

**Kansas Geological Survey
Aquifer Water Quality Assessment (AWQUA)
Program Annual Report 2024**

by
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Kansas Geological Survey

Aquifer Water Quality Assessment (AWQUA) Program Annual Report

2024

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Acknowledgments

We are grateful for the support of the Kansas Department of Health and Environment (KDHE) for their delegation of the project to the Kansas Geological Survey (KGS). KDHE provided funding and historical data to aid KGS in the successful revival of the statewide groundwater quality project. We also would like to thank the various organizations that helped spread the word about the program across the state. They include all five groundwater management districts (GMDs), the Kansas Rural Water Association, and other local groups. We also thank the cities and individual well owners that agreed to participate in the new program.

Introduction

Water quality is at the forefront of human, animal, and plant existence. Humans frequently have dug or drilled wells when surface water availability was insufficient to meet demand. The first question when the digging or drilling is complete is whether groundwater exists in that location. The second question is whether the water quality is sufficient for drinking and/or irrigating. Salty water is often the first parameter noted, as humans can easily distinguish saltwater by taste and it is not suitable for drinking or irrigation. However, there are dozens to hundreds of other water quality parameters that may be indistinguishable by taste or color that have negative effects on users. Therefore, laboratory analysis of a sample is necessary to see what may lie hidden and dissolved in the water.

In 2024, Kansas re-established a statewide groundwater quality monitoring program after more than 20 years without one. The U.S. Geological Survey (USGS) originated a groundwater quality program in Kansas in 1985, generally sampling the same 180–240 wells per year through 1991. The program was then transferred to the Kansas Department of Health and Environment (KDHE) for continuation. KDHE sampled approximately 80 to 140 wells per year, most on a biannual basis, until funding for the program was eliminated following the 2001 sampling year.

In 2023, KDHE determined that the program needed to be reinstated and granted the project to the Kansas Geological Survey (KGS) in 2024. The KGS hired personnel and purchased laboratory equipment to restart the program, now named the Aquifer Water Quality Assessment (AWQUA) program.

The AWQUA program's initial focus is measuring inorganic constituents dissolved in groundwater. Aquifers in Kansas have diverse lithological sedimentation, ranging from alluvial sands and gravels to glacial silts to bedrock sandstone and limestone. Each of these environments present different potentials for metals, nutrients, and other trace elements to dissolve into the groundwater. In addition, human activities alter groundwater quality characteristics. Due to these varied factors, the program was designed with equal geographical dispersion and long-term monitoring of the same wells to help track current conditions and future changes.

Historical USGS/KDHE Program

The plan for the original USGS program was to sample the same wells each year over time. They sampled approximately 180–240 wells each year from 1985 to 1991, with 1,332 well samples collected during this timeframe. The analytes tested included inorganic constituents such as nitrate, chloride, sulfate, arsenic, lead, and other metals and trace elements, as well as organics including chlorinated solvents, petroleum compounds, and disinfection byproducts. Several wells were also analyzed for pesticides and herbicides.

The majority of the wells were public water supply (PWS) wells, with many other types of wells- including irrigation, domestic, industrial, or feedlot- filling in the remainder. The KDHE slightly altered the approach to the program by splitting the wells into two groups and sampling half of the wells every other year. KDHE generally sampled between 80 and 140 wells each year and collected 1,070 total well samples from 301 wells from 1992 to 2001. No samples were collected in 1998. The analytes tested were largely the same as during the USGS program. Alterations included the addition of pesticide and herbicide testing on nearly every well sampled and the introduction of radiological element (uranium, radium, radon, and gross alpha) testing on 104 samples.

KDHE sampled multiple PWS wells in at least 22 communities. In most of these instances, alternate wells were tested in later years of the program because the original wells that had been sampled were plugged. Otherwise, one PWS well per community was chosen for sampling over the time period.

Figure 1 depicts the distribution and types of wells sampled during the USGS and KDHE programs from 1985 to 2001. Table 1 provides the number of wells sampled each year.

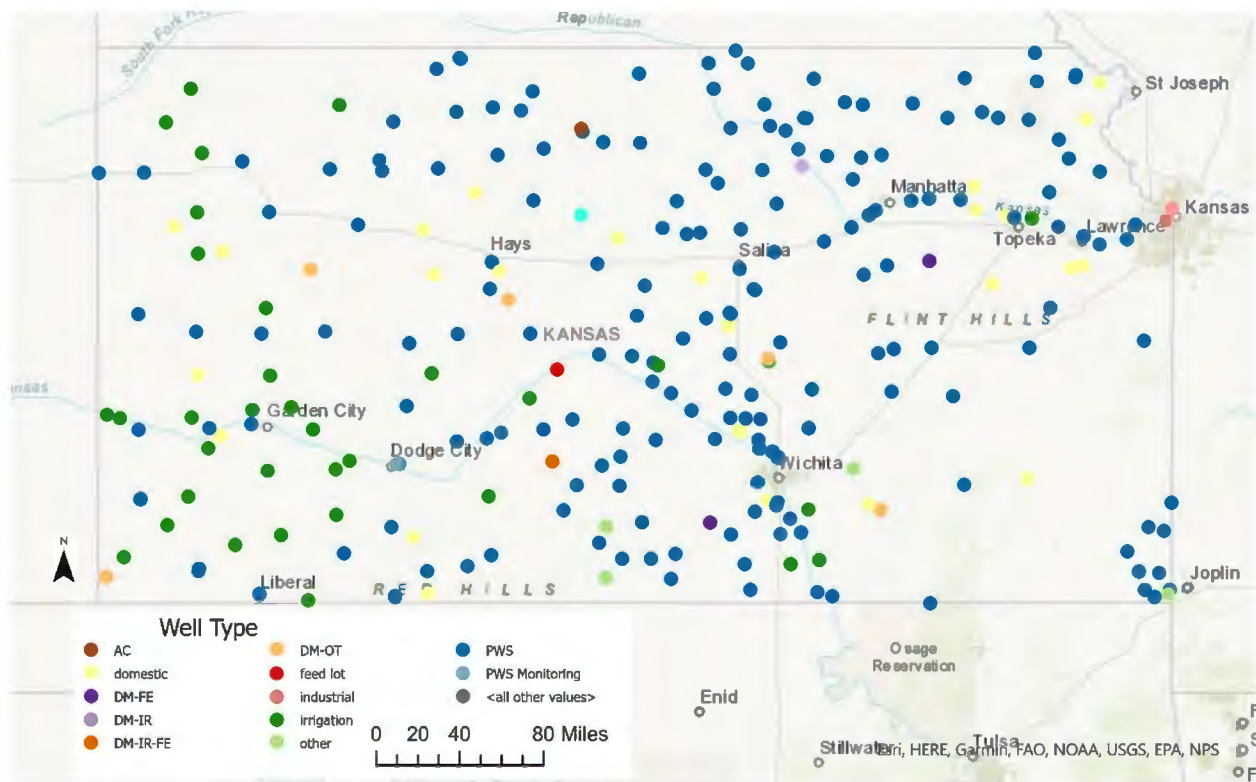


Figure 1. USGS and KDHE sampled well types.

Year	Number of Wells Sampled
1985	35
1986	238
1987	241
1988	238
1989	227
1990	187
1991	199
1992	124
1993	124
1994	128
1995	136
1996	137
1997	134
1998	0
1999	83
2000	101
2001	103

Table 1. Number of wells sampled by USGS or KDHE by year.

KGS AWQQA Program

The KGS groundwater quality program began in the summer of 2024 with the hiring of three program-dedicated personnel and acquisition of laboratory equipment. Personnel hired include a research project manager to oversee the program, a field hydrogeologist to collect samples, and a research analyst to handle the database of analytical results. Laboratory equipment purchased and installed includes a total organic carbon analyzer, nutrient analyzer, ion chromatograph, inductively coupled plasma mass spectrometer (ICP-MS), and ICP optical emission spectrometer. This equipment is housed within a laboratory at the KGS and operated by a dedicated laboratory program director. The goals of the program include the continuation and possible expansion of the groundwater well monitoring program, development of a publicly available online database of results, development of a publicly available online mapper of results, and education and outreach to inform and garner participation from well owners and the general public across the state. The initial goal of the monitoring program was to imitate the KDHE program and enter 300 wells in the program, sampling half of the wells every other year. Well owners also have the choice to have their well sampled only one time and not be included in the biannual sampling program. Wells largely will be sampled within the summer to fall time frame to reduce seasonality effects on groundwater quality and improve comparability from year to year.

Initial operational steps to restart the program included developing a website for a publicly verifiable presence, establishing a standard operating procedure (SOP) for how to collect samples, purchasing sampling equipment, finding well owners willing to join the program, and creating a database to store groundwater quality results and an online mapper to display results.

An SOP was developed using guidance from KDHE and Environmental Protection Agency (EPA) well-sampling SOPs. This is important because different sampling procedures, such as the filtering of well water, potentially can impact analytical results. The KGS SOP includes the use of a 0.45-micrometer filter to remove any sediment or particulates in the water that could be holding trace metals or other compounds that could then bias the result. This differs from EPA guidance because that agency monitors what people would be drinking, which would include any sediment or particulate matter if their well water was not also filtered prior to use. However, this may change on a well-to-well basis based on the quality of well construction, well type, etc., and therefore may not be indicative of the actual dissolved concentrations in groundwater. Filtering standardizes the sample to reflect only dissolved concentration of analytes.

Groundwater sampling involves several consumable and reusable pieces of equipment. Items purchased include sample bottles specific to analysis by each piece of laboratory equipment, filters, hand vacuum pumps, nitrile gloves, labeling tape, HydraSleeves, and twine.

The next step was to find wells to sample. Initial efforts focused on wells that had been sampled by the KDHE and USGS. Letters were sent to private well owners and emails were sent to cities who participated in the historical program. A majority of the cities renewed their participation in the program, although several had plugged the particular wells that had been sampled previously so a different well was sampled for the new program. In 2024, 64 wells from the previous program were sampled again in the new program. Participants also could enroll through the AWQUA program website, which includes a sign-up form for new well entrants. This form requested name, address, phone number, email address, and well type from the signee. Entries were forwarded to the research project manager, who contacted the signee to confirm the well's condition and use, and the desire to have it tested, with the results added to the KGS database.

Efforts to get new well owners to join the program included project employees attending conferences and sharing postcards with program information at KGS booths, sending information to or speaking with local or regional organizations, and asking GMD administrators to include information about AWQUA on their websites and in member newsletters. The KGS online form received 59 private well entries in 2024.

Work on the database in 2024 focused on the preliminary steps of determining what the schema would include. Discussions included not only groundwater quality data points but how users might interact with the database and what information they would want to see.

The AWQUA database ultimately will be available for search on the KGS website in a format similar to the existing Water Well Completion (WWC5) database, Water Information Management and Analysis System (WIMAS) database, and Water Information Storage and Retrieval Database (WIZARD).

The AWQUA database and mapper are designed to help people see groundwater quality results in their immediate area and to provide information that legislators and other local authorities can use when making decisions about water usage or remedial efforts. Monitoring the same wells over time also gives a trend analysis, which may be used for planning. The database will not only hold AWQUA sample results but also any historical groundwater quality data created by or submitted to the KGS for inclusion. The KGS has decades of groundwater-quality data housed within individual reports. Similarly, KDHE, GMDs, universities, and other organizations have groundwater data from historical studies, monitoring, or site investigations that would be eligible for inclusion into the database if the data owners allow it. The database ultimately will be a powerful tool that combines dozens to hundreds of individual reports' data points from various agencies into one location for easy reference.

The database and mapper also have been set up to display well-data results that align with well-owner privacy preferences and provide local relevance. The two choices available are a point-level display or a township-level display. The point-level display uses a Global Positioning System (GPS) reading for the well or property to display the well location and results. The township-level display was developed to allow well owners to retain an element of privacy while still participating in the program. This display only reveals well location information to a township, or 6-mile by 6-mile square. The database will only reveal the well's township and range, and the mapper will display a 6-mile by 6-mile square for the result display. If multiple wells are sampled within the township, the square will reveal the mean of the well results. Figure 2 shows an example of the point-level and township-level displays.

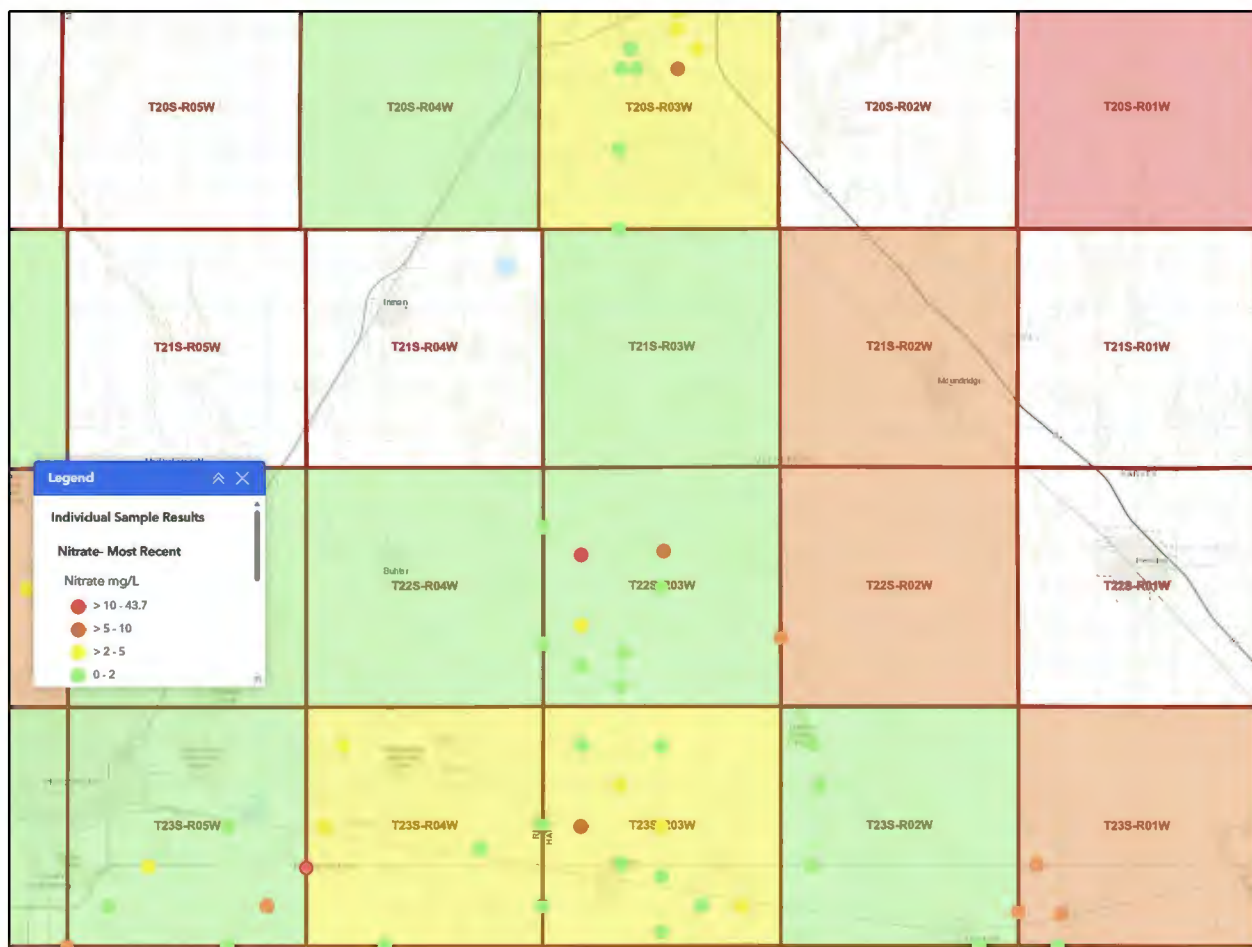


Figure 2. Online mapper showing point-level and township-level displays.

2024 Well Sampling

The 2024 well sampling campaign began in October and ended in December. The research project manager coordinated routes to allow the field technician to sample 10–15 wells per week in a specific region of Kansas. During that time, 151 wells were sampled; each sample took approximately 20 to 30 minutes to collect. Each well with a pump was turned on and allowed to purge for a minimum of 5 minutes prior to sample collection. This step allows water that had been sitting in the lines to be cleared and new water from the aquifer to be pumped through for the most representative sample possible.

Water chemistry can be altered by precipitation or dissolution of elements, air-water interactions, bacterial interactions, or other well- and water line-specific influences on analytes. Specific sample handling is required to minimize these effects. Samples were placed into an iced cooler for return to the KGS, where they were refrigerated, frozen, or had acid added to preserve the sample until analysis by each of the five instruments in the laboratory. Table 2 shows the full suite of elements and compounds that KGS analyzes.

pH	Silica	Barium
Nitrate	Potassium	Lithium
Ammonium	Bicarbonate	Beryllium
Phosphate	Strontium	Vanadium
Fluoride	Manganese	Chromium
Sulfate	Arsenic	Cobalt
Bromide	Selenium	Nickel
Chloride	Uranium	Zinc
Sodium	Lead	Silver
Calcium	Iron	Cadmium
Total Organic Carbon	Copper	Antimony
Total Dissolved Solids	Magnesium	Titanium
Electrical Conductivity	Boron	Thallium

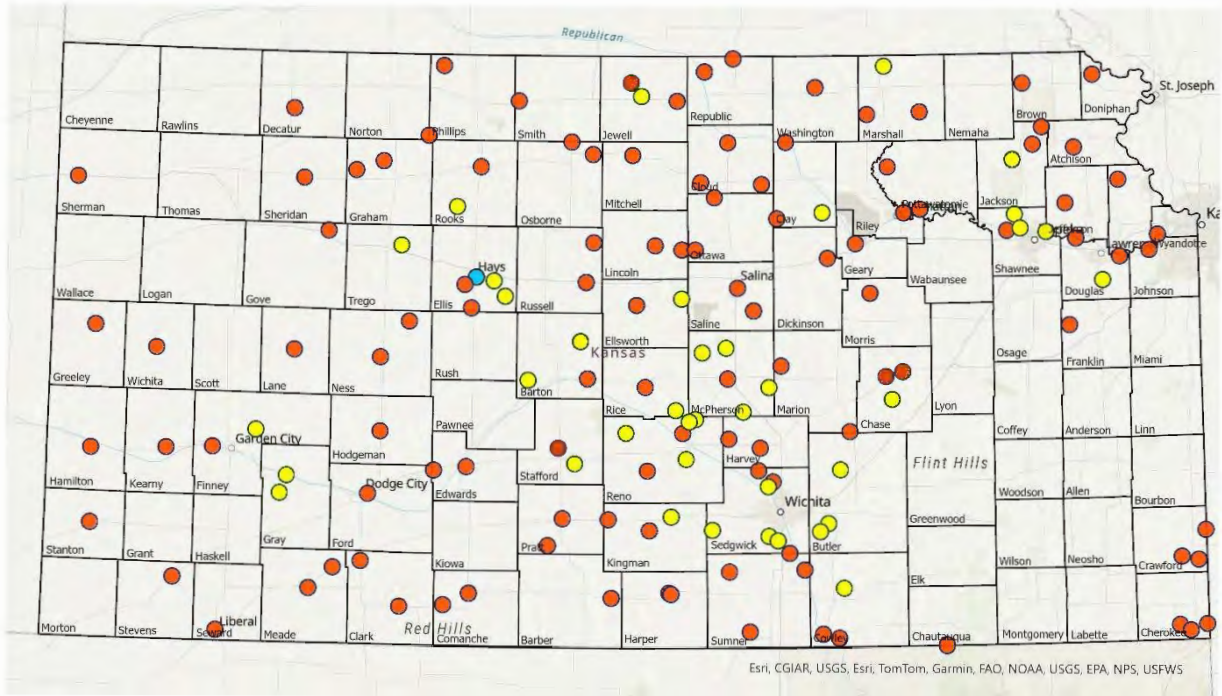
Table 2. Analytes reported by KGS laboratory.

Future expansion of analytes may include pesticides, herbicides, and poly- and perfluoroalkyl substances (PFAS) by outside laboratories.

Type of Well	PWS	Domestic	Irrigation	Lawn & Garden	Stock	Monitoring	Total
2024	112	38	0	1	0	0	151

Table 3. Number of each well type sampled by KGS in 2024.

Table 3 shows a breakdown of well types sampled in 2024. The wells were geographically distributed across the state, although several counties in southeast Kansas had no representation due to a limited number of groundwater wells in this area. Many areas in southeast Kansas have shallow bedrock, which restricts the availability of unconsolidated aquifer sediments and typically has salty water. Southeast Kansas also has more surface water available than the western half of the state. Therefore, most cities in this area use surface water intakes for PWS systems and are unavailable to be sampled for this program. This area of the state also has a relatively low population density, so the number of domestic wells in rural areas available for sampling is relatively low. A focus of the program in 2025 will be to add wells in southeast Kansas as well as the western third of the state. Figure 3 depicts well locations and types sampled during 2024.



- 2024 Samples**
- Lawn & Garden Well
 - Domestic Well
 - Public Water Supply Well

Figure 3. Locations of wells sampled by KGS in 2024.

Results from the KGS laboratory analysis were transferred to a template and emailed or mailed to well owners. The template includes primary and secondary maximum contaminant levels (MCLs and SMCLs) set by the EPA for comparison to results. Primary MCLs are set according to a health risk, while SMCLs are set for taste, odor, or color concerns. Results that exceed either primary or secondary MCLs are set in bold font on the template and are explained in the correspondence to the well owner. The AWQUA program developed a pamphlet to explain possible remedial actions that the well owner could take to lower these analyte concentrations, including installing a whole-house or a point-of-use system designed to reduce or remove the contaminant of concern. Examples of these systems include a water softener, reverse osmosis system, or activated carbon filter. Each has different properties that may work on a targeted contaminant.

2024 Analytical Results

Table 4 depicts the number and percentage of well samples collected in 2024 with measured exceedances of EPA MCLs or SMCLs.

151 Samples	Number of samples that exceed the EPA MCL	Number of samples that exceed the EPA SMCL	Percentage of samples exceeding MCL or SMCL	EPA MCL or SMCL
Nitrate	12		7.95%	10 mg/L
Chloride		8	5.30%	250 mg/L
Sulfate		23	15.23%	250 mg/L
Arsenic	6		3.97%	0.01 mg/L
Iron		14	9.27%	0.3 mg/L
Manganese		27	17.88%	0.05 mg/L
Uranium		3	1.99%	0.03 mg/L
Total Dissolved Solids		102	67.55%	500 mg/L
Fluoride	1	5	3.31%	4.0 mg/L (MCL) 2.0 mg/L (SMCL)

Table 4. Number of well samples exceeding MCLs or SMCLs for select analytes.
mg/L — milligrams per liter

Given the distribution of sampled well locations, it is reasonable to assume that these percentages roughly translate to the percentage of all wells across the state that would have exceedances of either MCLs or SMCLs for the analytes listed. Figures 4–8 depict the well locations and selected sample results. Locations shown with yellow or red dots exceed the MCL or SMCL for that analyte.

Nitrate

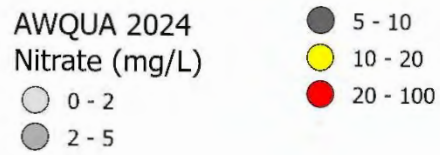
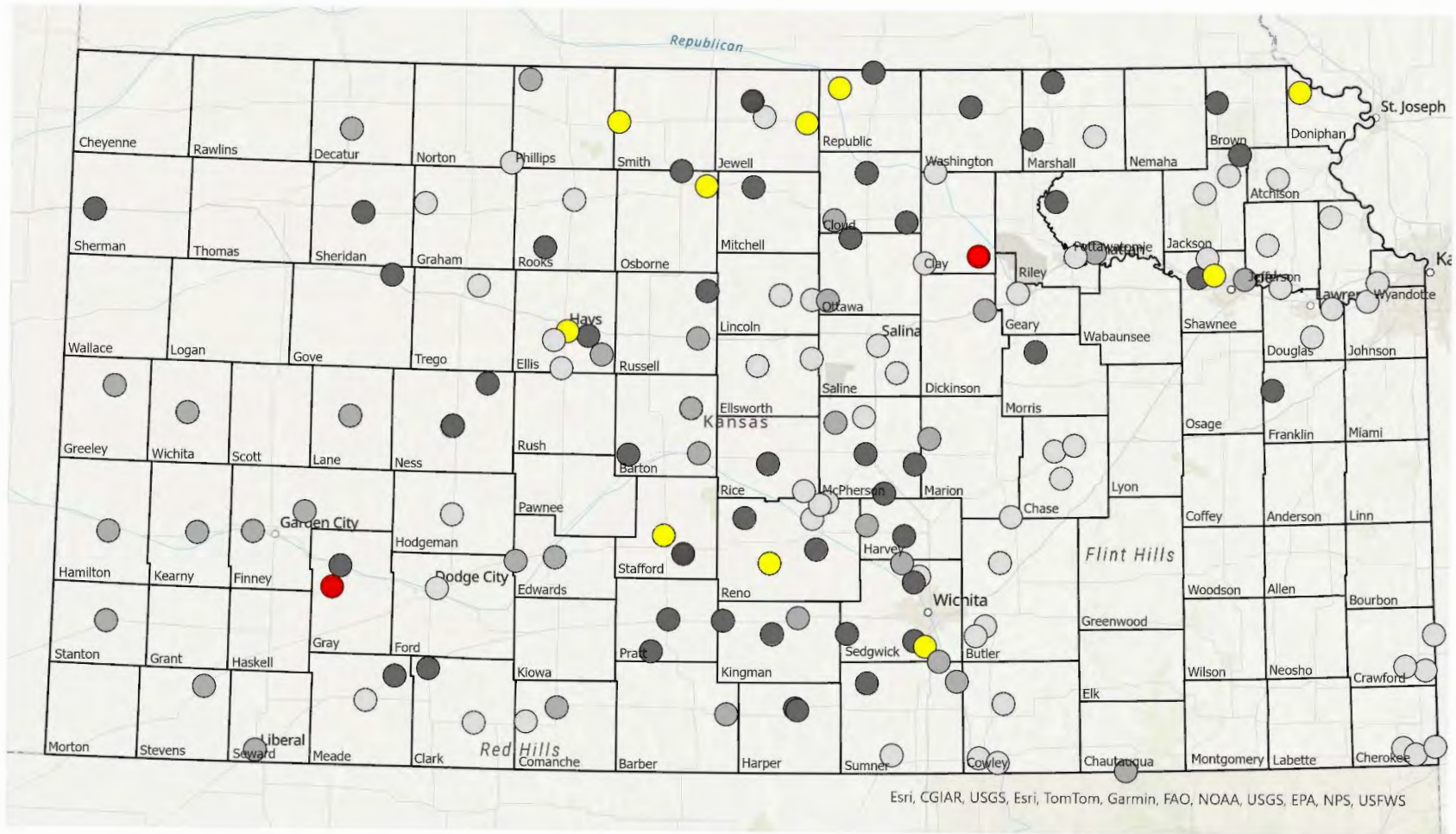


Figure 4. Concentration of nitrate in wells sampled by KGS in 2024.

Chloride

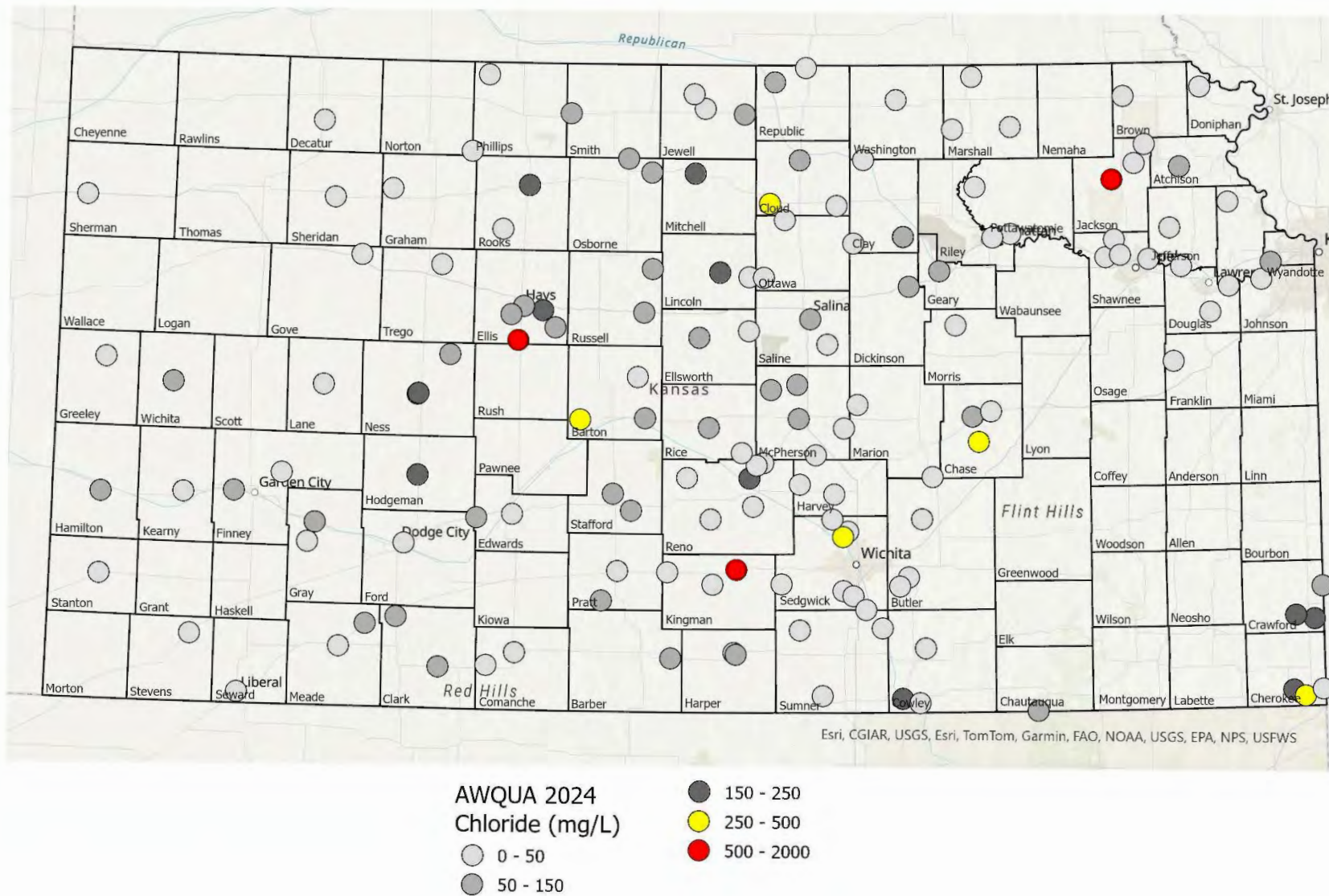


Figure 5. Concentration of chloride in wells sampled by KGS in 2024.

Sulfate

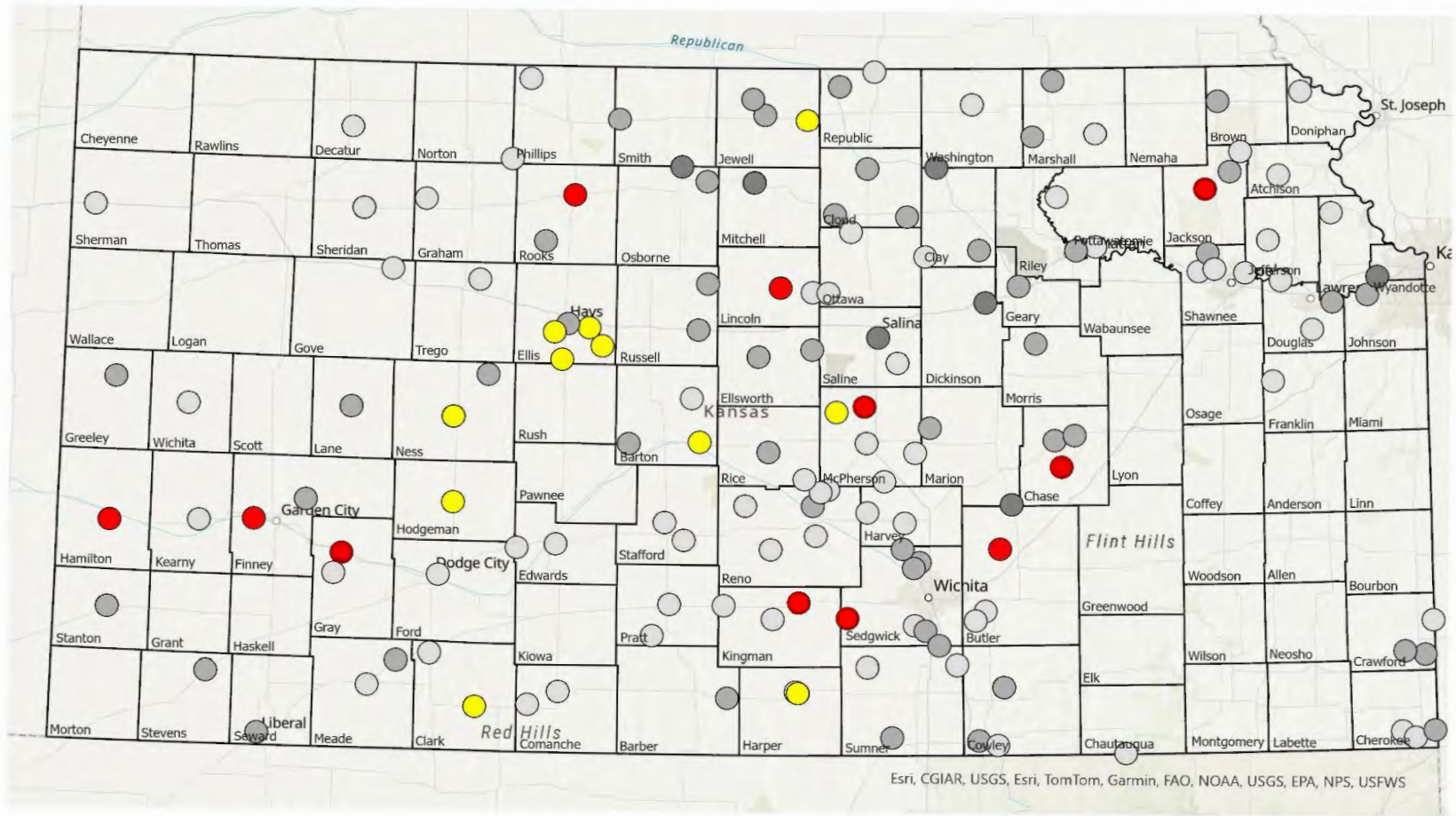


Figure 6. Concentration of sulfate in wells sampled by KGS in 2024.

Manganese

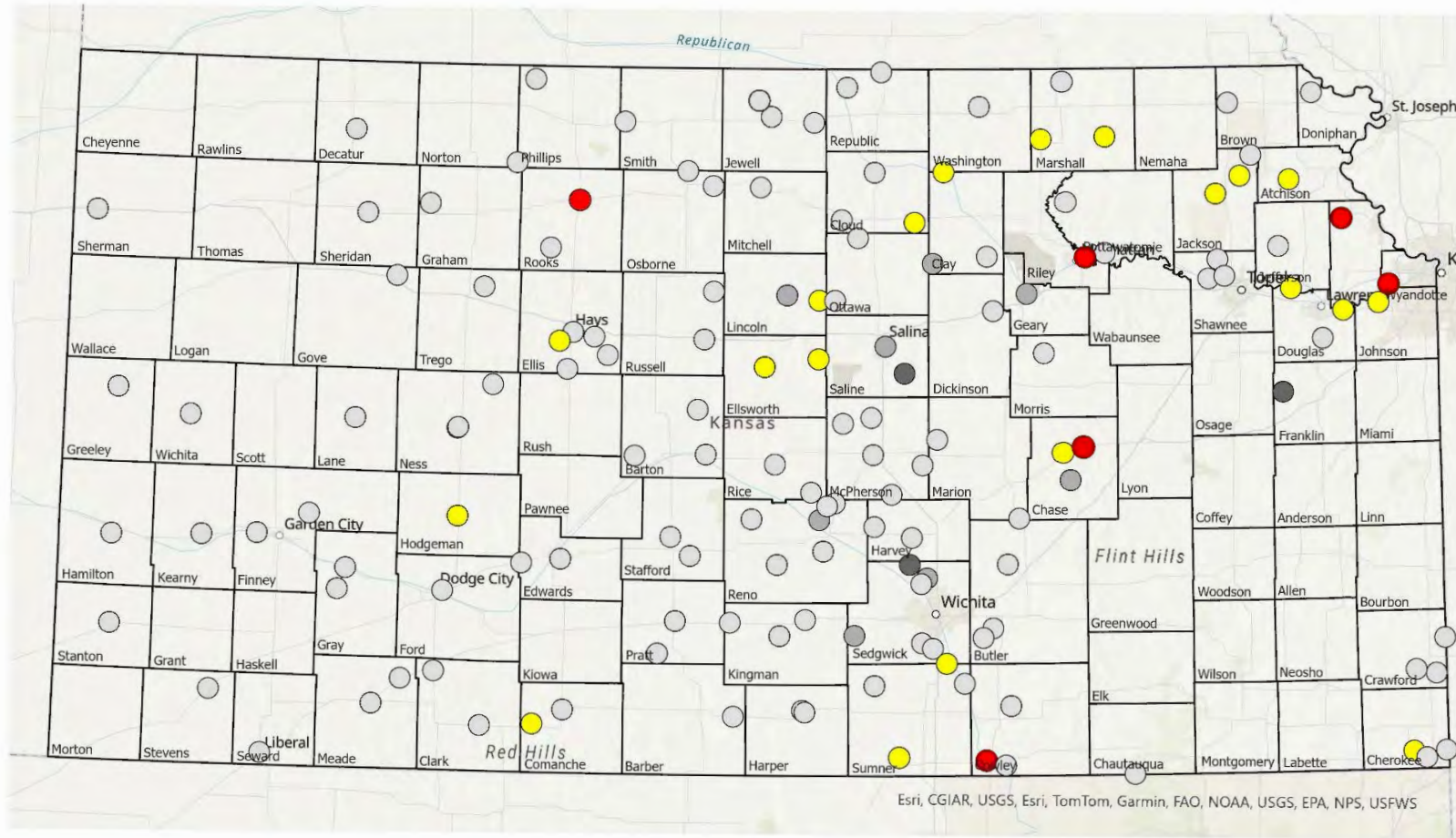


Figure 7. Concentration of manganese in wells sampled by KGS in 2024.

Total Dissolved Solids

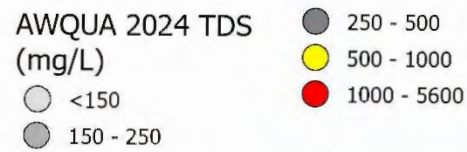
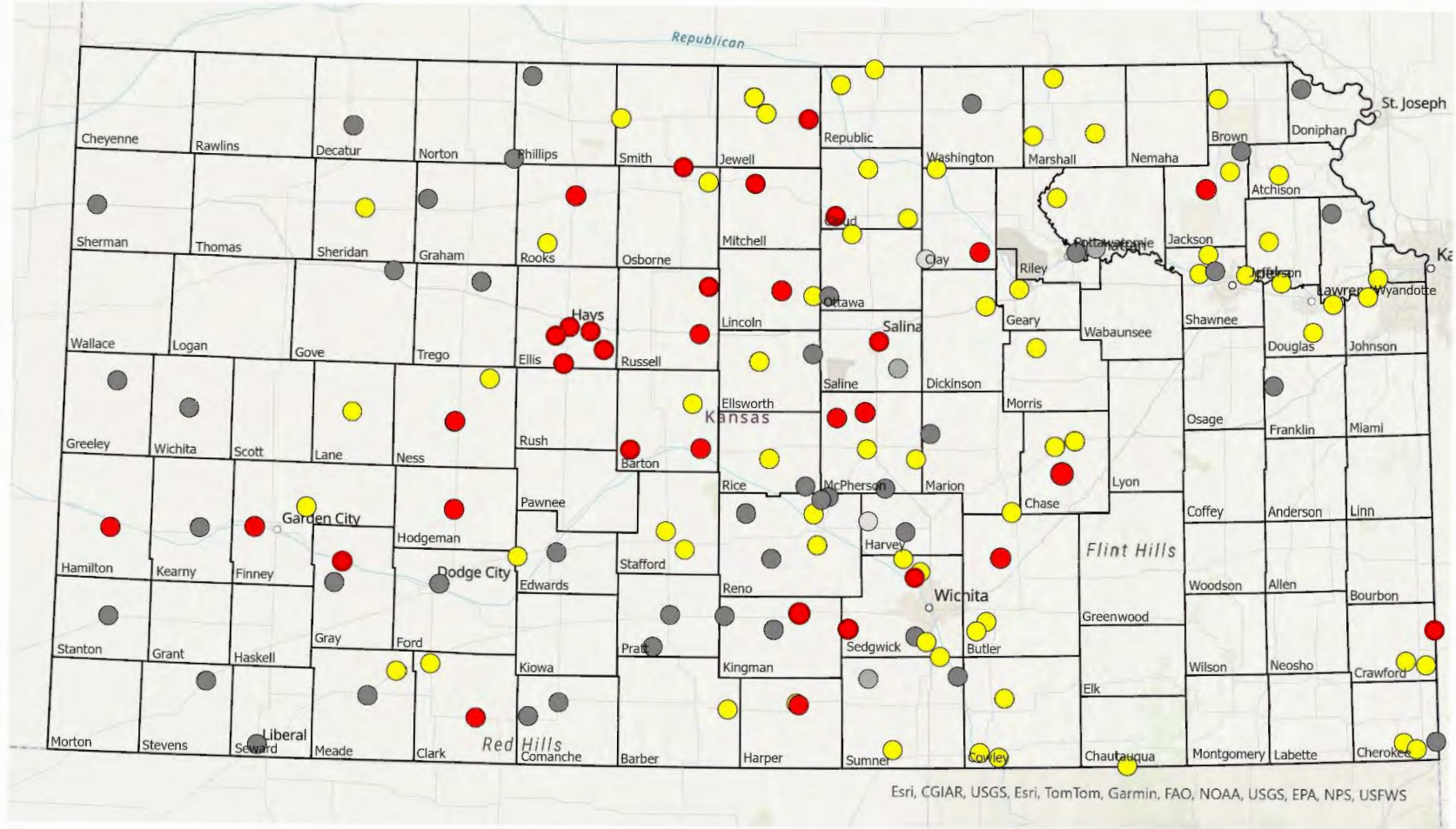


Figure 8. Concentration of total dissolved solids in wells sampled by KGS in 2024.

The wide dispersion of contaminant concentrations across the state indicates how groundwater quality issues can be both regional and localized. As additional wells are sampled and historical datasets are added to the AWQUA database, these local and regional variations will become more apparent and defined.

Nitrate is one of the main contaminants of concern across the state. In areas of heavy agricultural production, wells of all types are at risk of rising nitrates. During the USGS/KDHE program, 13 PWS wells that had been sampled were taken offline after high nitrates forced the cities to plug the wells or relegate them to emergency duty only. These wells had levels of nitrate exceeding the EPA MCL of 10 mg/L during their last sampling event. Figure 9 shows the average nitrate concentration of 60 wells tested by USGS/KDHE (1986–2001) and again by KGS (2024).

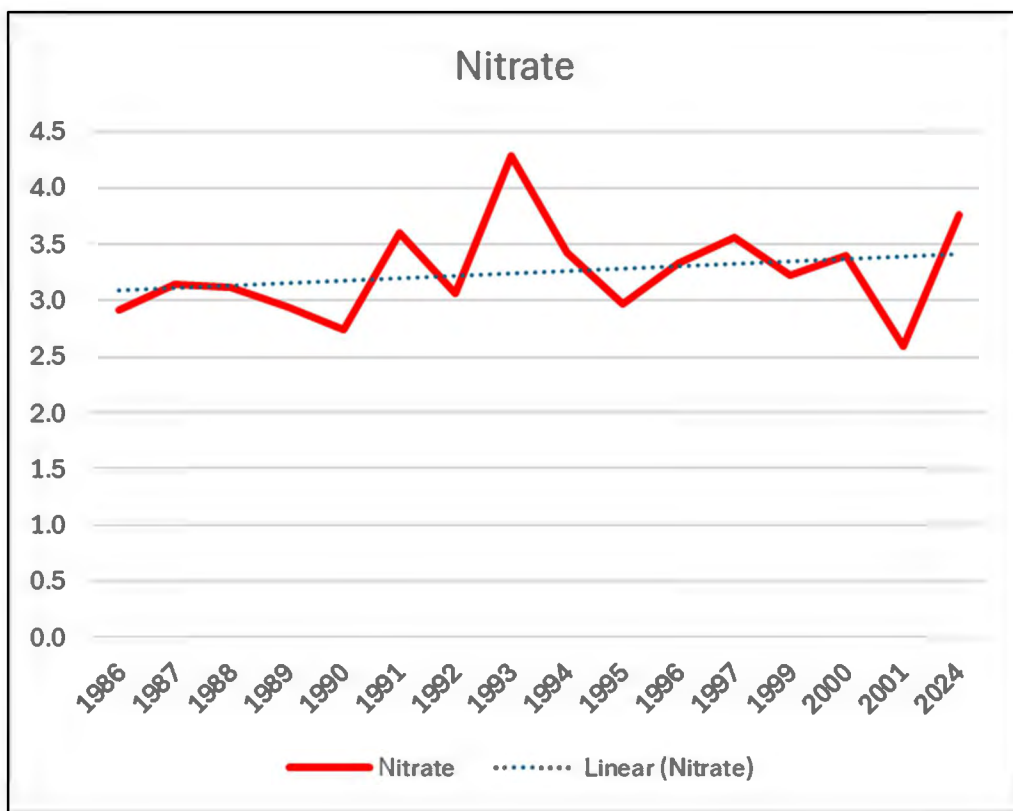


Figure 9. Average nitrate concentration in wells previously sampled by USGS/KDHE and in 2024 by KGS.

A line of best fit shows a slight upward trend over time. During that period, most wells in the dataset display relatively stable concentrations of nitrate. However, the importance of continual sampling of individual wells is shown when a well indicates a definitive trend over time. The graph of nitrate in Minneola’s PWS Well #7 (fig. 10) combines nitrate results from the USGS/KDHE dataset for 1987–2001, KDHE’s Drinking Water Watch results from city-provided samples for 2002–2021, and KGS from 2024.

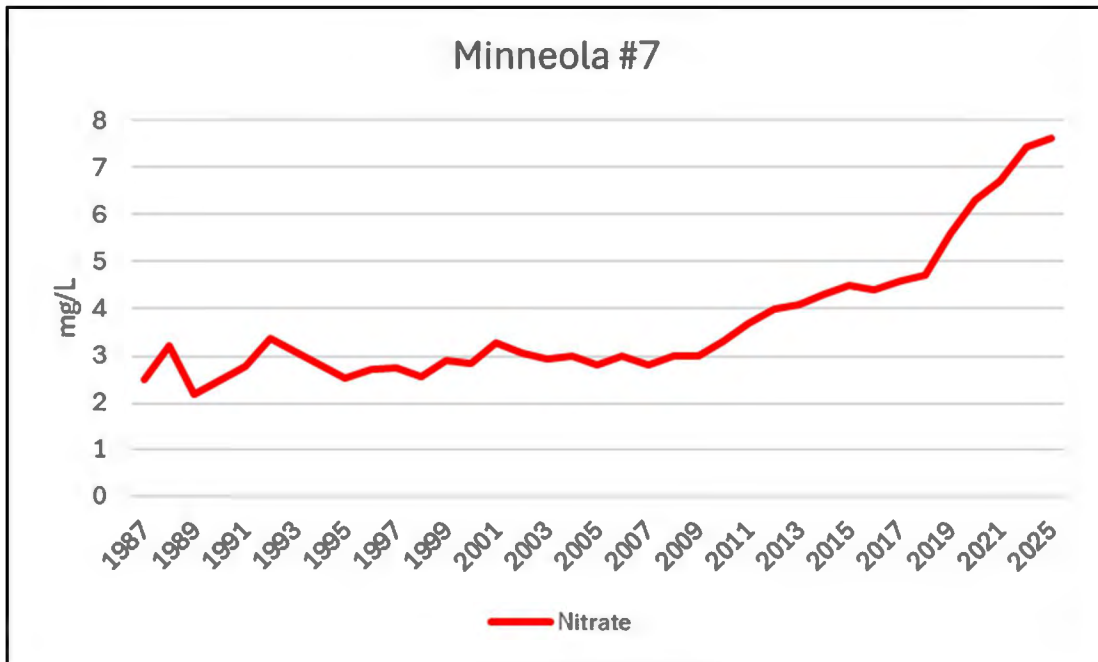


Figure 10. Nitrate concentration in Minneola #7 well.

The nitrate concentration is stable until 2011 when the concentration broke above 3.5 mg/L and has continued increasing since. This well may have nitrate above the EPA's MCL of 10 mg/L within several years if a change is not made to limit the amount of nitrate reaching the well.

Another example of a large, quick change in well water chemistry is seen in the nitrate level in a domestic well chart (fig. 11). The cause of the sudden spike and subsequent decrease is unknown.

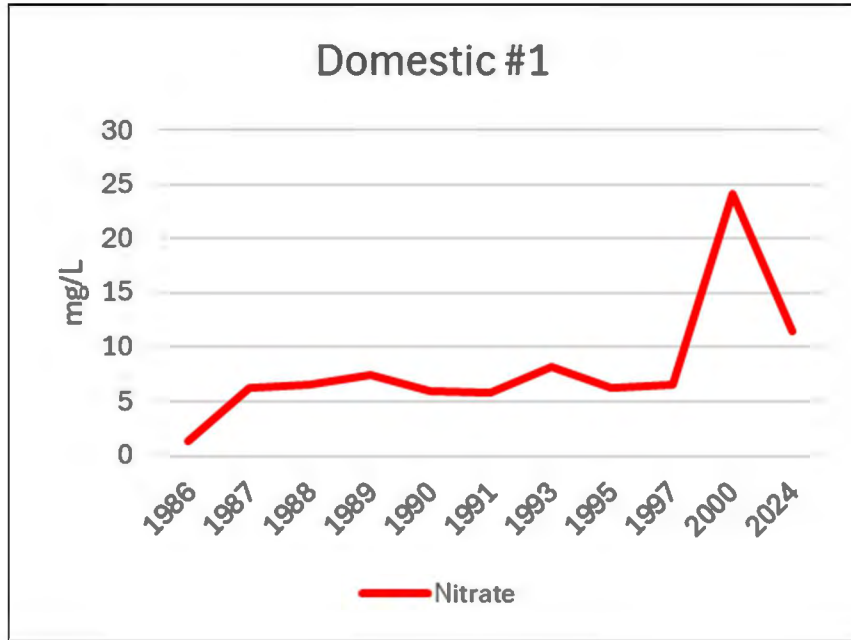


Figure 11. Nitrate concentration in a particular domestic well.

Nitrate contamination in groundwater can be a complicated function of source, lithology, depth to groundwater, soil bacteria, precipitation or irrigation, vegetation uptake, and other factors. However, to reach the groundwater table, the nitrate needs to be carried by infiltrating water vertically through the soil profile. Figure 12 depicts average nitrate concentration across all samples collected by USGS/KDHE during 1986–2001 and by KGS in 2024 as well as the average precipitation in Kansas for each year.

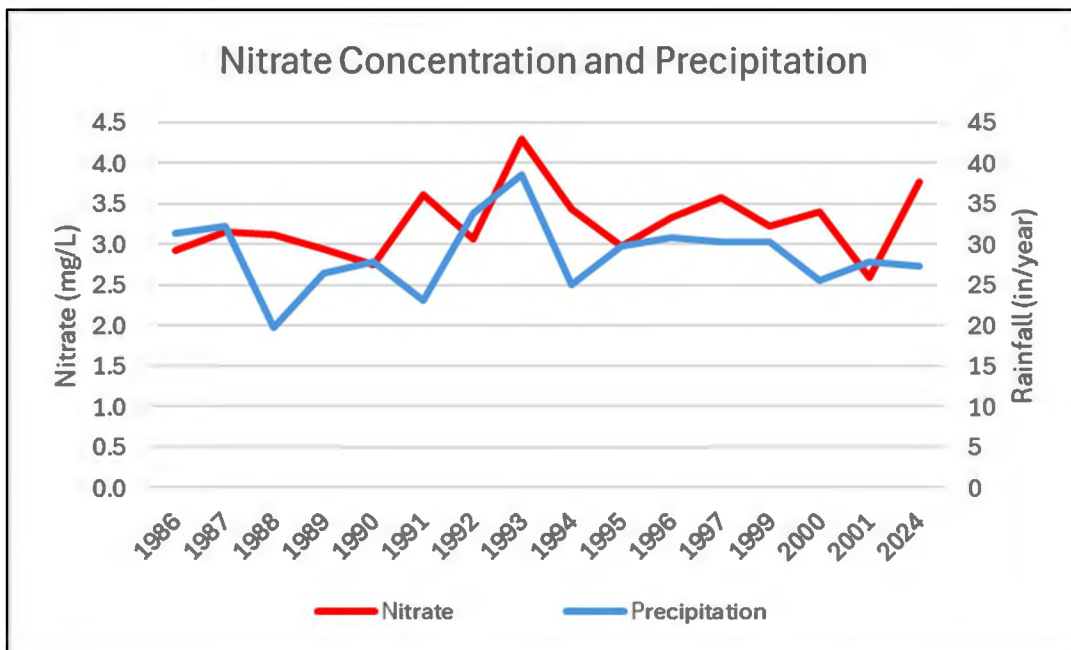


Figure 12. Average nitrate concentration in sampled wells and average annual rainfall in Kansas.

The correlation coefficient between average nitrate detected per year and precipitation is 0.266, which is generally considered a positive but weak correlation. This means as more precipitation falls, more nitrate is carried to the groundwater and nearby wells by the infiltrating water. However, advancing annual precipitation by one year shows how nitrate concentrations are affected by the previous year's precipitation (fig. 13).

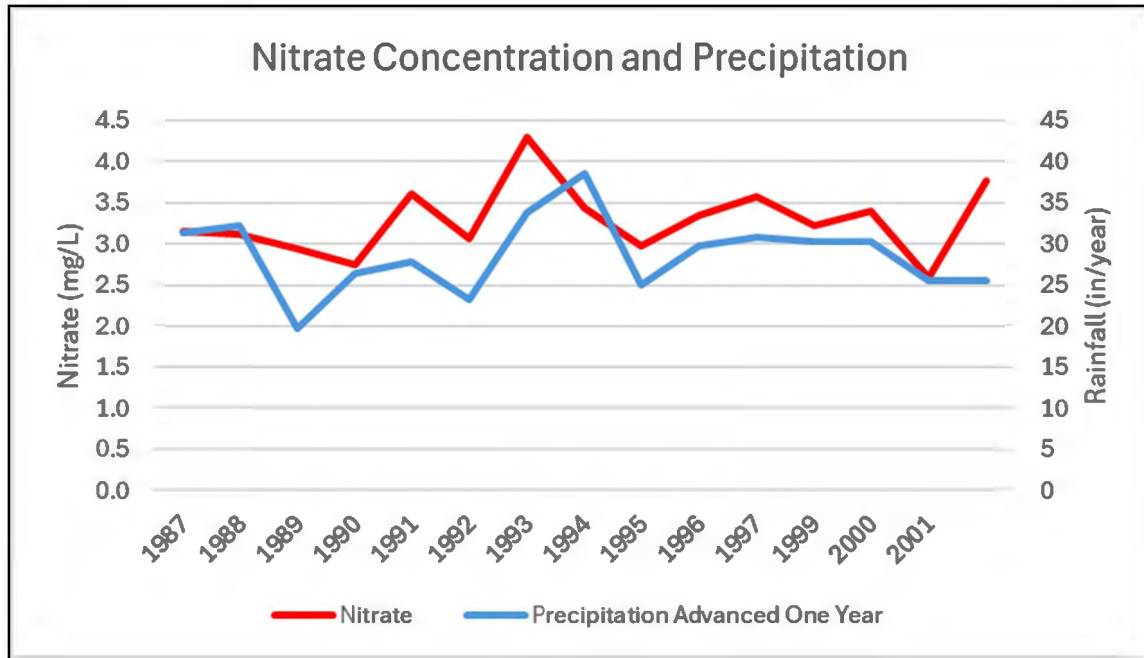


Figure 13. Average nitrate concentration in sampled wells and average annual rainfall in Kansas advanced one year.

The correlation coefficient between nitrate concentration and precipitation advanced one year is 0.416, which is considered a moderate positive correlation. This appears to reflect the time needed for groundwater to carry the additional nitrate to the wells being sampled.

Similarly to nitrate, chloride concentrations across the state appear to be slowly increasing over time. Figure 14 shows a slight positive slope in the line of best fit across the average chloride concentration from the 60 wells sampled during the 1986–2001 USGS/KDHE and 2024 KGS efforts.

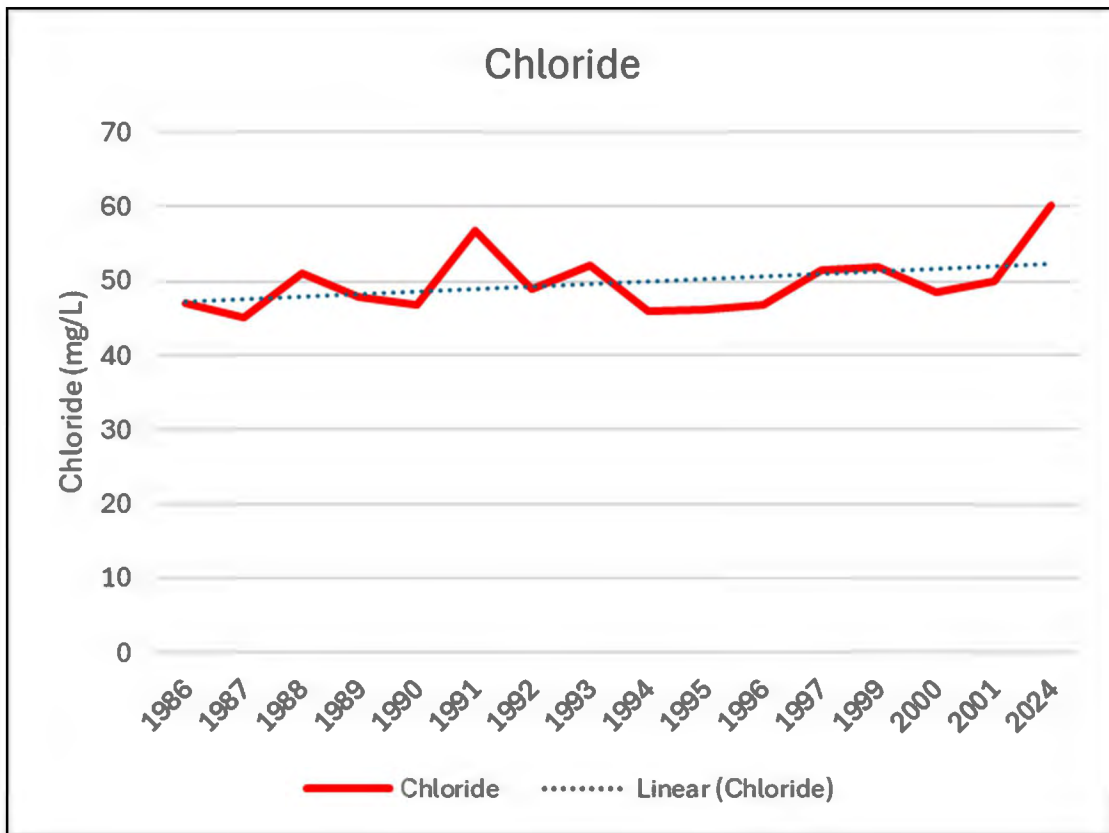


Figure 14. Average chloride concentration in USGS/KDHE/KGS sampled wells

A similar correlation coefficient analysis was conducted on chloride and precipitation (figs. 15–16). The correlation coefficient for chloride concentrations and precipitation in the same year is -0.175. The correlation coefficient for chloride concentrations compared to precipitation one year prior is -0.144. Although considered weak, both correlations are negative, indicating an inverse relationship between precipitation amount and chloride concentrations in wells. This relationship may indicate that a lower water table in years with less precipitation promotes higher chloride concentrations in the well. This may also indicate that the source of chloride is close to the well and therefore does not need to travel as far to reach the well, as nitrates do. Many irrigation and PWS wells are drilled deep into aquifers, with their total depth often very close to or at the top of bedrock. It may be possible that a lower water table in years with less precipitation provides less head pressure, allowing bedrock aquifer water, which often has a higher chloride content, to rise into pumping wells.

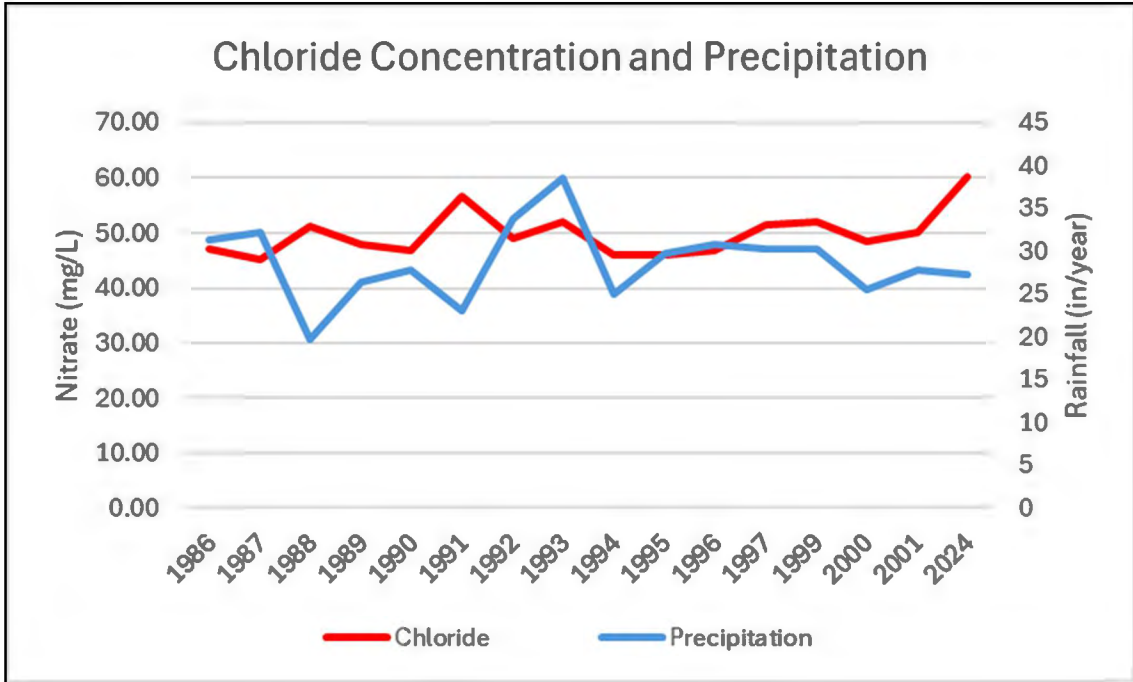


Figure 15. Average chloride concentration in sampled wells and average annual rainfall in Kansas.

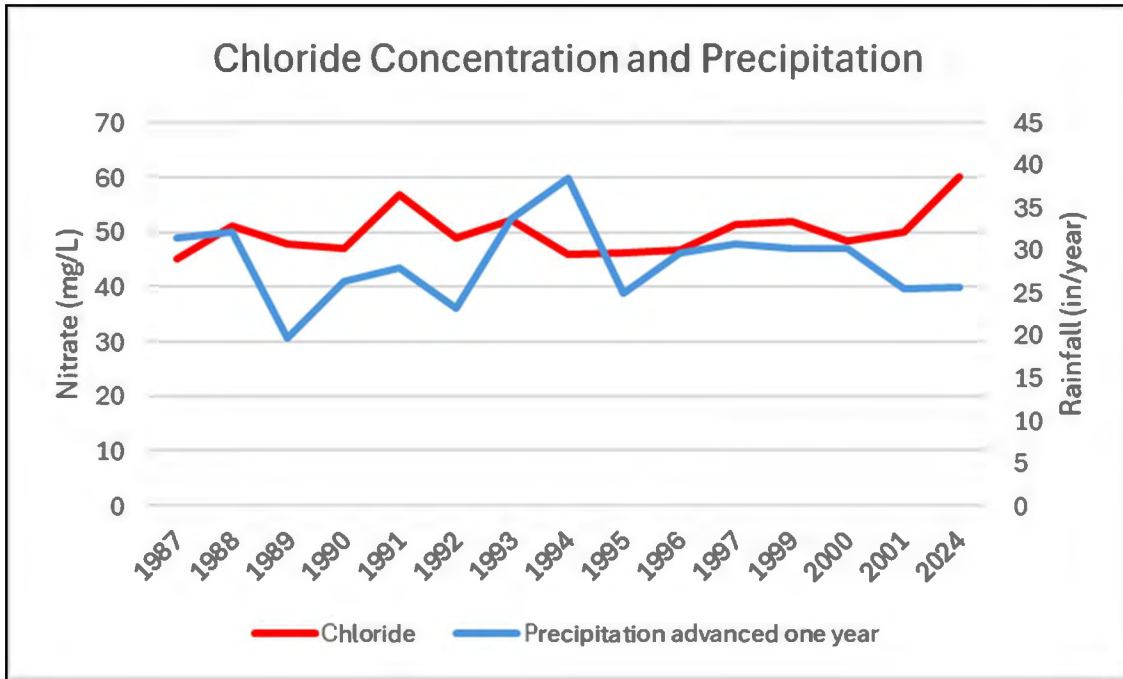


Figure 16. Average nitrate concentration in sampled wells and average annual rainfall in Kansas advanced one year.

These correlations were provided to give a brief introduction to the importance of long-term well-data collection and aggregation.

Conclusion

The AWQUA program was off to a successful start in 2024. The 151 wells sampled slightly exceeded the goal of 150 wells. The in-house laboratory became operational and returned quality, reproducible results. Goals for 2025 include sampling a minimum of 150 new wells and making progress on data storage and display. The AWQUA resources on the KGS website will be updated with additional program information and links. A database will be created to hold 2024 and other future AWQUA results, historical USGS/KDHE results, historical KGS groundwater quality study results, and additional groundwater quality results submitted by other organizations. This database will be searchable on the KGS website to enable users to find groundwater quality data in their area or an area of study. An online mapper will be created on the KGS website to allow for visual representation of groundwater quality results across the state, similar to the maps created with 2024 results provided in this report. Analytical testing on domestic wells will be expanded to include PFAS, pesticide, and herbicide analysis. Program updates and links are available at <https://kgs.ku.edu/awqua-kan-aquifer-water-quality-assessment-kansas>.

References

Extreme Weather Watch. *Average Precipitation in Kansas by Year*. Retrieved January 14, 2026. <https://www.extremeweatherwatch.com/states/kansas/average-precipitation-by-year>