

# NITROGEN CHEMISTRY IN THE UPPER FLORIDAN AQUIFER IN WELLS ON THE ICHAUWAY ECOLOGICAL RESERVE, NEWTON, GEORGIA

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**Abstract.** Between May 2001 and May 2002, water chemistry was measured in groundwater at four well sites on the Ichauway Ecological Reserve. Water samples were collected weekly from the wells and analyzed in the Jones Ecological Research Center analytical laboratory for a suite of inorganic constituents. Well 1 was the only well that regularly contained measurable levels of ammonium-N that ranged from 0 to 21 $\mu$ g/l. Well 1 was also found to have elevated levels of nitrate-N that were about 2-4-fold higher than at the other well sites. Well 2 showed an increase in nitrate-N during the period of study while well 3 showed a decrease. In addition, chloride concentrations were found to be higher in well 1 than the other wells. Overall, ambient water chemistry reflects a portion of the Upper Floridan Aquifer that is minimally impacted by human activities. Wells 2-4 have near historic background concentrations of nitrate-N, and are relatively unaffected by nitrate-N contamination. However, levels of nitrate-N in well 1 are above historic background values suggesting some impact of human activities on nitrogen chemistry in this portion of the aquifer. Further studies are needed to determine the source(s) of elevated nitrates (intensive livestock production, widespread application of nitrogen fertilizers, or wetland depressions), and whether relatively pristine portions of the Upper Floridan aquifer, such as those found underneath the Ichauway Ecological Reserve, will experience higher levels of contamination in the future.

## INTRODUCTION

Over the past few decades water quality has become an increasingly important concern in the Upper Floridan aquifer system. Nitrates and ammonium are two constituents of particular concern because concentrations are increasing in many of the regions groundwater wells and natural springs (e.g. Katz et al., 1999). Nitrates are an essential component of aquatic ecosystems, but when present in water in high

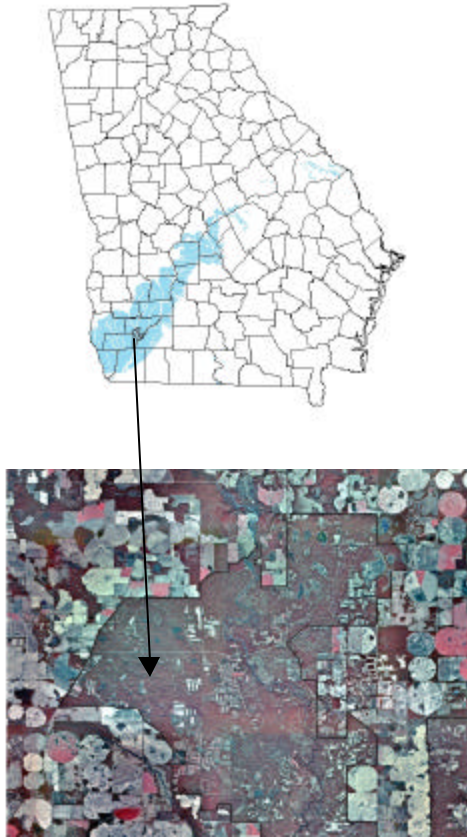
concentrations there are deleterious effects on both human health and ecosystem function. High concentrations of nitrates have been found to be toxic to humans and other animals (Frick et al. 1998). When ingested in levels above 10 mg/l, nitrates can cause methemoglobinemia, a blood disorder that affects infants. Furthermore, high nitrates often correlate to other contaminants, such as microbial pathogens and pesticides (Driscoll, 1986).

Sources of elevated nitrates in groundwater vary regionally, but elevated concentrations in the Flint River Basin are attributed primarily to animal wastes, fertilizers, and atmospheric deposition, all of which have increased dramatically since the 1950's (e.g. Katz et al. 1999). Further studies are needed to determine the causes of elevated nitrates and to develop strategies to deter further contamination.

The purpose of this study is to discuss the differences in water chemistry found in four reference wells on the Ichauway Ecological Reserve. The magnitude of differences in nitrogen chemistry will be described, as well as possible sources of elevated concentrations measured at specific sites. Studies in moderately impacted Upper Floridan aquifer recharge areas demonstrate that there is a need for more intensive studies using more sophisticated techniques so that the long-term prognosis of nitrate contamination on water quality and ecosystem health of southwest Georgia can be more accurately gauged.

## METHODS

The Ichauway Ecological Reserve is located on the Gulf Coastal Plain about 10 miles south of Newton, Georgia, on the Dougherty Plain physiographic district (Fig. 1). During spring 2001, four wells tapping the Upper Floridan aquifer were installed to provide irrigation water for a long-term research project. Wells 1 and 2 are located at the northwest periphery of the Ichauway Ecological Reserve, and wells 3 and 4 are



**Figure 1. Map of Georgia and the major recharge zones of the Upper Florida aquifer (blue), and an aerial view of the study area located on the northwest section of the Ichauway Ecological Reserve.**

located about 4,000 meters east near Ichawaynochaway Creek, which flows north to south through the Reserve.

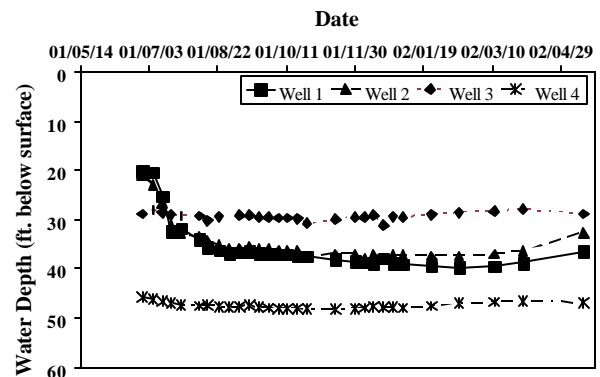
Water sampling began in May 2001 and continued for one year. Water depth measurements began in June 2001. Before the samples were collected, the water depth was recorded using a Slope Indicator electric tape. From April 2001 through January 2002, a single sample was collected from each of the four wells once a week. Then from January 2002 through May 2002, triplicate samples from each well were collected once every three weeks. The well was pumped for a minimum of 5 minutes at a pumping rate of 60 gpm to ensure that at least three well volumes were pumped before samples were collected. The samples were collected in acid washed 2-liter polycarbonate bottles, placed on ice and transported to the laboratory. In the laboratory, the samples were filtered the same day using a Whatman 142 mm GF75 filter and stainless

steel filter tower. From the filtered samples, subsamples were collected and analyzed for nitrate-N, ammonium-N, and chloride using a Latchet QuikChem 8000.

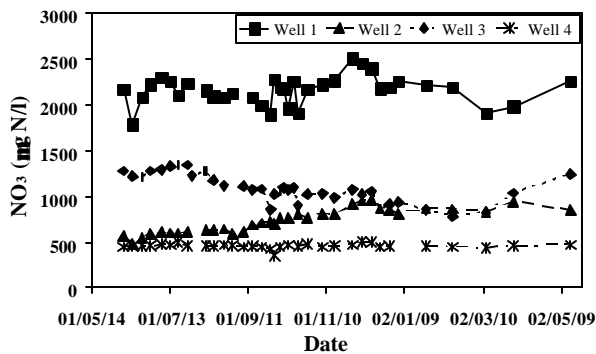
## RESULTS

Trends in water depth are provided in Fig. 2, although the data have not yet been corrected to a common reference. In wells 1 and 2 a decrease in water level was observed between June and August 2001. This corresponds to the peak irrigation months in this region. During this same period, no substantial changes occurred in wells 3 and 4. Towards the end of the study period, after significant rains in Spring 2001, the data show some recharge occurring in wells 1 and 2 but not in wells 3 and 4. Water depths in wells 3 and 4 remained relatively unchanged during the year.

Nitrate-N showed varying trends during the study (Fig. 3), with concentrations ranging from about 0.5 to 2.5 mg/l among the different wells. Based on historic data, background levels of nitrate in the Upper Floridan aquifer in southwest Georgia are estimated to be about 0.5 mg/l or below (Frick et al. 1998). The highest levels of nitrate-N were found in well 1 with concentrations ranging from 1.8 to 2.5 mg/l. Although no single trend in nitrate-N was apparent among the wells, the large range in values is suggestive of a dynamic hydrologic condition. Intermediate nitrate-N concentrations (0.5 to 1.5 mg/l) were measured in wells 2 and 3. Well 2, which is relatively close to well 3, showed an increase from near background levels (about 0.5 mg/l) to a final concentration of about 0.75 mg/l. In contrast, concentrations in well 3 steadily decreased from about



**Figure 2. Instantaneous water depths recorded for each of the four reference wells.**

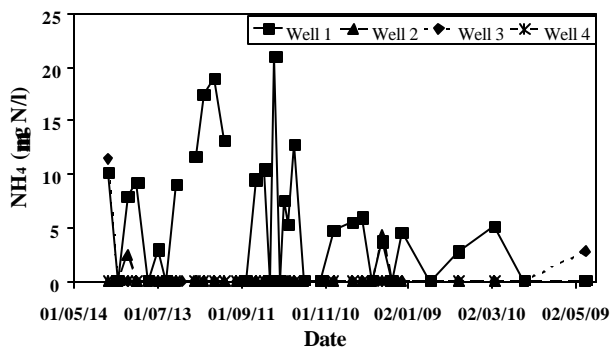


**Figure 3. Nitrate-N concentrations in reference wells from May 2001 through May 2002.**

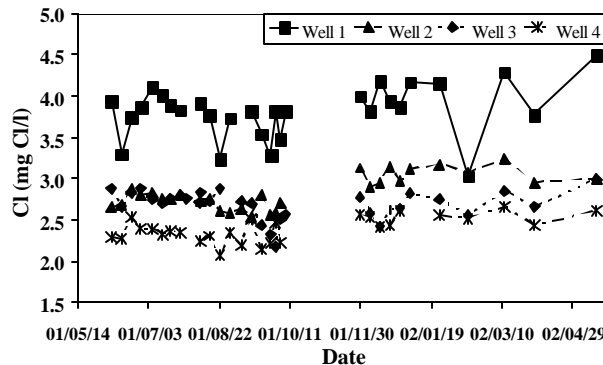
1.3 mg/l to about 0.75 mg/l, but then increased to about 1.2 mg/l. It appears as though the increase in well 3 was timed to the spring 2001 recharge event, although water levels at well 3 changed little during the entire study period. Nitrate-N concentrations in well 4 (about 0.5 mg/l) were the lowest among the four wells and remained relatively constant.

Ammonium-N was frequently detected in well 1 (Fig. 4), with concentrations ranging from 0 to 20  $\mu$ g/l. This was coincident with the highest nitrate-N levels. No consistent trend in ammonium-N was evident in well 1, although average concentrations in 2001 were higher than in 2002. There were sporadic occurrences of ammonium-N in wells 2 and 3, but not in well 4.

Chloride concentrations were consistently higher in well 1 (about 4 mg/l) than in wells 2-4 (2 to 3 mg/l; Fig. 5). There appeared to be more variability in well 1, with the highest values measured toward the end of the study when aquifer recharge was occurring (Fig. 2). The other three wells maintained approximately the same chloride concentrations throughout the study,



**Figure 4. Ammonium-N concentrations in reference wells from May 2001 through May 2002.**



**Figure 5. Chloride concentrations in reference wells from May 2001 through May 2002.**

with the lowest values found in well 4. These data suggest that the recharge water for well 1 has a different history than wells 2, 3, and 4.

## CONCLUSIONS

These initial monitoring efforts have helped characterize groundwater chemistry both spatially and temporally within a section of the Upper Floridan aquifer that is not influenced by large urban areas. Some interesting trends are apparent in the data, which stimulate additional questions regarding environmental variables that influence aquifer water chemistry in southwest Georgia. Well 1 appeared to be most heavily influenced by human activities based on nitrate-N concentrations that were above historic background levels. In contrast, well 4 had the lowest concentrations of nitrate-N and consistently yielded the highest quality water. Although the nitrate-N concentrations found were lower than the federal drinking water standards (10 mg/l) in all wells, long-term trends in regional nitrate concentrations need to be examined in the context of how different land use practices may be gradually affecting aquifer water quality.

For example, well 1 borders a plantation used for both agricultural farming and livestock farming, with particularly high densities of livestock over the past few decades. The elevated nitrate-N concentrations and the presence of ammonium in the aquifer at well 1 could be indicative of nitrogen fertilizers or from livestock waste. This area is up gradient of the generalized flow path of the Upper Floridan aquifer (Fig. 1), and contains many deforested wetland depressions that may contribute recharge water to the aquifer. In contrast, wells 3 and 4 are located in the interior of the Ichauway

Ecological Reserve, and are distant from agricultural fields. Nearby wetland recharge may also contribute to aquifer water in this area, but these wetlands are relatively pristine and may process excessive nitrogen more efficiently.

Although there are no immediate health concerns regarding the water that was sampled in this study, the possibility that nitrate-N concentrations may be slowly increasing at some of these sites raises questions regarding the long-term supply of high quality water in this region. Addressing this concern could be facilitated through the following efforts: First, a more concerted monitoring effort that includes both hydrologic and water chemistry data should be supported to evaluate the cause of moderately elevated nitrate-N in ruralized sections of the Upper Floridan aquifer in south Georgia. This will serve the purpose of identifying long-term trends in nitrate concentrations which, as seen in this study, can vary in both magnitude and direction. Second, the specific sources of nitrate need to be identified, particularly in areas where nitrate concentrations are beginning to rise. Identifying the specific sources of elevated nitrate in groundwater poses a number of challenges. However, sophisticated techniques, such as  $\delta^{15}\text{N}$  measurements, show promise for making distinctions among different nitrate-N sources including fertilizers, animal waste, human wastewater effluent, and natural sources. Third, these studies need to be placed in the context of relevant time scales. For example, changes in water chemistry in groundwater may have resulted from land use practices that occurred decades prior. Thus, age-dating techniques that are appropriate for use in the Upper Floridan aquifer need to be employed to make direct linkages between the timing and magnitude of nitrate contamination. CFCs and  $^3\text{H}/^3\text{He}$  measurements appear to hold the most promise for age-dating water in the Upper Floridan aquifer, and have been integral to identifying the causes of nitrate pollution in the Suwannee River Basin (Katz et al., 1999).

Only through integrated studies, can the trends in groundwater chemistry be understood. Such studies are needed to provide timely information to water resource constituents that direct activities including groundwater use and land management practices. Other areas of the Upper Floridan aquifer have been impacted to the point that water is unfit for human consumption and wildlife. The sustainability of these natural systems needs to be determined, because recovery of groundwater quality may take decades or longer to achieve.

## ACKNOWLEDGEMENTS

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