MGPUB2016297 INTERIM REPORT-Year5

Monitoring Field Level Groundwater Quality in the Upper Chester Watershed

Grant Recipient: U.S. Geological Survey

Short Summary of Project

Changes in water quality associated with improved conservation practices will be seen first in shallow groundwater directly beneath fields. Monitoring of shallow groundwater, therefore, is needed to better understand the water-quality response of recent (<20 years) conservation efforts and the lag time between changes in shallow groundwater and the expression of those changes in stream quality. To address this, the goals/objectives of this research are to 1) evaluate the effectiveness of a selected conservation practice (irrigation) in reducing nitrate concentrations in shallow groundwater (Grain Producers) and 2) provide a better understanding of the transport and fate of nitrate in shallow groundwater in an agricultural setting (Soybean Board).

This field-scale research is unique in that it combines agronomic mass balances directly to their effects on nitrate transport to shallow groundwater. Initial agronomic mass balance data collected from the 2014 corn crop indicate that irrigated cropland was more efficient at utilizing nitrogen than dryland. However, there was an observed difference in nitrate and conservative anion (chloride) transport to groundwater. More data is needed to better understand how the difference in agronomic benefit is related to the difference in soil zone nitrate transport. Data is currently being analyzed for the 2016 corn crop to add to this finding.

The following sections describe data-collection activities for the past year (December 2015-November 2016) and results of recent data analysis. Soybeans were grown in 2015 and corn was grown in 2016.

Data Collection

Groundwater and soil samples were collected from both study fields in the spring prior to nutrient application and in the fall after harvest, as in prior years of the study. Samples were collected in December, 2015; March, 2016; and November, 2016. Groundwater samples were analyzed for nutrients and major ions at the USGS National Water-Quality Laboratory in Denver, Colorado. Field parameters, including specific conductivity, pH, dissolved oxygen, alkalinity, and water temperature were also measured for each sample. Soil samples were collected at intervals from the land surface to a depth of 3 ft adjacent to each well. Samples were sent to the USDA Agricultural Research Service Laboratory in State College, Pennsylvania, for analysis of Total Kjeldahl Nitrogen (TKN).

Soil-water samples were collected after significant rainfall through February, 2016 using suction lysimeters at depths of 1 ft (to represent the root zone) and 3 ft (to represent water leaving the root zone) to study the effects of the soybean crop on soil water. Specific conductivity was measured for each sample, and, if sample volume was sufficient, nutrients and major ions also were analyzed.

Groundwater levels were monitored continuously in two wells on each field through March 2016. Discreet water-levels were collected from the remainder of the wells in conjunction with sampling events.

Whole corn plants were sampled shortly before harvest by University of Delaware extension staff. Plants were dried to a consistent mass before processing and analysis at the UD soil test lab. (Note: these data have not yet been returned from the lab.)

Results

Soil TKN Profiles

Analytical results from soil analysis show that the dryland field had slightly higher mean TKN than the irrigated field (table1). There is a wide variation in TKN between individual sample locations on each field (fig. 1). Overall, the dryland field shows little variation in mean TKN at depth over time and less variation than the irrigated field over time. In the irrigated field, after two years of irrigation, concentrations of TKN at depth were somewhat higher than fall concentrations. This may indicate more leaching from the surface, but, because of the variation in different samples, the difference may not be significant. More time is needed to determine the effects of irrigation on soil nutrient transport at this site.

Table 1. Mean TKN (mg/kg) concentrations in soil samples collected from fall 2014 to spring 2016 from the dryland and irrigated fields.

		Depth (in)				
Field	0-2	2-6	6-12	12-24	24-36	sample n
DRY	848	545	292	210	112	164
IRR	799	537	277	175	101	171

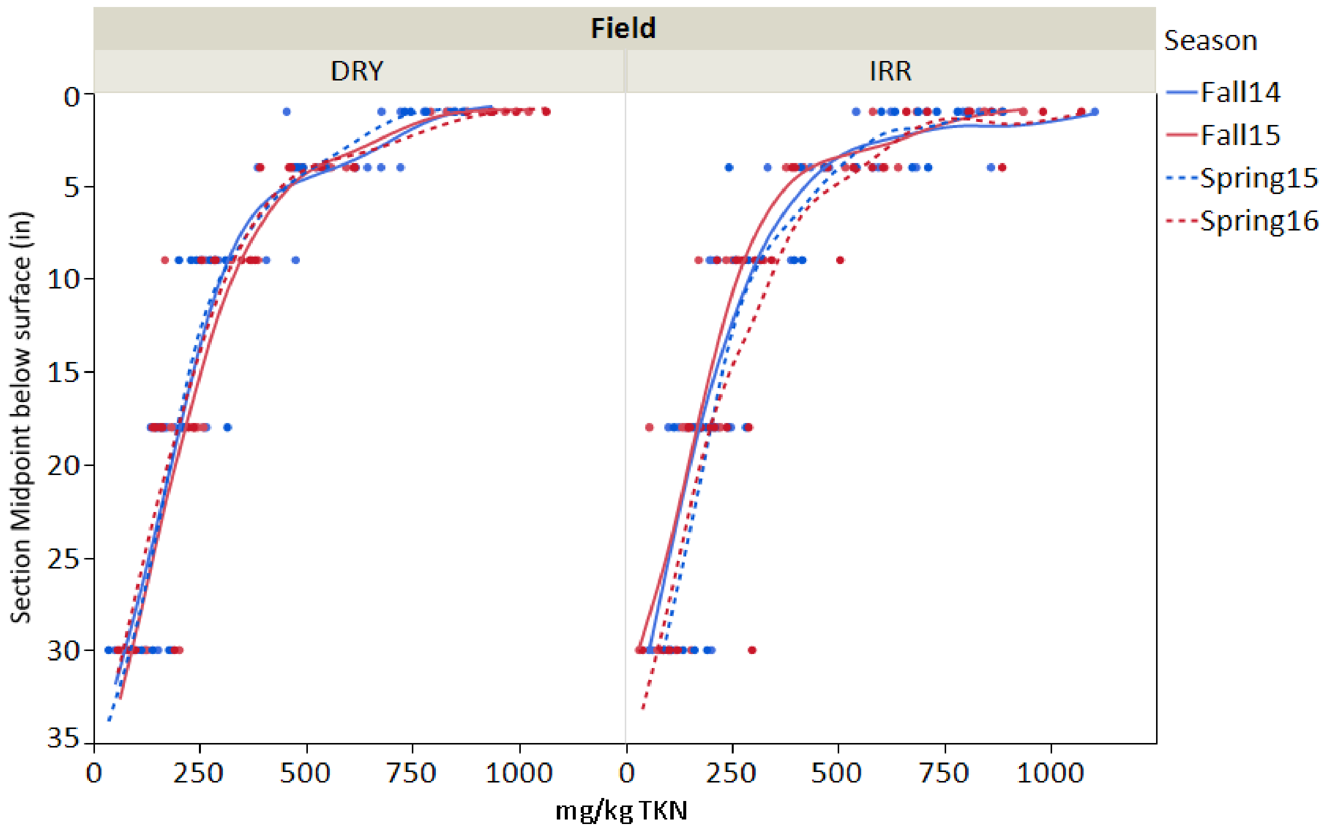


Figure 1. Soil TKN concentrations with depth from fall 2014 to spring 2016 sample collection beneath the dryland and irrigated fields. Sample points show concentration from sample points adjacent to all well sites. Lines represent mean for one sample event.

Lysimeter and Shallow Groundwater Data

Suction lysimeters were sampled in both fields after significant rainfall. Lysimeter data collected in 2014 when corn was grown show higher specific conductance and concentrations of nitrate after rainfall during and after the growing season in both the irrigated and the dryland fields (fig. 2). Recovery of water from lysimeters was much greater under the irrigated field than the dryland field, especially during the growing season when irrigation was occurring. Higher concentrations in water collected from the 3 ft depth indicate chemical movement below the root-uptake zone. Higher concentrations and greater recovery of water from the irrigated field indicates a greater leaching potential under that field than under the dryland field. There is no immediate response to these higher concentrations observed in groundwater from leaching of these higher levels of nitrate. This was the first year of irrigation at this site and long-term effects of differences in recharge water cannot be determined from one year.

Soybeans were grown in 2015 and lysimeter sampling began after the growing season as the crop dried prior to harvest. Similar specific conductance and nitrate concentrations were observed in lysimeters from both fields, with concentrations close to those in shallow groundwater (fig. 2).

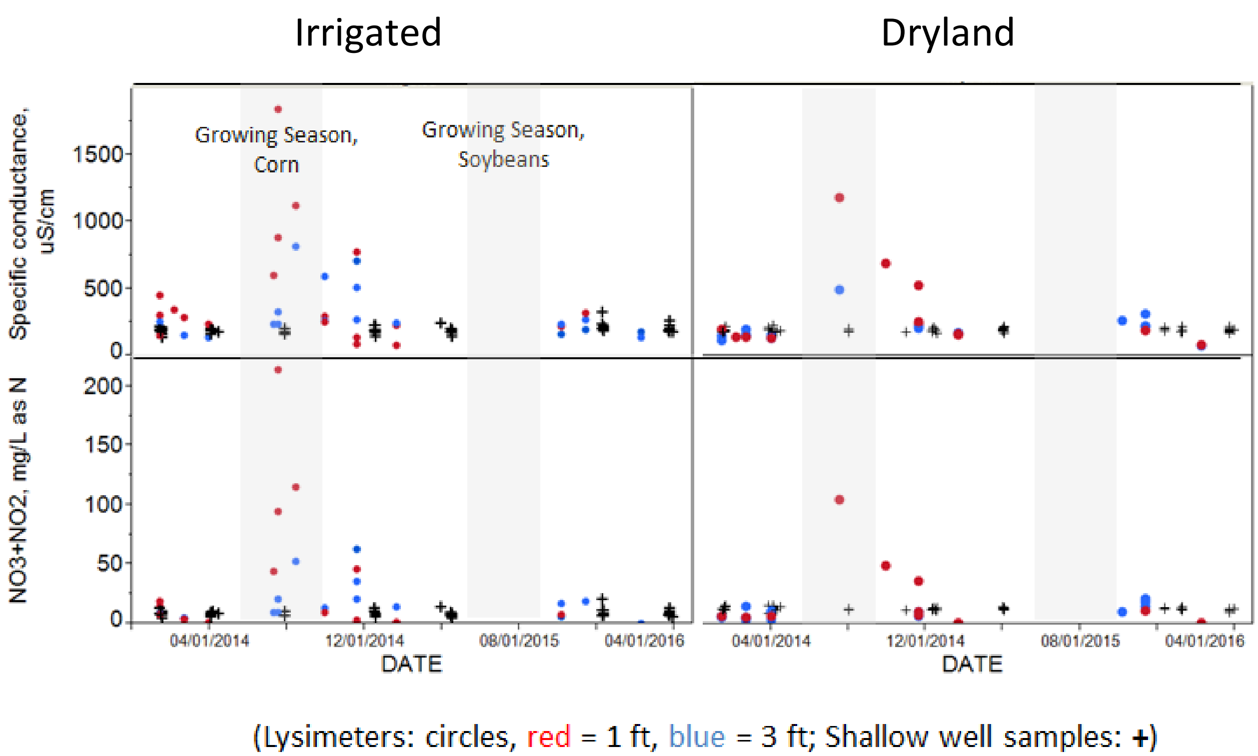
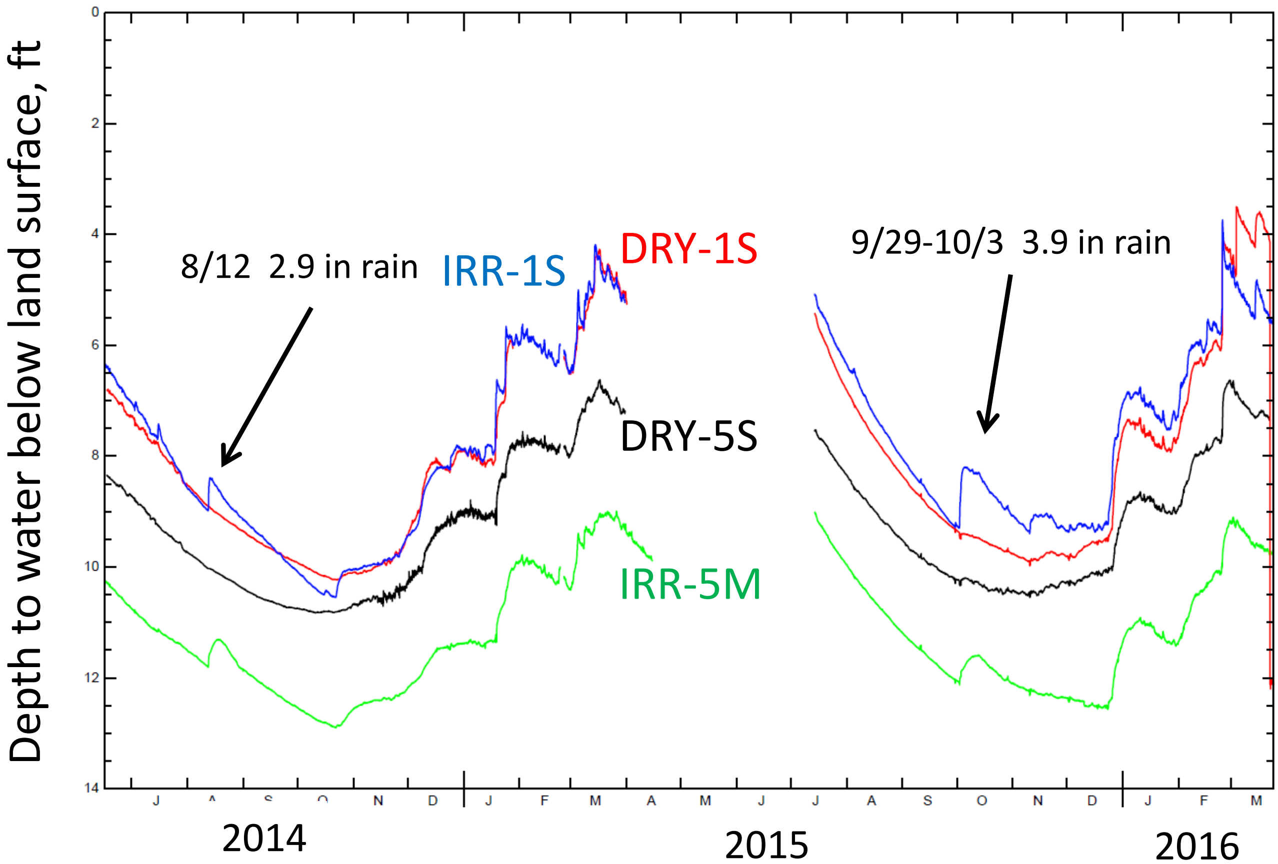


Figure 2. Nitrate/Nitrite and specific conductance data from Shallow (red), deep (blue) lysimeter data and shallow groundwater well data (black crosses) are shown overtime from the irrigated and dryland fields of the Andover field site.

Groundwater Recharge

Continuous water levels were collected in two wells on each field (fig. 3). Recharge to the groundwater system is shown by decreases in the depth to water below land surface. Most recharge occurs in cooler parts of the year when light and plant uptake of water (evapotranspiration) is low. The water table generally declines over the growing season. Exceptions to this pattern were seen beneath the irrigated field when large storms caused recharge to the water table during the period when soil water content was influenced by irrigation. Heavy rainfall under these conditions can cause nutrients to leach more readily. The dryland field did not see an increase in the water table after growing season storms, indicating less movement of chemicals past the root zone.



Irrigated field: IRR-1S, IRR-5S; Dryland field: DRY-1S, DRY-5S

Figure 3. Depth to water below land surface beneath the irrigated and dryland fields. Overall, depth to water is least in the center of the fields (IRR-1S, DRY-1S) and greater near the hillslope into the riparian zone (IRR-5S, DRY-5S). Recharge to the water table causes the depth to water table to decrease (become shallower).

Trends in Groundwater

Shallow groundwater samples were collected before and after the main growing seasons (fig. 4). The first sample collected in April 2014 occurred before implementation of irrigation at the site. Subsequent groundwater samples showed no apparent difference in either specific conductance or nitrate/nitrate concentrations. However, chloride under the irrigated field shows increasing mean values and variability over time. As a conservative, non-reactive parameter, chloride is suspected to move through the soil matrix without transformation or metabolism. As field management was the same over the two year period, changes in chloride may indicate an impact of irrigation. Due to variability in sample concentration, two years of data are insufficient to determine if irrigation has in fact raised chloride transport to groundwater or to observe trends in nitrate concentrations.

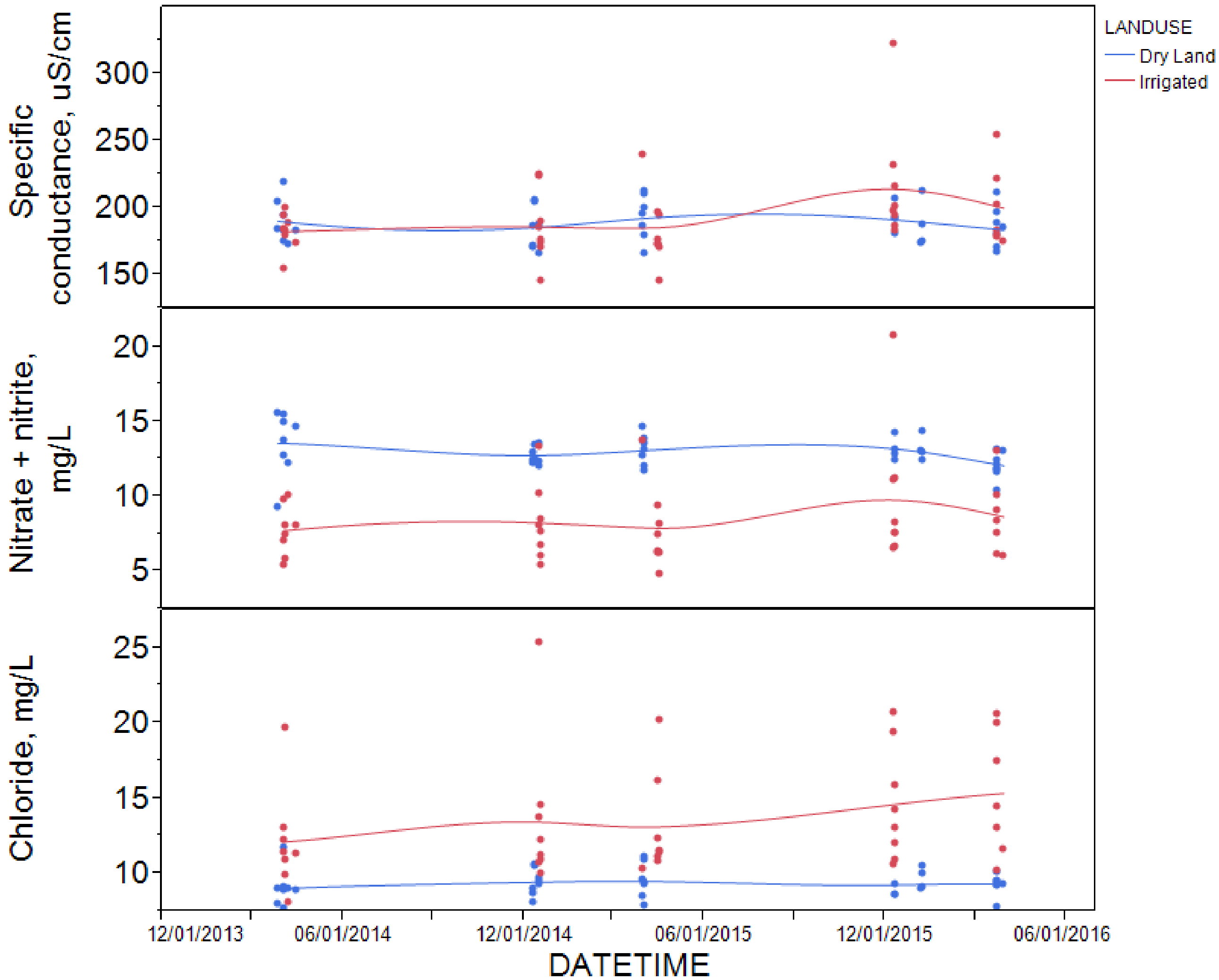


Figure 4. Specific conductance, nitrate/nitrite and chloride data from shallow groundwater wells over time for the dryland (blue) and irrigated (red) fields at the Andover site.

Summary

Soil and water sampling has been conducted on adjacent irrigated and dryland fields in the Upper Chester River Basin for over three years. The sample period includes the implementation of an irrigation system on one field in 2014, while the other field remains rainfed. Soil samples indicate no significant difference in total Kjeldahl nitrogen between the two fields; however, the irrigated field shows greater variability between growing seasons. Within growing seasons shallow soil water concentrations of nitrate were elevated around primary fertilizer application periods (June). More soil water samples were attained under the irrigated field than the dryland field. Recharge to the water table occurred during the corn growing season under the irrigated field, but not the dryland field. It is not yet evident how the additional high-nitrate recharge during the growing season affects groundwater quality beneath the irrigated field. Specific conductance values in shallow groundwater samples were similar between fields over the study period. Shallow groundwater concentrations of nitrate/nitrite and were higher under the dryland field prior to study inception and remained higher through present sampling. Chloride concentrations in shallow groundwater remained constant under the dryland field but were highly variable under the irrigated field and appear to have increased over time. As a smaller, more conservative anion, chloride may be the first to respond to changes induced by irrigation. Data from two years of sampling are insufficient to determine a difference in groundwater nitrate concentrations related to irrigation. Post-growing season results from the third year of sampling during irrigation are not yet available. Data from additional growing seasons is needed at this site to determine irrigation effects on water quality.