Hydroclimatic Drivers on Groundwater Nitrate Variability in Western Wisconsin

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INTRODUCTION

Summer 2025 saw the testing of 82 wells across Pierce, Polk, and St. Croix Counties (WI).

Wells with a ±3 ppm change in nitrate concentration were labeled sensitive and re-tested in July and August.

4 oz samples were collected after system purge to measure pH, conductivity, temperature, chloride, and nitrate.

Results were interpreted and reported back to landowners and the farmer council to guide land and nutrient management practices.

METHODS

A faucet or spigot connected to the main well was purged for about 10 minutes for direct well sampling.

Conductivity and temperature were collected from a YSI multiparameter water quality sonde at initial purge time and 10 minutes later. pH was collected using a field pH probe at the same intervals to confirm that freshly drawn water from the well was being sampled.

Samples were analyzed using a benchtop probe for Cl^-, and the Lachat flow injector for NO_3^-.

Nitrate results were compared with PRISM data for precipitation at each site.

RESULTS

Nitrate levels increase at sites with lower precipitation, with some localized results showing the opposite.

Drier periods show reduced transport rates, consistent with vadose zone recharge rate.

A 1-month lag analysis further shows a delayed hydrologic response in nitrate mobilization.

Precipitation variability influences pollutant transport into groundwater and will continue to do so under changing climatic conditions.

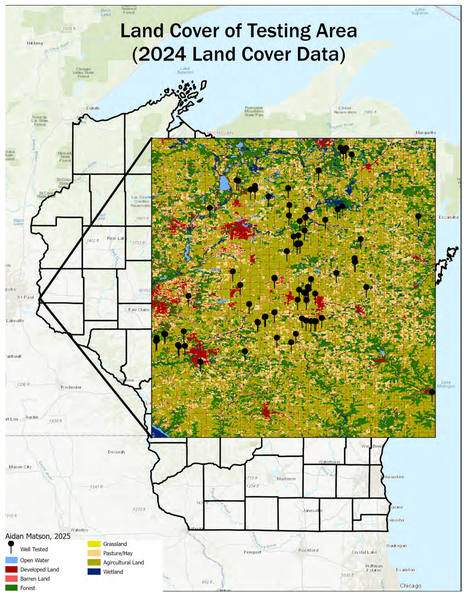

Figure 1. Map of 2024 land cover data within testing area with wells tested.

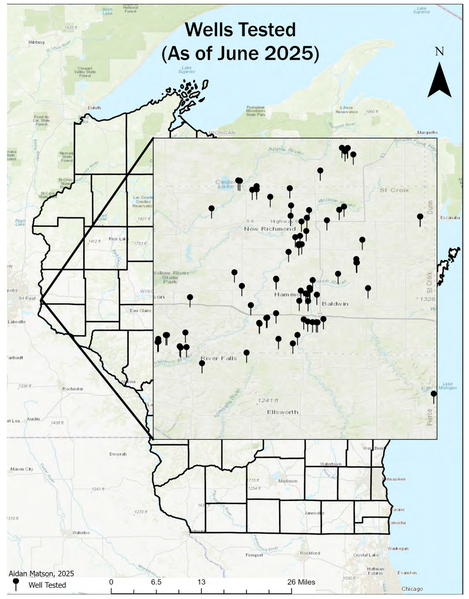

Figure 2. Map of all wells tested (as of June 2025) and their relative location in Wisconsin.

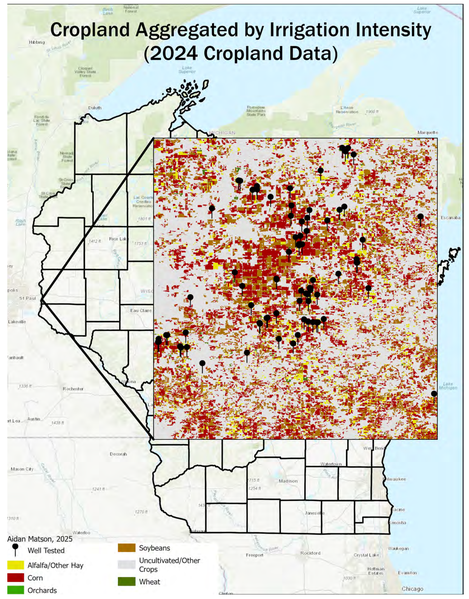

Figure 3. Map of 2024 cropland data sorted by irrigation intensity with wells tested.

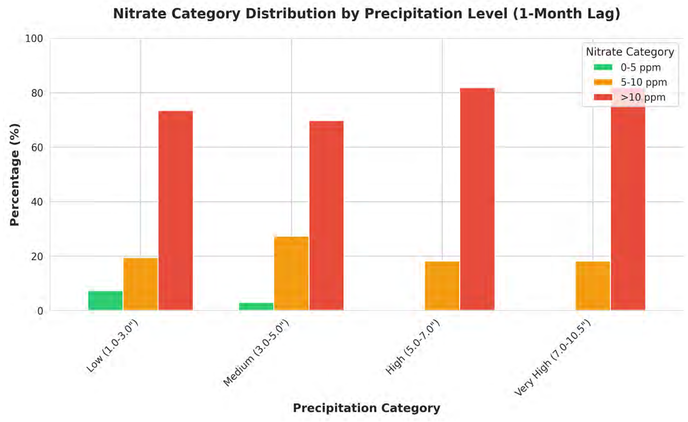

Figure 4. Distribution of nitrate category by 1-month lag time precipitation level across testing area.

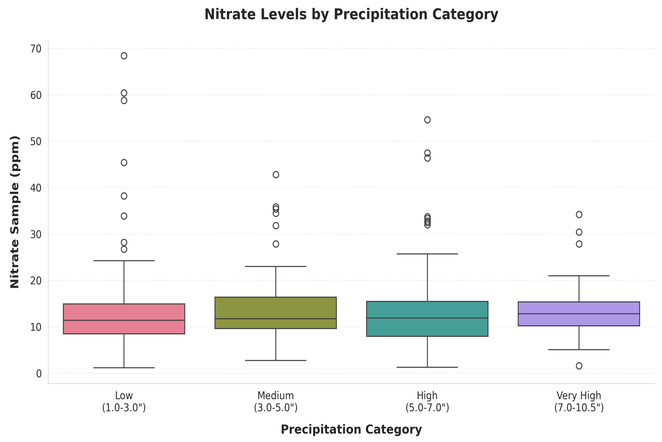

Figure 5. Boxplot of nitrate category by category of monthly precipitation intensity across testing area.

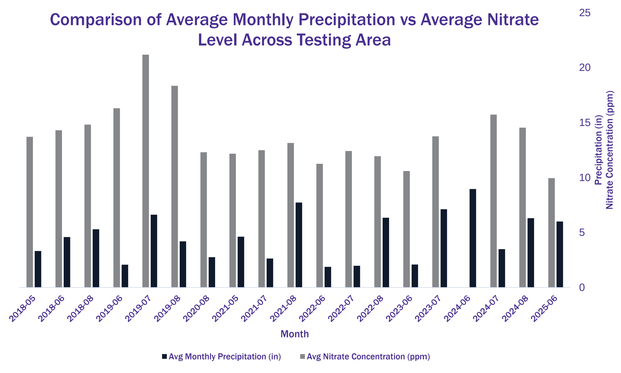

Figure 6. Comparison of average nitrate concentration (ppm, in grey) to average monthly precipitation (in., in black) across testing area.

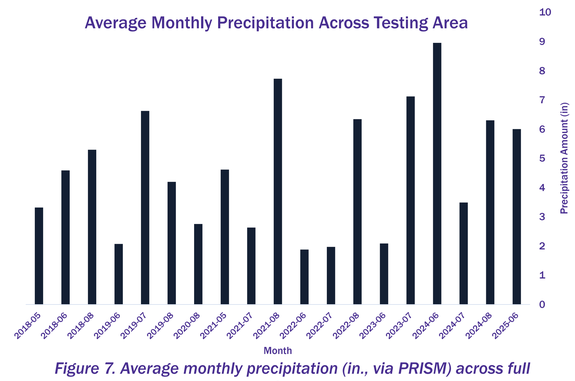

Figure 7. Average monthly precipitation (in., via PRISM) across full testing area.

CONCLUSION

Precipitation variance is a key driver of nitrate levels in groundwater systems. Current findings highlight the importance of understanding transport lag times and recharge dynamics.

Future research could refine lag-time analysis to predict transport, incorporate climate change scenarios to assess changing precipitation patterns, and apply particle tracing/modelling to better understand nitrate transport and recharge processes.
Soil analysis of the region (hydraulic conductivity, preferential flow, and soil structure) will help further understand transport.

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