

## Session H5: Understanding Nutrients: Groundwater/Surface Water Interactions

Room C123  
8:00 – 9:30 am

**0028**  
**H5-1**

### Hydrologic and Geochemical Factors Influencing Stream Vulnerability to Legacy Nutrients

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Groundwater age and water chemistry data along flow paths from recharge areas to streams at 20 sites were used to evaluate the trends and transformations of agricultural chemicals. Results from this analysis indicate that median nitrate recharge concentrations in these agricultural areas have increased markedly over the last 50 years from 4 mg N/L in samples collected prior to 1983 to 7.5 mg N/L in samples collected since 1983. The effect that nitrate accumulation in shallow aquifers will have on stream ecosystems will depend on the rate of redox reactions along flow paths and on the age distribution of nitrate discharging to streams.

Nutrient and redox chemistry and groundwater age data were examined in various environmental compartments (*e.g.*, stream, streambed, tile drains, upland groundwater) in watersheds having a range of base flow index (BFI) values to determine the age and pathways of nutrient inputs to streams. Base flow index is the ratio of base flow to total stream flow volume. Redox reaction rates in groundwater and hydrology influenced nutrient pathways to streams. For example, aquifers with low dissolved oxygen reduction rates resulted in groundwater that remained oxic from recharge to discharge. In these oxic, high BFI watersheds, orthophosphate concentrations in streams were low due to sorption to oxides prior to discharge and minimal overland sediment transport. In contrast, nitrate concentrations in these streams were high because groundwater denitrification was inhibited by oxic conditions. Groundwater was the dominant source of nitrate in these streams, with inflows often more than 25 years old. These legacy sources of nutrients have important implications for assessing time lags between when changes in land use practices occur and when effects from these changes are observed.

**0061**  
**H5-2**

### Nitrate Trends in the Mississippi River and its Tributaries: Evidence of Groundwater/Surface Water Interaction

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Changes in nitrate concentration and flux between 1980 and 2008 at eight sites in the Mississippi River basin were determined using a new statistical method that accommodates evolving nitrate behavior over time and produces flow-normalized estimates of nitrate concentration and flux that are independent of random variations in streamflow. The results show that little consistent progress has been made in reducing riverine nitrate since 1980, and that flow-normalized concentration and flux are increasing in some areas. Flow-normalized nitrate concentration and flux increased between 9 and 76 percent at four sites on the Mississippi River and a tributary site on the Missouri River, but changed very little at tributary sites on the Ohio, Iowa, and Illinois Rivers. Increases in flow-normalized concentration and flux at the Mississippi River at Clinton, Iowa, and the Missouri River at Hermann, Missouri, were more than three times larger than at any other site. The increases at these two sites contributed much of the 9 percent increase in flow-normalized nitrate flux leaving the Mississippi River basin and entering the Gulf of Mexico. At most sites, concentrations increased more at low and moderate streamflows than at high streamflows, suggesting that increasing groundwater concentrations are having an effect on river concentrations. Significant correlations were observed between lagged fertilizer use and flow-normalized flux and concentration at most sites, suggesting that there is a lag between changes in fertilizer use on the land surface and changes in riverine nitrate at these sites. The length of the lag varied among sites from 0 to 12 years. Because of these lags, the full effect of any changes on the land surface may not be seen in these rivers for many years.

**0195**  
**H5-3**

### Nutrient Loads and Concentrations in the Nation's Streams during Base Flow

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An analysis of the loads and concentrations of nitrogen and phosphorus in selected streams nationwide indicates that the contribution of nutrients to streams by groundwater is an important process that warrants consideration in nutrient management strategies. Available streamflow and nutrient data collected from 1990 through 2009 at 153 sites across the nation were used to determine base flow nutrient loads. Base flow index (BFI, the ratio of base flow to total flow) for these sites has a median of 0.45, and ranges from 0.04 to 0.98. The distribution of nitrate load ratios (the ratio of base flow load to total flow load) is very similar to that of BFI, ranging from 0.04 (sites where surface transport processes are dominant) to 0.98 (sites where groundwater or in-stream process are dominant) with a median of 0.44. The median orthophosphate load ratio is 0.29, lower than that of nitrate. Landscapes with impermeable soils and bedrock have statistically lower BFI and nitrate load ratios. Orthophosphate loads ratios also tend to be lower in these same landscapes, although the contrast is not as large. A general positive correspondence between orthophosphate and nitrate load ratios is seen among many of the study sites. Base flow loading is often greater for nitrate than for orthophosphate. Base flow nutrient concentrations are generally greater in areas of greater non-point source nutrient inputs with the relation for nitrate statistically stronger than for orthophosphate. Areas with lower base flow load ratios could be more responsive to nutrient management strategies designed to reduce transport to streams by runoff. Conversely, in areas with high base flow ratios, improvements in water quality due to remedial measures may not be apparent for years to decades due to the slow rate of groundwater flow. Even where base flow contributions of nutrients are relatively low, nutrient transport by groundwater to streams can occur during ecologically sensitive low-flow periods. Mean annual base flow concentrations exceeded proposed USEPA nutrient criteria at 58 percent of sites for nitrate and 30 percent of sites for orthophosphate, showing that groundwater contributions of nutrients are important for the ecological health of streams.

0327

H5-4

#### Surface Water and Groundwater Interaction and Processes Affecting Nitrogen Speciation in a Karst Aquifer

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The Barton Springs segment of the karstic Edwards aquifer, in central Texas, is in an area undergoing rapid growth in population, and there is concern as to how increased amounts of wastewater might affect groundwater quality. We measured concentrations and estimated loads of nitrogen (N) species in recharge to and discharge from the Barton Springs segment to evaluate processes affecting the transport and fate of N species in groundwater. Water samples were collected during November 2008-March 2010 from five streams that contribute about 85% of recharge to the aquifer segment and from Barton Springs, the principal point of discharge from the segment. Meteorological conditions during the sampling period ranged from exceptional drought to above-normal rainfall. Samples were analyzed for N species and loads of organic N and nitrate were estimated with a regression-based model.

Concentrations of organic nitrogen and dissolved oxygen were higher and concentrations of nitrate were lower in surface water than in spring discharge, consistent with conversion of organic nitrogen to nitrate and consumption of dissolved oxygen in the aquifer. The total average N load in recharge from streams and discharge from Barton Springs, however, was not significantly different (mean monthly loads (mml) of 162 and 157 kg/d, respectively), indicating that surface-water recharge can account for all of the N in Barton Springs discharge. Differences in the timing of recharge and discharge of loads were marked: During the drought period, loads of total N in recharge from streams (mml 2.4 kg/d) were much less than those in Barton Springs discharge (mml 70 kg/d), and during the wet period those in recharge from streams exceeded those in Barton Springs discharge (mml of 395 and 282 kg/d, respectively). This indicates that total N entering the aquifer during periods of high recharge likely goes into groundwater storage, then discharges gradually as water-level altitudes in the aquifer decrease.