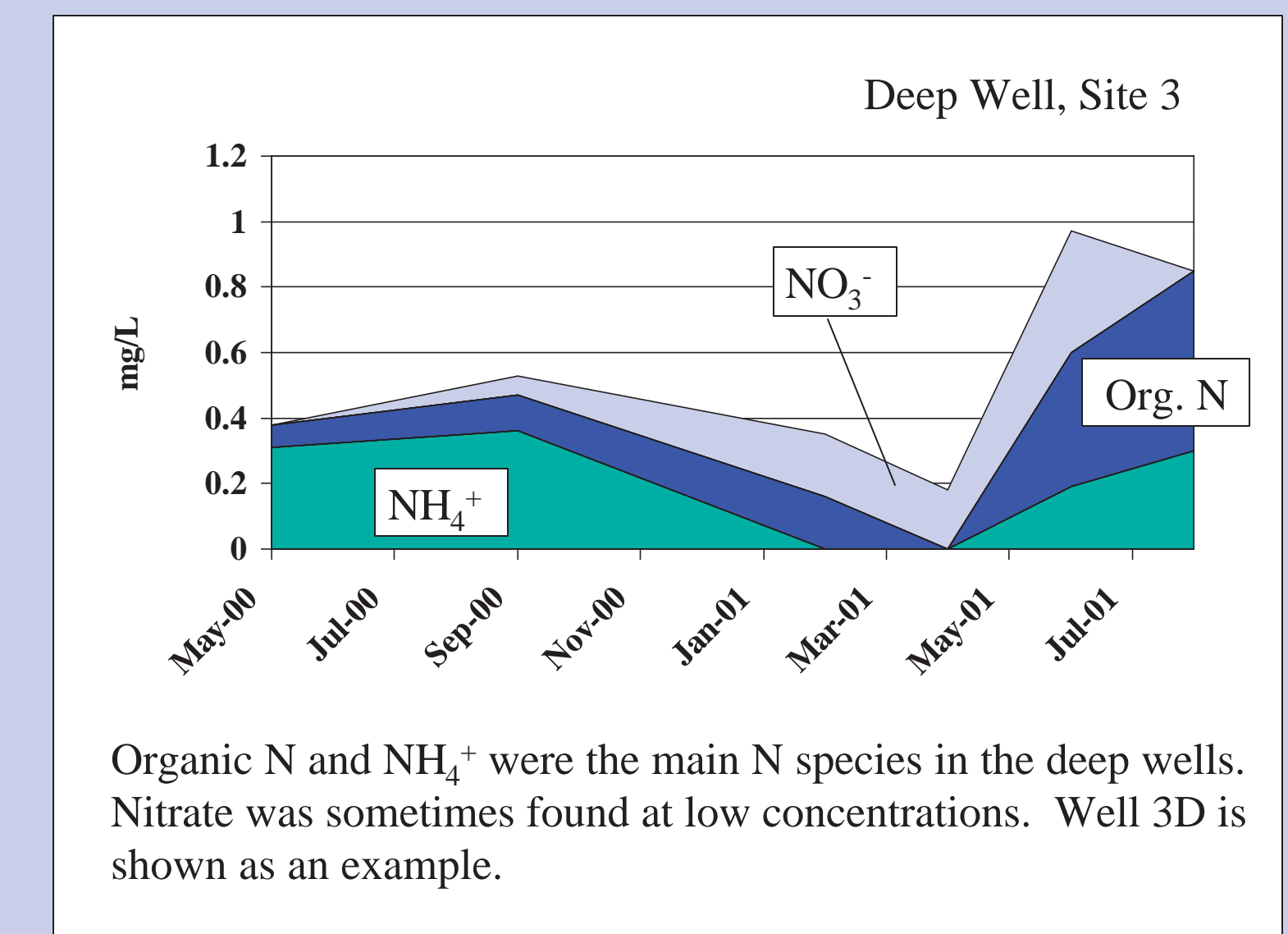
Soil boring log from a location northeast of Site 8. The numbers in parentheses indicate layer thickness (m). There are sand layers (yellow) which we believe conduct most of the ground water at the site. Two wells were installed at this site to monitor the water levels and sample water from these sand layers.



Nitrate was the main N species in wells 3S, 6S, 5S, and 11S. Well 3S is shown as an example.

Plans for Further Work

- Continue monitoring water levels and water chemistry
- Continue to develop the ground-water flow model
- Estimate ground-water flux using potentiometer



Organic N and NH_4^+ were the main N species in the deep wells. Nitrate was sometimes found at low concentrations. Well 3D is shown as an example.

Acknowledgement

This research was sponsored by the Illinois Council on Food and Agricultural Research through the Water Quality Strategic Research Initiative (WQ-SRI). The goal of the WQ-SRI is to characterize the mass balance of nutrients (N and P) in the watershed. The Illinois State Water Survey (ISWS) and Illinois State Geological Survey are determining components of the mass balance for the shallow groundwater. Researchers from the ISWS and UI College of Agriculture, Consumer and Environmental Sciences are determining the other components (tile drainage, atmospheric deposition, fertilizer application, surface water flux, ...).

