# The Dakota Aquifer of Eastern SEWARD COUNTY, NEBRASKA

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**Dakota Formation Outcrop in Northeast Nebraska**

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## DEDICATION

**This paper is dedicated to the present and future users of the Dakota Aquifer in eastern Seward County, Nebraska who depend on this aquifer as their sole source of drinking water, and agricultural use water.**

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## OVERVIEW

**The well-known High Plains Aquifer in Nebraska (often called the Ogallala Aquifer) stretches across much of Nebraska and in many areas, it yields large amounts of high-quality water. This aquifer in considered to be a primary aquifer in Nebraska. In eastern and extreme northern Nebraska, the High Plains Aquifer does not exist. Domestic water production in this area is often produced from the Dakota Aquifer, and the eastern portion of Seward County is no exception. There are other aquifers located in eastern Nebraska, however, in eastern Seward County, and much of Lancaster County, the Dakota Aquifer is the primary domestic water producer. The Dakota Aquifer is also present across much of Nebraska, but is considered to be a secondary aquifer, meaning that the water in this aquifer does not have the yield or the water quality compared to the High Plains Aquifer. Where the Dakota Aquifer resides below the High Plains Aquifer in Nebraska, it is generally not utilized resulting in very little Dakota Aquifer information being available.**

**In Seward County, the High Plains Aquifer feathers out approximately six miles west of the Lancaster County line. This six-mile-wide area running north and south through eastern Seward County, is the area that residents depend on the Dakota Aquifer for their drinking water, and is the area this paper will examine.**

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## HISTORY

**The age of the Dakota Formation and aquifer is very old. The Dakota Formation resides at the bottom of the Cretaceous time period, dating it to approximately 125 to 145 million years old. The Dakota Aquifer's suitability as a water source is primarily**

the result of melting glaciers, as they withdrew from the central U.S. during warmer time periods, and infiltrated the sandstone units. The surface waters at the time of the Dakota's deposition were subsequently covered up by younger formations, and left in-place. In Seward County, the Dakota Formation sits on top of the much older Paleozoic bedrock units representing a gap in time of around 150 to 200 million years. Groundwater this old has had time to dissolve minerals contained within the surrounding rock, and the Dakota Aquifer of eastern Seward County is no exception, being relatively high in iron, and also containing calcium, magnesium and several other minerals. These minerals are generally not harmful to humans, and are considered to be beneficial by some, however, they can be an issue with indoor porcelain fixtures, and plumbing in general.

## WATER CONSERVATION DISTRICT

In 2007, Seward County adopted resolution #2567, which is better known as the Zoning Regulations of Seward County, Nebraska. Within these zoning regulations, Section 4.13.01 through Section 4.13.05 created a Water Conservation District (WCD) for approximately the eastern 1/3 of Seward County (see figure 1). The WCD was adopted to provide additional criteria to help conserve all aquifers present through conservation practices that restrict intensive uses, and density through zoning regulations. As far back as the early 2000's the Planning and Zoning Commission, and the County Commissioners realized that they had a resource worth conserving. This WCD in Nebraska is the only one in the State, and therefore deserves a closer examination of the Dakota Aquifer.

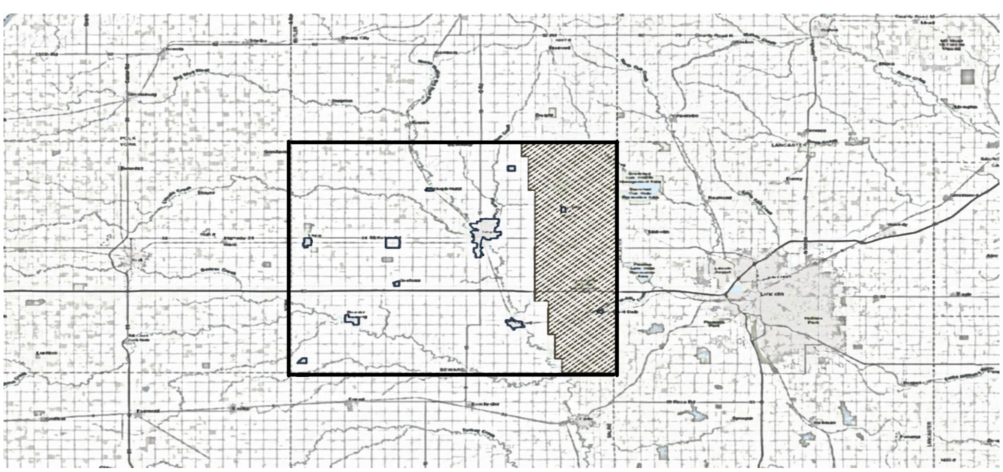


Figure 1. Seward County and Water Conservation District

**The Water Conservation District is roughly bordered on the west side by 224th Road, running north to Butler County, and extending south to Saline County. The east side of the WCD is entirely bordered by Landcaster County. There are small deviations on the northwest and southwest corners of the WCD, but for the purposes of this paper, we will assume a perfect rectangle for this study. This study area will encompass approximately 144 square miles.**

## GEOLOGY

**Three papers published by the University of Nebraska, Conservation and Survey Division, and one professional paper published in 1984 by the USGS will be primarily cited in this paper, and listed in the references section. Dozens of other references are also available, but not listed herein concerning the general Dakota Formation, its aquifer, and water chemical properties.**

**Recharge of the Dakota Aquifer can occur from several mechanisms.**

1. **Soil absorption from rain water and rivers resulting in downward migration. The Dakota Aquifer's average depth in the study area is 322 feet below surface, and with the soils being primarily clay from the surface to the top of the Dakota Formation, very little recharge is likely occurring resulting in the Dakota Aquifer being a confined aquifer (Keech, Engberg 1978, Divine, Sibray 2017). From local observations, it is evident that rain water from eastern Seward County is being discharged into Lancaster County surface water bodies, such as Pawnee Lake and Branched Oak Lake due to relative high surface relief, soil type, and near surface glacial deposits. This rapid runoff allows for very little absorption beyond a few feet in depth during high runoff events. Area ponds should not significantly affect the Dakota Aquifer recharge due their limited lateral extent, and Dakota Aquifer depth.**

2. **Eastward migration of in-place Dakota Aquifer waters. Regional flow of Dakota water is west to east (Gosselin, Harvey, Frost et al. 2001). Very little is known concerning the local east to west water gradient (the speed of aquifer water migration horizontally) due to the lack of local Dakota Aquifer studies. Many aquifers in Nebraska have very slow horizontal migration rates, to almost stationary.**

**These migration rates can typically be in the inches per year range or less. It would be realistic to expect the same in the Dakota Aquifer due to its confinement, depth and recharge rates (Gosselin, Harvey, Frost et al. 2001).**

3. **Aquifer recharge from below. It is well documented that high sodium waters exist below the Dakota Aquifer. With limited recharge from above, this may be the biggest threat to the local aquifer as fresh water is extracted. If the fresh groundwater is extracted at a rate that cannot be maintained by recharge, then the water chemistry will change as the interface between fresh and saline waters move. (Gosselin, Harvey, Frost, 2001). The source of the high sodium chloride is probably dissolution of evaporite layers in underlying Paleozoic rocks; the saline water in the Paleozoic rocks moves into the Dakota Aquifer where the pressure head pushes groundwater upward through gaps in the confining units. (Kelly, 2011; Harvey et al., 2007). Confined aquifers also experience more drawdown than do unconfined aquifers, resulting in an increased upward migration of the waters from below (Divine, Sibray, 2017). Geologists and engineers understand that over pumping of any aquifer can result in waters migrating upwards from a lower aquifer into a higher aquifer, and in the case of the Dakota Aquifer, the lower water is saline.**

## WELL LOG DATA

**Over 100 water-well drillers logs located within the WCD were examined for empirical geological data by the author. Of these, 81 well logs were finally selected for the geological data used in this overview (see attachment 1). These well logs and drilling data are available to the public from the Nebraska Department of Natural Resources (NDNR) website. The water wells used in this study are indicated on Attachment 2, and numbered from 1 through 81. Many other types of wells are also shown on the map, including abandoned wells, geothermal wells, monitor wells, and wells completed in shallower aquifers. These shallow aquifers are often very limited in aerial extent, thickness, low pumping capabilities due to capacity, and several other problems which will not be addressed here.**

**From Attachment 1, it is noted that the Dakota Aquifer in Eastern Seward County ranges in depth from 462 feet below surface, to 173 feet below surface. These depths are consistent with the general trend of the Dakota Aquifer becoming shallower as it moves east into Lancaster County. This trend is supported in the study area with the**

**deepest Dakota Aquifer wells residing in the western part of the WCD, and the shallowest Dakota Aquifer wells in extreme eastern Seward County. The examined well logs also indicate that the average thickness of the Dakota Aquifer is approximately 17 feet thick overall in the study area, but this number may be optimistic due to well sample interpretation at the time of drilling. More exact measurements of the Dakota Aquifer in Seward County have indicated the Dakota Aquifer thickness is typically between four and 12 feet. The well log overall average aquifer thickness of 17 feet in Seward County raises concerns about the total fresh water capacity held within the aquifer. Comparably, aquifer thickness of the High Plains Aquifer can be more than a thousand feet thick (Weeks & Gutentag et al., 1984).**

## SUMMARY

**Seward County has designated the area of eastern Seward County as a Groundwater Conservation District because of several concerns with the Dakota Aquifer. The geohydrologic assessment of these concerns appears to be valid. Continuing residential development, and water well placement in eastern Seward County, will place additional demands on the aquifer system. The limited thickness of the aquifer (fresh water capacity), minimal fresh water recharge rates into the aquifer, and probable recharge of the aquifer from a deeper saline aquifer, support the current Seward County density restrictions within the Water Conservation District.**

### REFERENCES

**Keech, C.F. 1978, Water Resources of Seward County, Nebraska. Nebraska Water Survey Paper 46. Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.**

**Divine, D. and S. Sibray 2017, An Overview of Secondary Aquifers in Nebraska. Education Circular 26. Conservation and Survey Division, School of Natural Resources, University of Nebraska-Lincoln.**

**Gosselin, D.C., F. Edwin Harvey, Carol D. Frost, 2001, Geochemical Evolution of Ground Water in the Great Plains (Dakota) Aquifer of Nebraska: Implications for the Management of a Regional Aquifer System, School of Natural Resources, University of Nebraska-Lincoln.**

**Gutentag, E.D., F.J. Heimes, N.C. Krothe, R.R. Luckey, J.B. Weeks, 1984, Geohydrology of the High Plains Aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. U. S. Geological Survey Professional Paper 1400-B.**

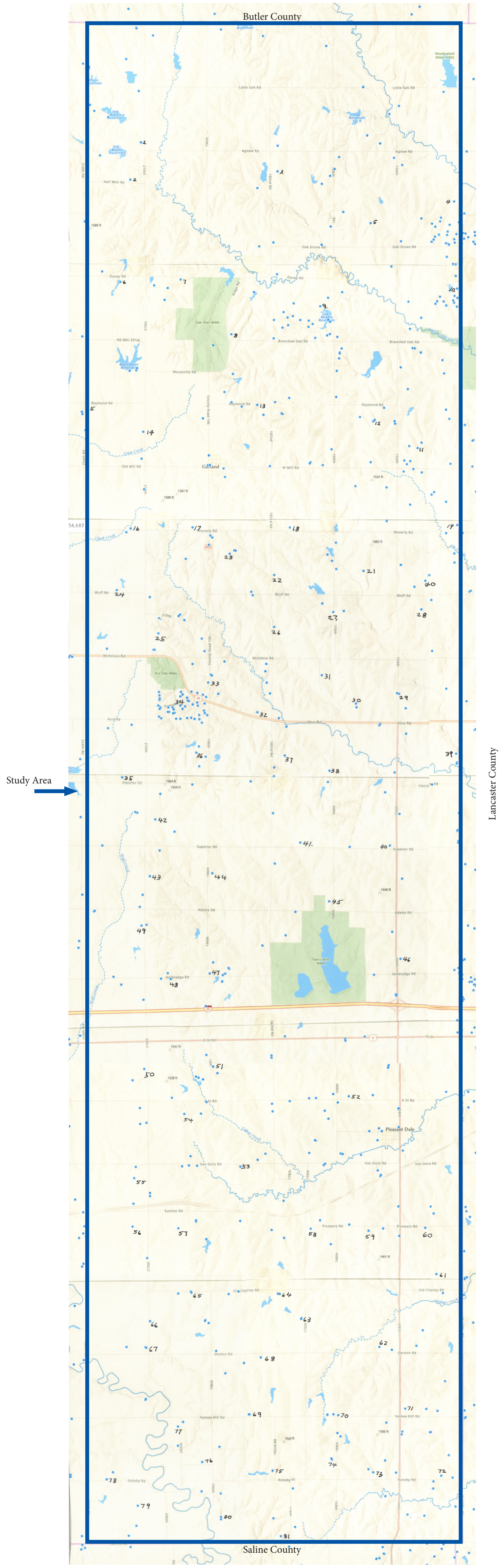
### ACKNOWLEDGEMENTS

**Reviews by Richard Ehrman, Nebraska Professional Geologist G-023, and Kathleen Cameron, Nebraska Professional Geologist, G-0283, plus two anonymous reviewers significantly improved this paper.**

| Map Well Number | DNR Reg. Number | Legal S-T-R | Depth to Dakota Aquifer from surface. | Estimated thickness of Dakota Aquifer. |
|---|---|---|---|---|
| **1** | **G-139650** | **SE SE 7-12-4** | **450’** | **20’** |
| **2** | **G-142457** | **NE NW 18-12-4** | **373’** | **24’** |
| **3** | **G-110369** | **SW NW 15-12-4** | **372’** | **12’** |
| **4** | **G-116688** | **SE SE 13-12-4** | **320’** | **9’** |
| **5** | **G-121950** | **NW NE 23-12-4** | **352’** | **15’** |
| **6** | **G-153699** | **NW NE 30-12-4** | **398’** | **5’** |
| **7** | **G-197687** | **NW NE 29-12-4** | **425’** | **20’** |
| **8** | **G-099129** | **SE SW28-12-4** | **417’** | **20’** |
| **9** | **G-117781** | **SE NE 27-12-4** | **277’** | **20’** |
| **10** | **G-195837** | **NE NE 25-12-4** | **173’** | **20’** |
| **11** | **G-105251** | **NE SW 1-11-4** | **327’** | **10’** |
| **12** | **G-109467** | **NW NE 2-11-4** | **270’** | **5’** |
| **13** | **G-141441** | **NE NE 4-11-4** | **282’** | **10’** |
| **14** | **G-100555** | **SE NE 6-11-4** | **462’** | **15’** |
| **15** | **G-197999** | **NW NW 6-11-4** | **440’** | **15’** |
| **16** | **G-141286** | **SW SE 7-11-4** | **397’** | **16’** |
| **17** | **G-107790** | **SW SE 8-11-4** | **429’** | **10’** |
| **18** | **G-198311** | **SE SW 10-11-4** | **290’** | **30’** |
| **19** | **G-176291** | **SE SE 12-11-4** | **288’** | **15’** |
| **20** | **G-115319** | **SE SW 13-11-4** | **374’** | **10’** |
| **21** | **G-089517** | **NE SW 14-11-4** | **395’** | **25’** |
| **22** | **G-195847** | **NW SW 1 5-11-4** | **350’** | **20’** |
| **23** | **G-168414** | **SE NW 16-11-4** | **403’** | **7’** |
| **24** | **G-175107** | **SW SE 18-11-4** | **390’** | **10’** |
| **25** | **G-194920** | **NW SW 20-11-4** | **440’** | **20’** |
| **26** | **G-198334** | **NW SW 22-11-4** | **310’** | **30’** |
| **27** | **G-148958** | **SE NE 22-11-4** | **263’** | **12’** |
| **28** | **G-190667** | **NE NW 24-11-4** | **316’** | **20’** |
| **29** | **G-107546** | **NW SW 25-11-4** | **327’** | **20’** |
| **30** | **G-168012** | **NE SW 26-11-4** | **312’** | **11’** |
| **31** | **G-098159** | **SE NE 27-11-4** | **346’** | **12’** |
| **32** | **G-132728** | **SE SE 26-11-4** | **314’** | **10’** |
| **33** | **G-080538** | **SE NE 29-11-4** | **308’** | **20’** |
| **34** | **G-185826** | **SW SE 29-11-4** | **460’** | **13’** |
| **35** | **G-136933** | **SW SE 31-11-4** | **431’** | **12’** |
| **36** | **G-085101** | **NE SE 32-11-4** | **444’** | **4’** |
| **37** | **G-139960** | **NW SW 34-11-4** | **340’** | **23’** |
| **38** | **G-098246** | **SE SE 34-11-4** | **303’** | **23’** |
| **39** | **G-110656** | **NE SE 36-11-4** | **180’** | **10’** |
| **40** | **G-176976** | **SE SE 2-10-4** | **282'** | **10'** |
| **41** | **G-085851** | **SE SW 3-10-4** | **204'** | **24'** |

| | | | | |
|---|---|---|---|---|
| 42 | G-120118 | NW SW 5-10-4 | 425' | 15' |
| 43 | G-104546 | SW NW 8-10-4 | 406' | 8' |
| 44 | G-129091 | SW NW 9-10-4 | 407' | 23' |
| 45 | G-140492 | SE SE 10-10-4 | 228' | 20' |
| 46 | G-141846 | SW SW 13-10-4 | 189' | 5' |
| 47 | G-080509 | SW SW 16-10-4 | 358' | 10' |
| 48 | G-139932 | NE NW 20-10-4 | 379' | 25' |
| 49 | G-107184 | SE NE 18-10-4 | 376' | 14' |
| 50 | G-124430 | SE SW 29-10-4 | 400' | 25' |
| 51 | G-091016 | SE NW 28-10-4 | 380' | 24' |
| 52 | G-137815 | SW SW 26-10-4 | 223' | 20 |
| 53 | G-092573 | NE NW 4-9-4 | 297' | 18' |
| 54 | G-145943 | NW NE 32-10-4 | 380' | 25' |
| 55 | G-112958 | NE NE 6-9-4 | 356' | 20' |
| 56 | G-166777 | NE NE 7-4-9 | 365' | 19' |
| 57 | G-167017 | NE SE 6-9-4 | 398' | 9' |
| 58 | G-142699 | NW NE 19-9-4 | 215' | 17' |
| 59 | G-182245 | NW NE 11-9-4 | 255' | 25' |
| 60 | G-168880 | NE NW 12-9-4 | 230' | 45' |
| 61 | G-156904 | SW SE 12-9-4 | 259' | 11' |
| 62 | G-118784 | SW SE 14-9-4 | 222' | 16' |
| 63 | G-176789 | SE NW 15-9-4 | 293' | 11' |
| 64 | G-185451 | NW NW 5-4-9 | 253' | 22' |
| 65 | G-173898 | NW NE 17-9-4 | 260' | 23' |
| 66 | G-186415 | SW NW 17-4-9 | 300' | 23' |
| 67 | G-134959 | SE SE 18-9-4 | 260' | 20' |
| 68 | G-082834 | NE NE 21-9-4 | 262' | 35' |
| 69 | G-173917 | SW SE 21-9-4 | NA | NA |
| 70 | G-146164 | SW SW 23-9-4 | 335' | 9' |
| 71 | G-153253 | SW SW 24-9-4 | 324' | 12' |
| 72 | G-164478 | SW SE 25-9-4 | 307' | 10' |
| 73 | G-130509 | SW SE 26-9-4 | 199' | 14' |
| 74 | G-175769 | NE SE 27-9-4 | 288' | 15' |
| 75 | G-149105 | SE SE 28-9-4 | 265' | 29' |
| 76 | G-139577 | NE SE 29-9-4 | 246' | 27' |
| 77 | G-103762 | NE NW 29-9-4 | 280' | ? |
| 78 | G-104565 | SE SW 30-9-4 | 245' | 11' |
| 79 | G-157780 | NE SE 31-9-4 | 233' | 12' |
| 80 | G-106259 | NW SW 33-4-9 | 183' | 5' |
| 81 | G-182027 | SW SW 34-9-4 | 262' | 11' |
| Average | | | 322.2 | 16.7 |

**Attachment 1.**




Attachment 2.