Geochemical Identification of Salinity Source Affecting a House Well in Southwest Pawnee County, Kansas: Addendum

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Donald O. Whittemore

for the

Oil & Gas Conservation Division,

Kansas Corporation Commission

Kansas Geological Survey Open-File Report No. 2026-37

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GEOHYDROLOGY

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INTRODUCTION

A new house well completed on February 9, 2023, in southwest Pawnee County was found to yield saline water of unknown origin. The Kansas Corporation Commission (KCC) Oil and Gas Conservation Division sent samples collected from the house well and a nearby irrigation well in October 2024 and from the end of a pumping test of the house well in January 2025 to the Kansas Geological Survey (KGS) for chemical analysis and geochemical identification of salinity source(s). The KCC also provided the KGS with specific conductance and chloride concentration data it had obtained for samples collected during the pumping test. The KGS reported the results and interpretation in KGS Open-File Report No. 2025-25.

The legal location of the house well is SE NE NE/4 Sec. 25, T. 22 S., R. 20 W. (22S-20W-25AAD based on U.S. Geological Survey designation). It was completed with a screened interval of 60–100 ft. The irrigation well is located approximately 0.3 mile northeast of the house well and was completed in 2022 with a screened interval of 157–217 ft. Both wells draw water from the Dakota aquifer. Additional well construction information is included in KGS Open-File Report No. 2025-25.

This addendum explores several developments since that report was completed. In January 2026, the KCC collected samples from the backside tubing (annular space above the upper packer) of an oil well in the area and sent them to the KGS for analysis and interpretation of the geochemistry. The location of the oil well is SW SW NE Sec. 19, T. 22 S., R. 19 (22S-19W-19AAD) (38.12469, -99.45027), which is approximately 0.6 mi northeast of the irrigation well and 1 mi northeast of the house well. The KCC determined by titration a chloride concentration of 41,100 mg/L in the water coming up the backside of the oil well tubing. The saltwater was thought to be possibly due to a break in the well to the Cedar Hills Sandstone, which has enough pressure to force water to the surface. The KCC later found that the chloride concentration of water from the irrigation well had increased to 51 mg/L in May 2026 from 7.3 mg/L in October 2024. The KCC collected samples from the irrigation well in June 2026 and sent them to the KGS for analysis. The KCC also found a 1982 report of investigation concerning illegal dumping of saltwater in a trench silo very close to the site of the house and its water well.

METHOD INFORMATION AND DATA

A description of the sample analysis methods is included in KGS Open-File Report No. 2025-25. Sample information and chemical data for the water collected from the oil well and irrigation well in 2026 are listed in table 1. The data for the irrigation well in this table and in table 1 in the previous report were plotted along with the KGS data for the house well (table 1 of the previous report) in fig. 1 to show the relationship for chloride and specific conductance in the Dakota aquifer at the study location.

IDENTIFICATION OF SALINITY SOURCES

The sources contributing to elevated chloride in the groundwater were identified using the geochemical methods described in the previous report. Figures 2 and 3 are updated from the previous report to include points for the 2026 samples from the irrigation well and the backside of the oil well tubing (table 1) and a sample from an observation well in the Cedar Hills Sandstone in Ellis County collected in 1992 during the KGS Dakota aquifer program.

The low bromide/chloride ratio for the brine from the oil well shown on fig. 2 and the higher sulfate/chloride ratio than for oil brine on fig. 3 fit the type of ratios for the dissolution of rock salt in Permian strata in Kansas unaffected by oil brine. The Ellis County sample from the Cedar Hills Sandstone could be affected a little by oil brine disposed in that general area into the sandstone in the past; that could explain the somewhat higher bromide/chloride ratio on fig. 2 than for the brine from the backside oil well tubing and Permian saltwater in the Great Bend Prairie region. The KCC indicated that it thought that the backside tubing brine could be due to a Cedar Hills break in the well, which appears to be correct based on the bromide/chloride and sulfate/chloride ratios at the high chloride concentration.

The chloride concentration of the sample collected in June 2026 from the irrigation well was 51 mg/L (table 1), an increase of 44 mg/L from the October 2024 sample. The trend of the point for 2026 from that for 2024 on figs. 2 and 3 fits the mixing of freshwater in the Dakota aquifer at that location with saltwater derived from the dissolution of rock salt in Permian strata. The rock salt in the Permian is accompanied by anhydrite (calcium sulfate) or gypsum (hydrated calcium sulfate) resulting in the higher sulfate/chloride ratios than for oil brine in which much or most of the sulfate has been chemically reduced to sulfide. Thus, the source of the additional chloride in the irrigation well water from 2024 to 2026 could be contamination of the Dakota aquifer by brine released by the oil well from the Cedar Hills Sandstone if a break also allowed brine to enter the Dakota strata.

Table 1. Sample collection information and chemical data for the waters collected from the backside of the oil well and from the irrigation well. Sp.C. is specific conductance.

KGS lab no.	Site name	Sample date	Sp.C. µS/cm	Cl mg/L	SO4 mg/L	NO3-N mg/L	Br mg/L	Br/Cl x 10000	SO4/Cl
2026026-1	Backside tubing oil well, bottle 1	1/21/2026	98,470	36,970	3,440	0.2	5.3 5.0*	1.43 1.34	0.0931
2026026-2	Backside tubing oil well, bottle 2	1/21/2026	99,100	36,840	3,270	#	#	-	0.0889
2026026-3	Backside tubing oil well, bottle 3	1/21/2026	98,660	36,910	3,270	#	#	-	0.0887
2026201	Irrigation well, bottle 1	6/16/2026	784	51.0	60.8	0.004	0.090	17.5	1.191
2026202	Irrigation well, bottle 2	6/16/2026	780	51.4	60.8	0.002	0.088	17.1	1.184
2026203	Irrigation well, bottle 3	6/16/2026	780	51.2	60.5	0.003	0.090	17.6	1.183

* Sample analyzed for bromide in a dilution six times less dilute than for other analyses. Bromide in sample analyzed at same dilution for other constituents was estimated from chromatogram although below quantifiable limit on chromatogram. Estimate was relatively close to that for less dilute sample for which bromide peak was quantifiable.

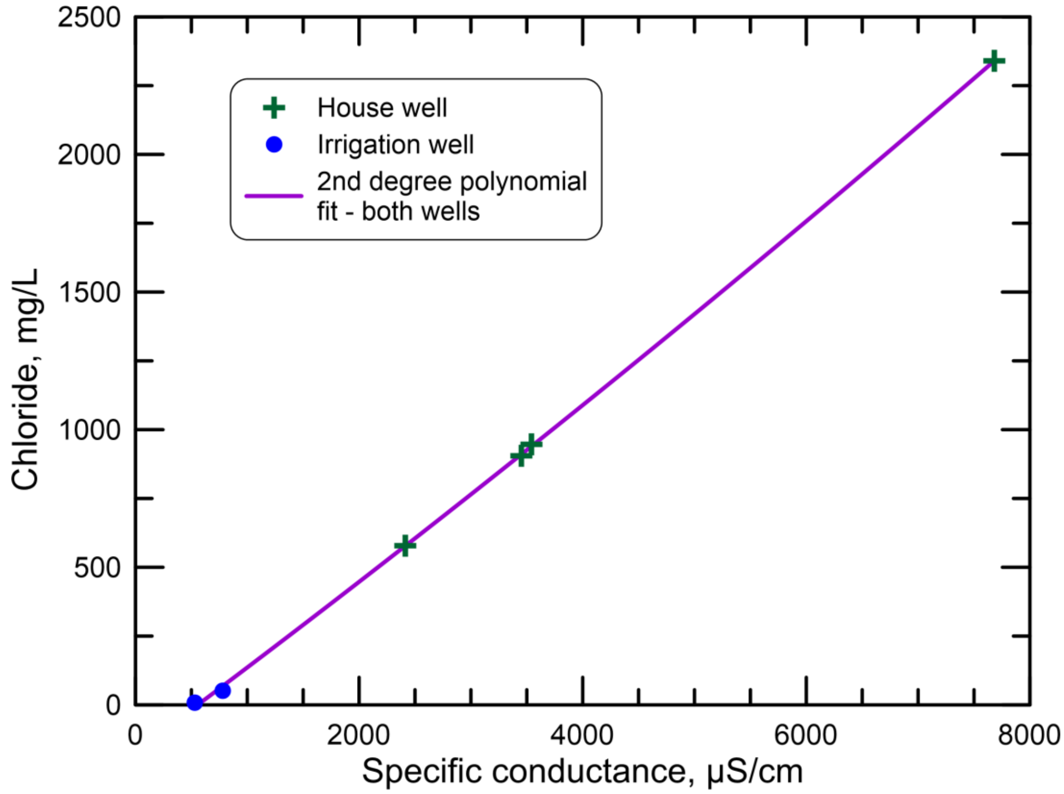

Figure 1. Relationship between specific conductance and chloride concentration for samples collected from the house well on October 16, 2024, and January 17, 2025, and the irrigation well on October 16, 2024, and June 16, 2026, as determined by the KGS.

The KCC discovery of the 1982 report of investigation indicating that oil field saltwater was illegally dumped in a trench silo very close to the site of the house and its well fits with the interpretation of oil brine contamination from the surface. According to a field report, Groundwater Management District No. 5 (GMD5, which includes part of Pawnee County) contacted the Kansas Department of Health and Environment (KDHE), Bureau of Oil Field and Environmental Geology, on August 12, 1982, concerning the dumping. The KDHE found that the landowner had given permission for the dumping for the purpose of weed control in the trench. The KDHE called the owner of the tank truck company and indicated that this dumping was not allowed, and the dumping ceased. A KDHE inspection found dead weeds in the bottom of the trench along its length (100 ft) and approximately 5 ft across its width. The inspection also found a washed-out area where saltwater ran from the tank truck. A KDHE report for August 19, 1982, indicated that the trench silo was "cut into the west bank of an intermittent stream" and that "early dumping had flowed through the silo and out into the drainage valley." The report stated that "An earthen dike (2 ft high) has been placed across the outlet of the silo. … Truck tracks at the upper end of the silo where the dumping took place indicates that probably 6–10 loads of water had been dumped. There is an irrigation well and a domestic well about ¼ mile to the north (down gradient) of the silo. A water sample from the domestic well shows 15 mg/L chloride." The irrigation well had not been sampled at that time (Fred Cure complaint, 1982).

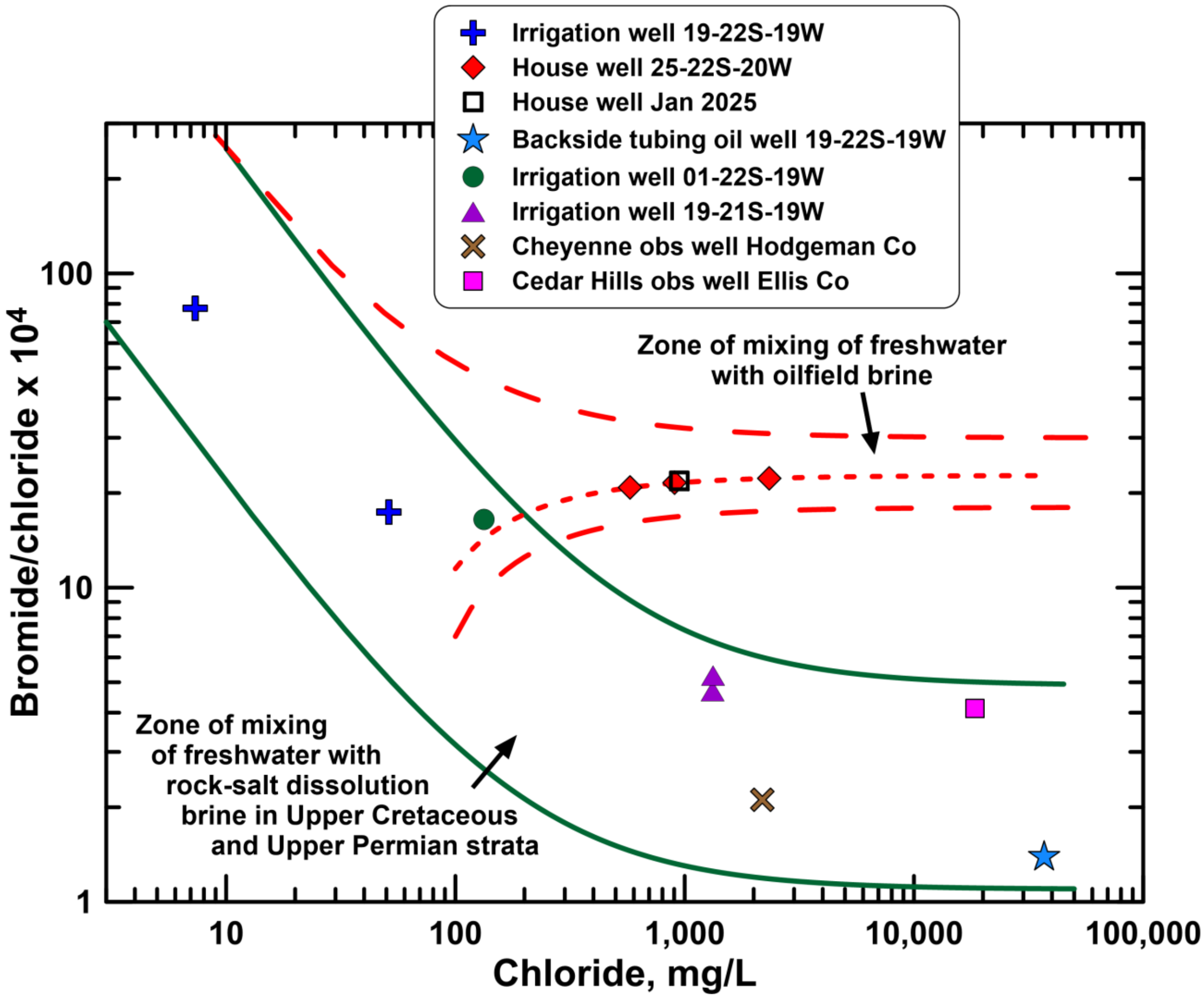

Figure 2. Bromide/chloride ratio versus chloride concentration for groundwater from the house well and nearby irrigation well, two other irrigation wells in Pawnee County, an observation well in the Cheyenne Sandstone in Hodgeman County, an observation well in the Cedar Hills Sandstone in Ellis County, and the backside tubing of an oil well at the study location. Each curve represents the mixing of an end point for freshwater with an end point for either natural saltwater from the Dakota aquifer system and Permian strata or from expected oil brine fitting as a source for the house well salinity. Each pair of solid and long dashed curves encloses a zone of mixing between freshwater and saltwater or brine. The curve with short dashes is calculated to pass through the points for the house well samples.

The typical capacity of an oil field saltwater truck is 4,000–6,000 gal. Based on eight tank loads (approximately 40,000 gal of saltwater) and the average chloride concentration of 73,500 mg/L for the 12 oil brines in Pawnee County in the study area (fig. 3), the mass of chloride discharged into the trench would have been over 11 metric tons. This would have been enough to contaminate nearly 12 million gal of groundwater to the recommended drinking water limit of 250 mg/L for chloride. If the porosity of the Dakota sandstone layers tapped by the house well at the study site were 25%, that could contaminate over 6 million ft^3 of aquifer to over 250 mg/L.

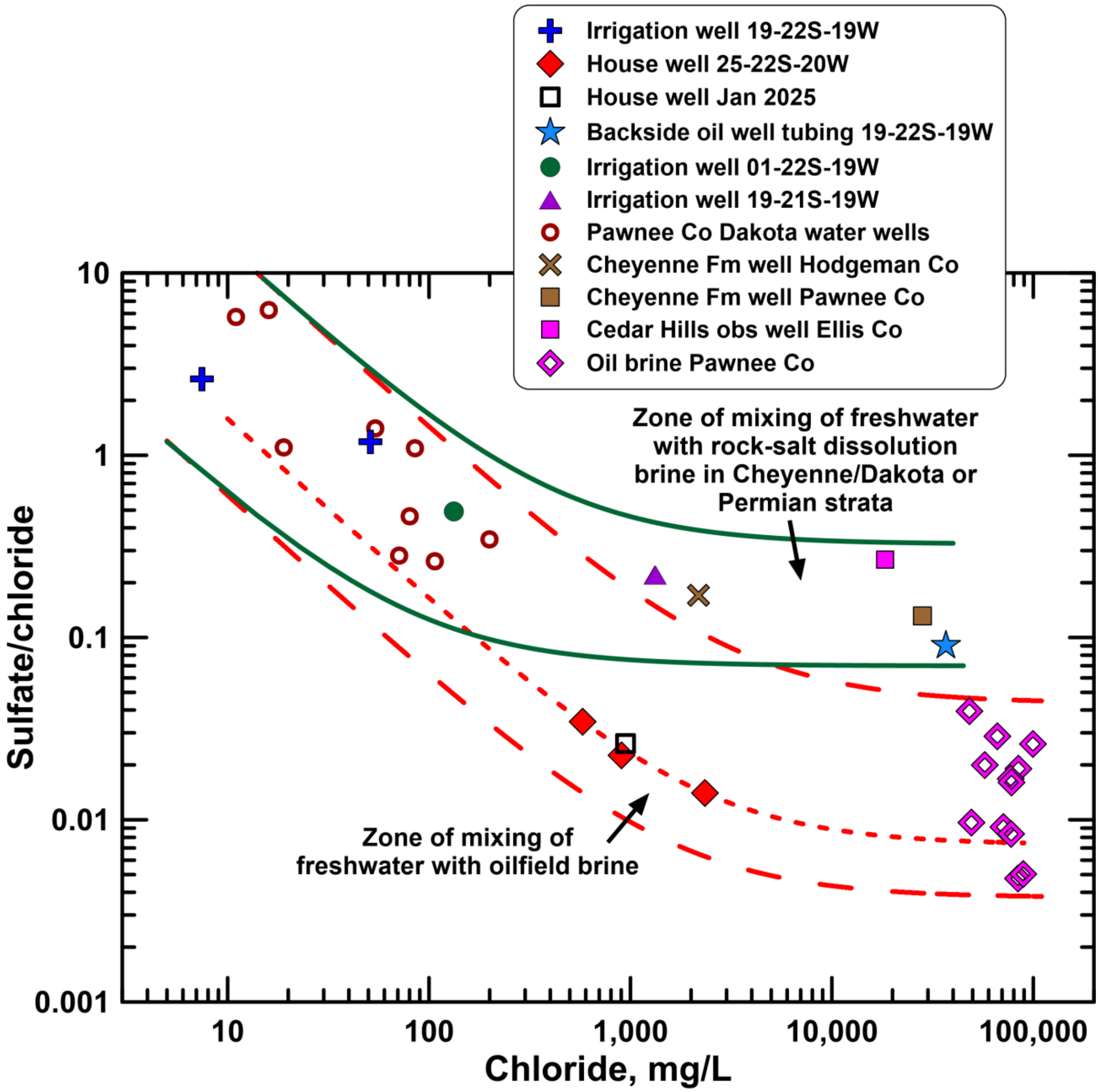

Figure 3. Sulfate/chloride ratio versus chloride concentration for groundwater from the house well, nearby irrigation well, two other irrigation wells in Pawnee County, water wells in the Dakota aquifer within a 10-mile radius of the house well, observation wells in the Cheyenne Sandstone in central Hodgeman and central Pawnee counties, the backside tubing of an oil well at the study location, an observation well in the Cedar Hills Sandstone in Ellis County, and oil brines in Pawnee County. Each curve represents the mixing of an end point for freshwater with an end point for either natural saltwater from the Dakota aquifer system and Permian strata or from oil brines in Pawnee County. Each pair of curves encloses a zone of mixing between freshwater and saltwater or brine.

A black-and-white aerial photo from 1991 available on the online WWC5 water well database of the KGS shows two elongated trenches, each approximately 200 ft long, that extend in a north-south direction at the future house well site (one trench to the north and one to the south). Evidence of the trenches remains in a 2021 color aerial photo; the next available photo from 2023 shows the house being built in the area of the trenches, which are no longer visible. The KDHE 1982 inspection of the trench silo stated that the weeds extended 100 ft along the trench in which the saltwater had been dumped. This likely is the length of the full depth of the trench silo; the additional length on the photos appears to be the sloped entrances at both ends.

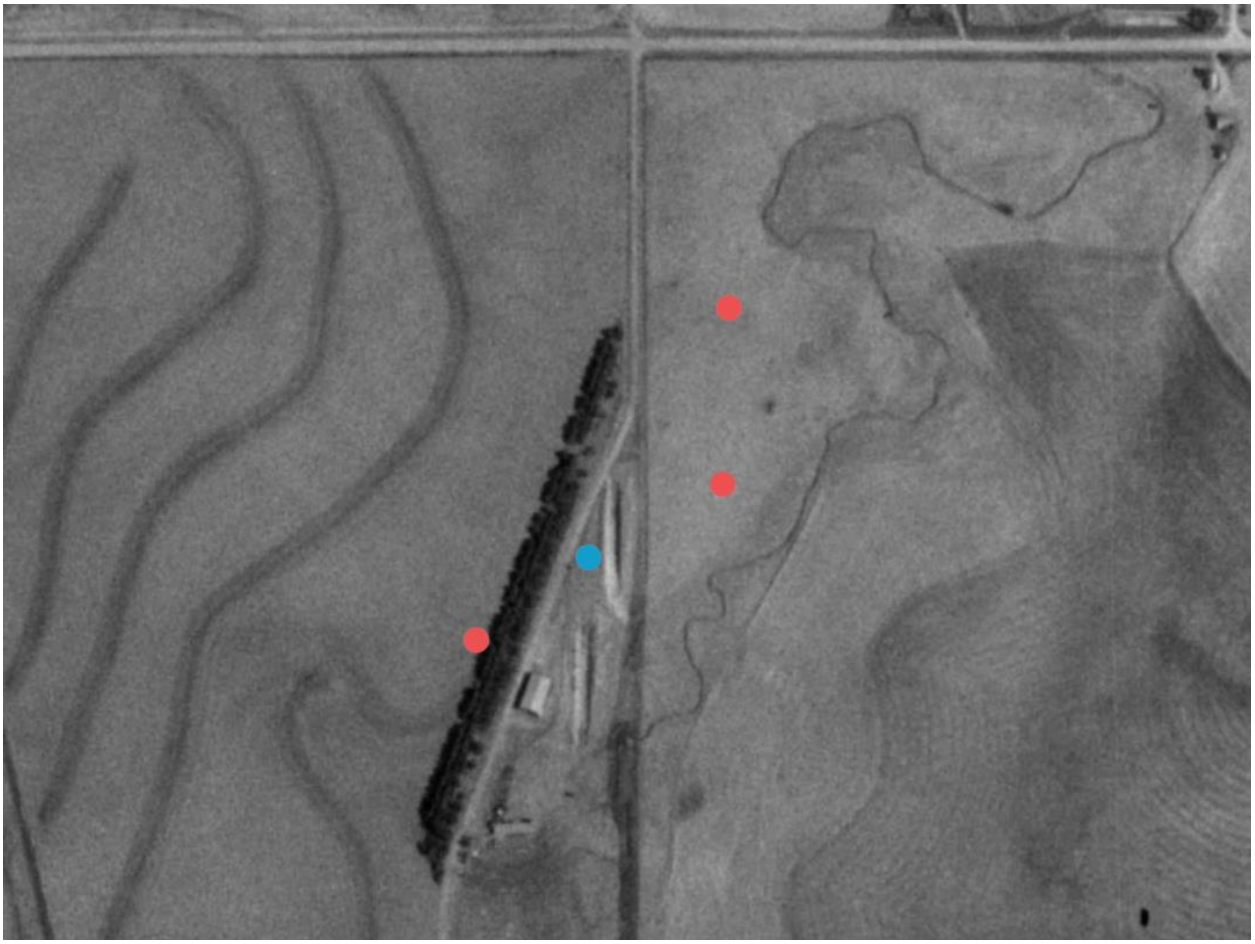

Figure 4. Portion of 1991 aerial photo showing the location of the future house well (blue circle) and three monitoring wells drilled in April and May 2026 for the KCC (red circles).

The house well log indicates a completed depth of 100 ft, a static water level of 43 ft below land surface on the day of completion (February 9, 2023), and lithology of topsoil at a depth of 0–3 ft, clay 3–30 ft, slightly weathered shale 30–50 ft, slightly weathered sandstone 50–83 ft, and slightly weathered shale 83–100 ft. If the static water level were about the same in 1982, only 7 ft of weathered shale was present to impede movement of the saltwater to the sandstone interval. The high salinity of the dumped water would have decreased the swelling of clays in the weathered shale and increased its permeability to allow migration of the saltwater into the sandstone.

The latitude-longitude location of the house well (and the evidence of a small structure at that location near the house on Google map) places it approximately 10 ft west of the northern trench and 150 ft north of the northern end of the southern trench visible in the 1991 aerial photograph. The initial chloride concentration of water sampled from the house well on October 16, 2024, was 2,340 mg/L. Based on the 100 ft length of the full depth part of the trench silo reported by the KDHE in 1982, the 33 ft sandstone interval, a 25% porosity, and migration of the dumped saltwater into the sandstone interval, the dumped saltwater could have contaminated groundwater in the sandstone to 2,340 mg/L chloride in a zone 200 ft long and 81 ft wide. The KDHE report indicated that some of the saltwater ran out of the trench, so the contaminated groundwater footprint could have increased outside of the trench. Part of the saltwater could be in the 7 ft interval of weathered shale below the water table underlying the entire surface of contamination. However, the contamination footprint certainly would encompass the location of the house well.

The contamination footprint and the chloride concentration could be greater than the 2,340 mg/L in the sandstone interval if the saltwater were not distributed evenly through the sandstone at the house well. The prior KGS report discussed possible avenues for saltwater contamination based on the pumping test conducted by the KCC in January 2025, including from the surface and from deeper in the Dakota aquifer. The discussion for the scenario of contamination from the surface indicated that the changes in specific conductance and chloride concentration during the pumping test fit best with a greater salinity in the upper part of the sandstone unit. Then lenses of clay in the sandstone interval could have slowed the downward migration of the saltwater as it mixed with the native Dakota groundwater and the density gradient decreased.

CONCLUSIONS

The prior KGS report indicated that the most probable salinity source contaminating the groundwater of the house well was oil or gas field brine based on the geochemical signature of the groundwater. The 1982 KDHE report of investigation corroborates this as the source because oil brine was found to have been illegally dumped into a trench silo either less than 20 ft to the east or approximately 150 ft to the south of the house well location, depending on which of two trenches visible in aerial photos was the dumping site. Although the amount of saltwater dumped into the silo trench was substantial, if the volume was limited to no more than 10 tank truck loads, the mass of chloride was probably not sufficient to substantially affect the irrigation well northeast of the house well, which has a screened interval of 157–216 ft in the Dakota aquifer below the depth of the 100 ft house well.

The brine from the backside tubing of an oil well approximately a mile to the northeast of the house well and 0.6 mile northeast of the irrigation well was identified as Permian saltwater consistent with the dissolution of rock salt based on its geochemical signature.

The June 2026 sample of the irrigation well had a chloride concentration of 51 mg/L compared to 7.3 mg/L in October 2024. Although the increase in chloride was only 44 mg/L, the trend on plots of bromide/chloride versus chloride and sulfate/chloride versus chloride indicate that the extra chloride fits the addition of Permian saltwater. Thus, the potential of contamination by the brine coming up the backside tubing of the oil well to the northeast bears investigation. A plot of chloride concentration for the house and irrigation well samples displays a high correlation between specific conductance and chloride. Therefore, a simple manner for monitoring the irrigation well water quality would be to measure the conductance of water samples from the well and estimate the chloride concentration using Figure 1. Sampling at the beginning and end of the irrigation season could be valuable. This would determine how extended pumping by the well affects changes in chloride concentration caused by the extension of the drawdown cone toward the oil well where brine had been coming up along the backside tubing.

ACKNOWLEDGMENTS

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