2013 Nebraska Groundwater Quality Monitoring Report

Prepared Pursuant
to Neb. Rev. Stat. §46-1304
(LB329 – 2001)

Nebraska Department of Environmental Quality
Water Quality Assessment Section
Groundwater Unit
December 2013

Photo on front cover:

Farmer checking pivot in northeast Buffalo County, Dale R. Link

Acknowledgements:

This report would not be possible without the cooperation of the agencies and organizations contributing groundwater data to the "Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater", most notably the State's 23 Natural Resources Districts. The University of Nebraska must be thanked for their on-going work on the Database and attention to detail in assessing the quality of data presented for inclusion. Thanks to Marty Link and Ryan Chapman, NDEQ, for most of the maps and data analysis for this report, while Marty Link, Jon Kenning, and Tom Lamberson, NDEQ helped with editing, and Tom Heatherly for his statistical expertise. Direct any questions regarding this report to David Miesbach, Groundwater Unit, NDEQ, at (402) 471-4982.

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2013 Nebraska Groundwater Quality Monitoring Report

Introduction

The 2001 Nebraska Legislature passed LB329 (Neb. Rev. Stat. §46-1304) which, in part, directed the Nebraska Department of Environmental Quality (NDEQ) to report on groundwater quality monitoring in Nebraska. Reports have been issued annually since December 2001. The text of the statute applicable to this report follows:

> "The Department of Environmental Quality shall prepare a report outlining the extent of ground water quality monitoring conducted by natural resources districts during the preceding calendar year. The department shall analyze the data collected for the purpose of determining whether or not ground water quality is degrading or improving and shall present the results to the Natural Resources Committee of the Legislature beginning December 1, 2001, and each year thereafter. The districts shall submit in a timely manner all ground water quality monitoring data collected to the department or its designee. The department shall use the data submitted by the districts in conjunction with all other readily available and compatible data for the purpose of the annual ground water quality trend analysis."

The section following the statute quoted above (§ 46-1305), requires the State's Natural Resources Districts to submit an annual report to the legislature with information on their water quality programs, including financial data. That report has been prepared by the Nebraska Association of Resources Districts and is being issued concurrently with this groundwater quality report.

Groundwater in Nebraska

Groundwater can be defined as water that occurs in the open spaces below the surface of the earth (Figure 1). In Nebraska (as in many places worldwide), useable groundwater occurs in voids or pore spaces in various layers of geologic material such as sand, gravel, silt, sandstone, and limestone. These layers are referred to as aquifers where such geologic units yield sufficient water for human use. In parts of the state, groundwater may be encountered just a few feet below the surface, while in other areas, it may be a few hundred feet underground. This underground water "surface" is usually referred to as the water table, while water which soaks downward through overlying rocks and sediment to the water table is called recharge as shown in Figure 2. The amount of water that can be obtained from a given aquifer may range from a few gallons per minute (which is just enough to supply a typical household) to many hundreds or even thousands of gallons per minute (which is the yield of large irrigation, industrial or public water supply wells).

Public Water Supply well capable of pumping thousands of gallons per minute (Hastings, NE).

Depth & Velocity of Groundwater

The depth to groundwater plays a very important role in Nebraska's valuable water resource. Obviously, a shallow well is cheaper to drill, construct, and pump. Conversely, shallow groundwater is more at-risk from impacts from human activities. Surface spills, application of agricultural chemicals, effluent from septic tank leach fields, and other sources of contamination will impact shallow groundwater more quickly than groundwater found at depth. The map in Figure 3 shows the great variation of depth to water across the State.

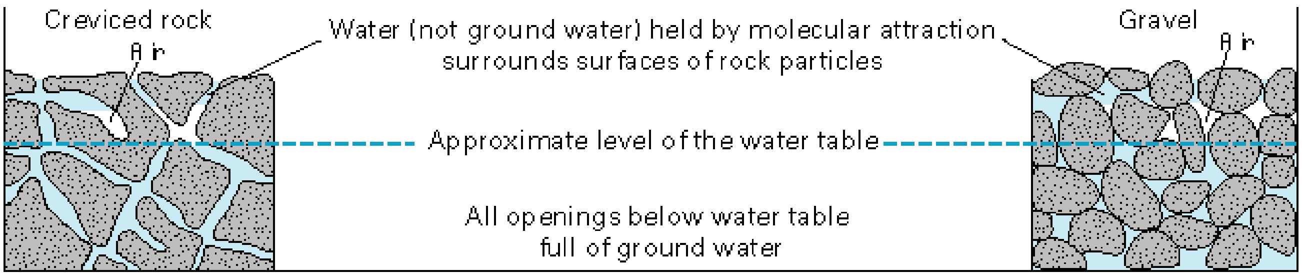


Figure 1. Basic aquifer concepts (U.S. Geological Survey).

In general, groundwater flows very slowly, especially when compared to the flow of water in streams and rivers. Many factors determine the speed of groundwater and most of these factors cannot be measured or observed directly. Basic groundwater features are shown in Figures 1 and 2. The most important geologic characteristics that impact groundwater movement are as follows:

- The sediments in the saturated zone of the aquifer – for example, groundwater generally flows faster through gravel sediments than clay sediments.
- The 'sorting' of the sediments. Groundwater in aquifers with a mix of clay, sand, and gravel (poor sorting) generally does not flow as fast as in aquifers that are composed of just one sediment, such as gravel (good sorting).
- The 'gradient' of the water table. Groundwater flows from higher elevations toward lower elevations under the force of gravity. In areas of high relief, groundwater flows faster. A typical groundwater gradient in Nebraska is 10 feet of drop over a mile (0.002 ft/ft).
- Well pumping influences. In areas of the State with numerous high capacity wells (mainly irrigation wells), groundwater velocity and direction can be changed seasonally as water is pumped.

Ultimately, groundwater scientists have determined that groundwater in Nebraska can flow as fast as one to two feet per day in areas like the Platte River valley and as slow as one to two inches per year in areas like the Pine Ridge in northwest Nebraska or the glacially deposited sediments in southeast Nebraska.

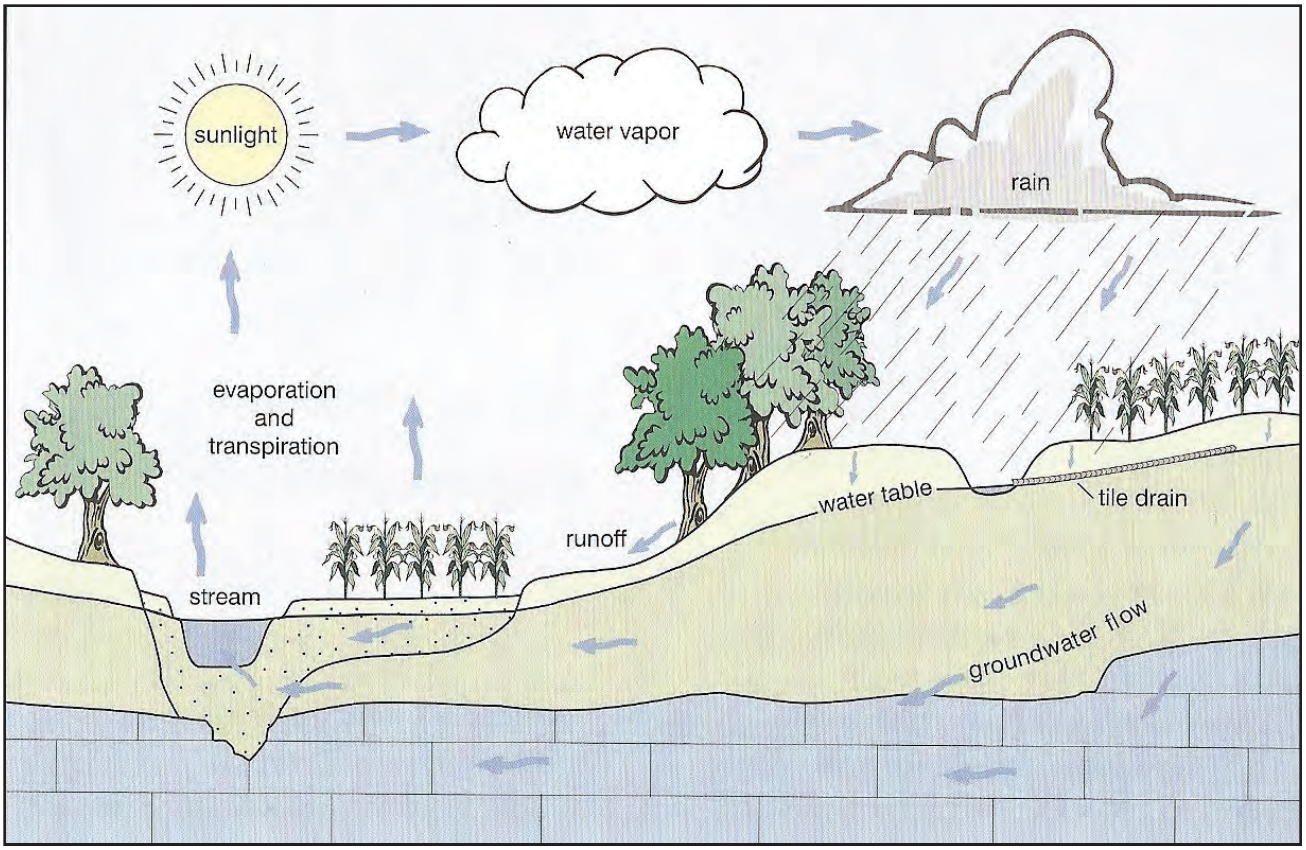


Figure 2. Generalized hydrologic cycle. (Prior, 2003).

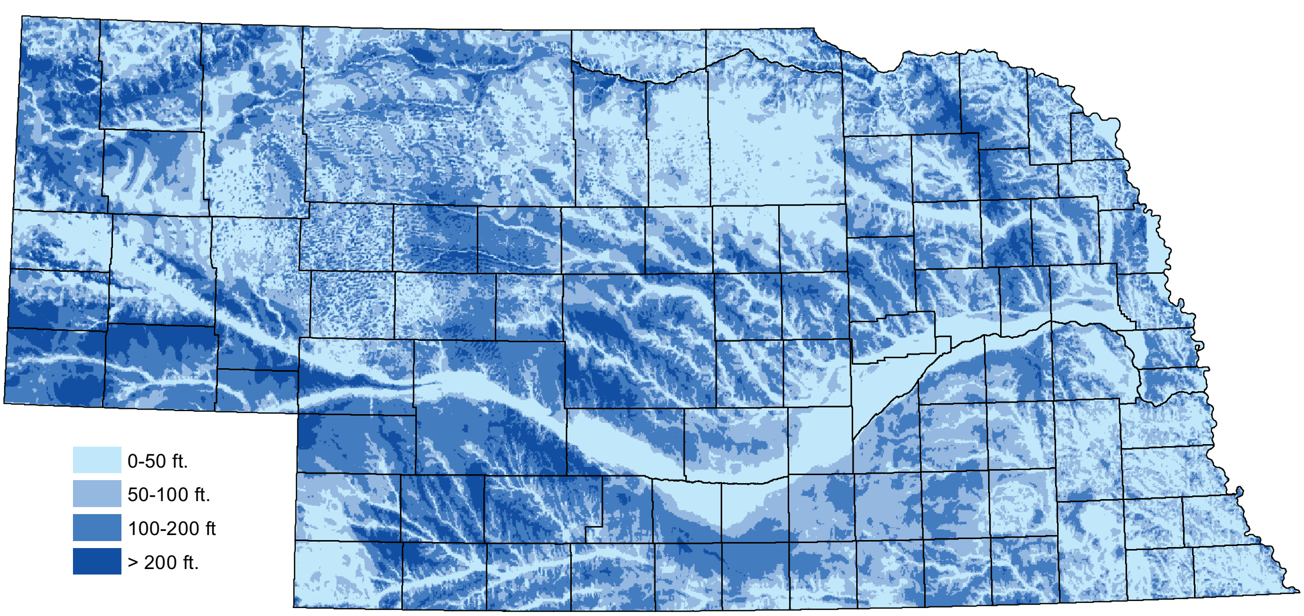


Figure 3. Generalized depth to groundwater. (Source: University of Nebraska, Conservation and Survey Division, 1998)

Geology and Groundwater

Nebraska has been "underwater" most of its history. Ancient seas deposited multiple layers of marine sediments that eventually formed sandstone, shale and limestone. These units are now considered "bedrock" and have limited fresh water supplies, such as in portions of the Dakota and Niobrara. After the seas retreated, huge river systems deposited sand and gravel eroded from mountain building to the west to form groundwater bearing formations such as the lower Chadron, Ogallala (Figure 4 and 5) and Broadwater. Next, the combination of erosion (statewide) and glaciation in the east introduced new material that was deposited by wind, water and ice to form the remainder of the High Plains Aquifer (Figure 4 and 5).

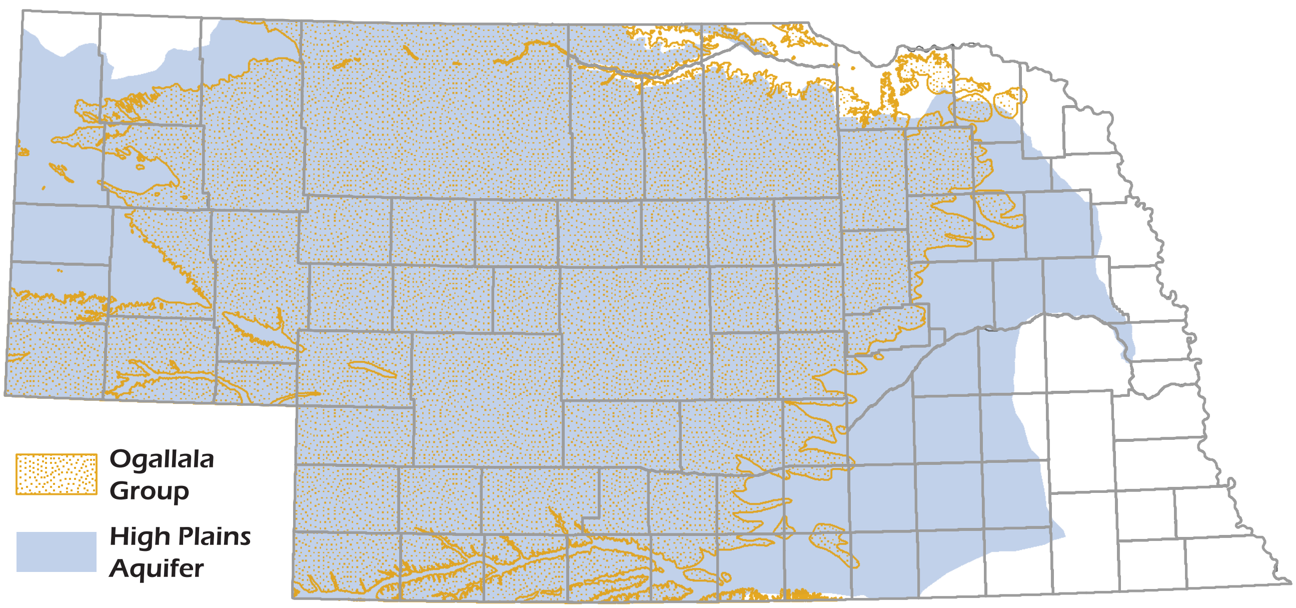


Figure 4. Map of the High Plains aquifer identifying the Ogallala Group. (Source: University of NE, Conservation and Survey Division, 2013)

The High Plains Aquifer is a conglomeration of many separate groundwater bearing formations such as the Brule, Arikaree, Ogallala, Broadwater, and many more recent unnamed deposits (including the Sand Hills). Many of the unnamed deposits are found mainly within the stream valleys (recent or ancient) and are a common source of groundwater (Figure 6, left pane). No single formation completely covers the entire state. However, when these numerous formations and deposits are combined, they form the High Plains Aquifer, covering almost 90% of Nebraska.

There are parts of eastern Nebraska where the High Plains Aquifer is not present. These areas rely heavily on groundwater from buried ancient river channels, recent alluvial valleys (Missouri, Platte, and Nemaha Rivers) or surface water intakes from the Missouri River (Figure 6, right pane).

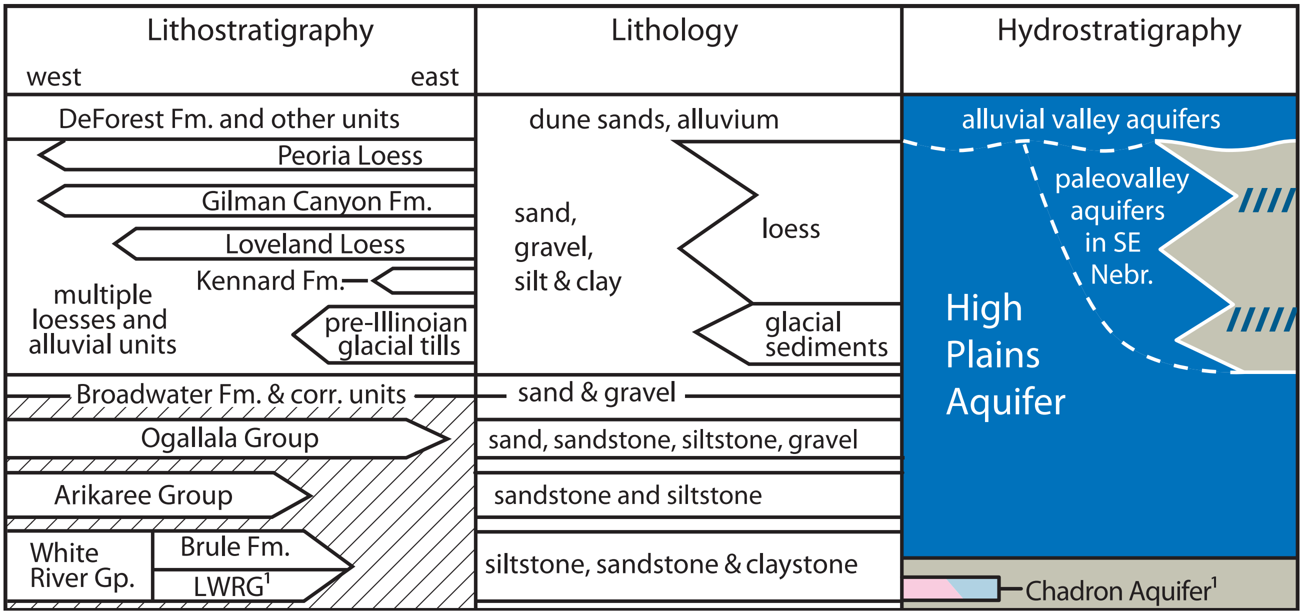


Figure 5. Excerpts from the generalized geologic and hydrostratigraphic framework of Nebraska. (Source: University of NE, Conservation and Survey Division, 2013)

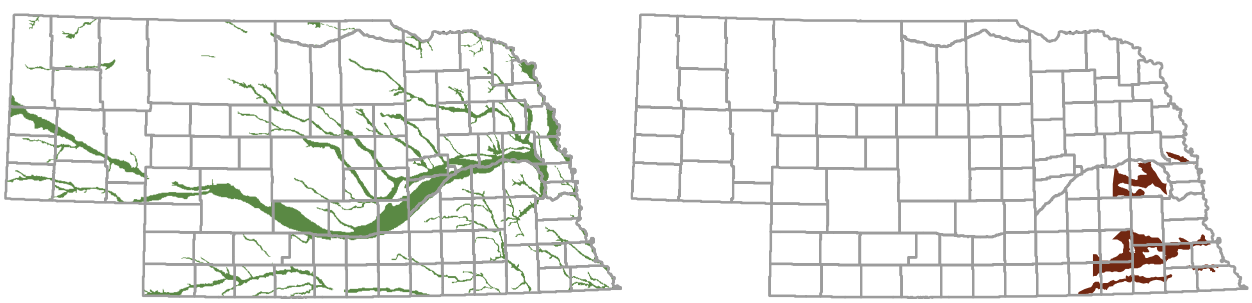


Figure 6. Map of valleys topographic region (left) and paleovalley aquifers (right). (Source: University of Nebraska, Conservation and Survey Division, 2013)

Importance of Groundwater

Nebraska is one of the most groundwater-rich places in the entire world. Approximately 88% of the state's residents rely on groundwater as their source of drinking water. If the public water supply for the Omaha metropolitan area (which gets about a third of its water supply from the Missouri River) isn't counted, this rises to nearly 99%. Essentially all of the rural residents of the state use groundwater for their domestic supply. Not only does Nebraska depend on groundwater for its drinking water supply, the state's agricultural industry utilizes vast amounts of groundwater to irrigate crops. Most of Nebraska experiences variable amounts of precipitation throughout the year, so irrigation is used, where possible, to ensure adequate amounts of moisture for raising such crops as corn, soybeans, alfalfa, and edible beans. As of November 2013, the Nebraska Department of Natural Resources (NDNR) listed 94,882 active irrigation wells and 26,596 active domestic wells registered in the state. Domestic wells were not required to be registered with the state prior to September 1993, therefore thousands of domestic wells exist that are not registered with the NDNR. Figures 7 and 8 and information shown in Table 1 help illustrate this.

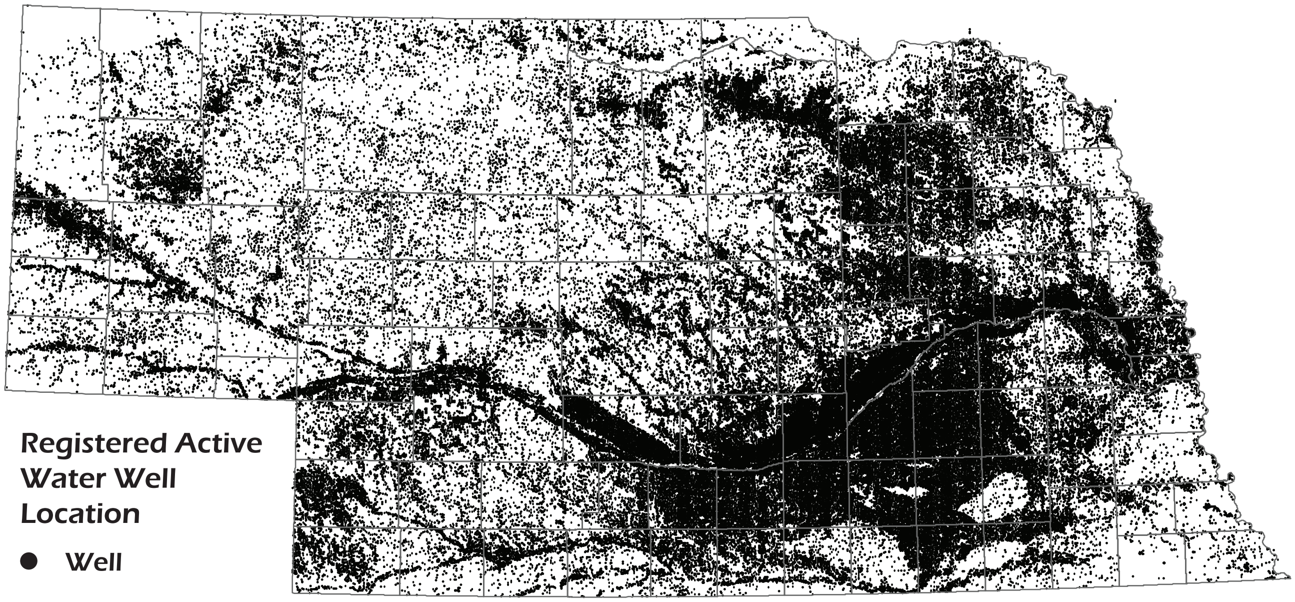


Figure 7. Active registered water wells as of November 2013. (Source: Nebraska Department of Natural Resources Registered Well Database, 2013)

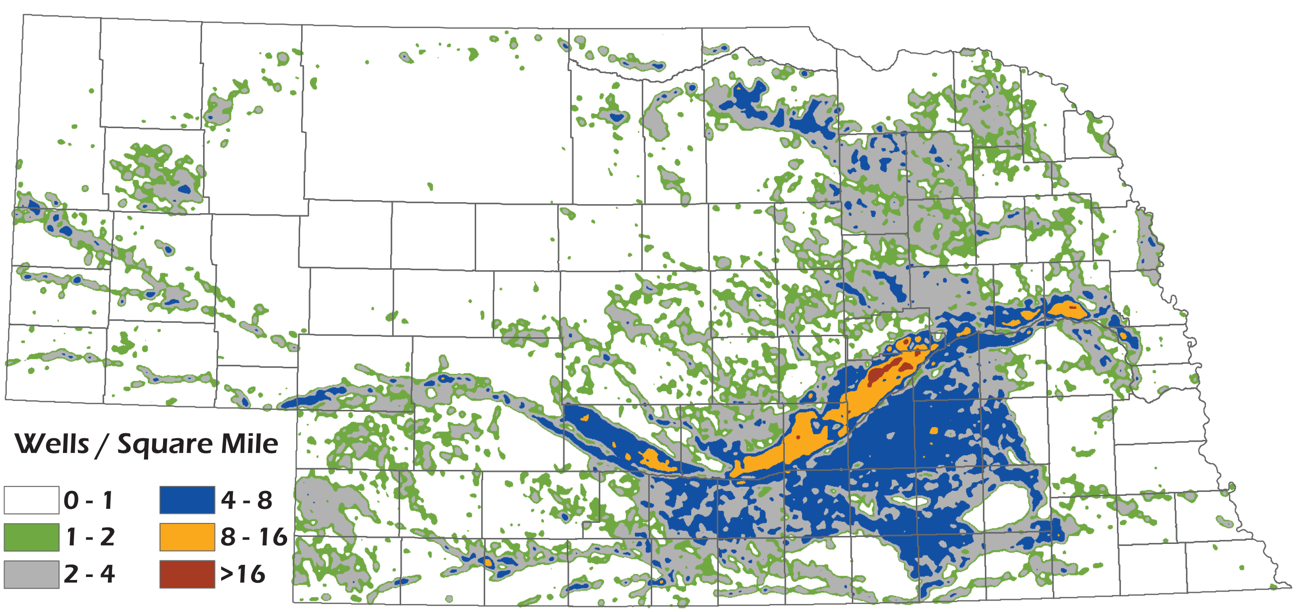


Figure 8. Density of active registered irrigation wells as of November 2013. (Source: Nebraska Department of Natural Resources Registered Well Database, 2013)

Flowing artesian irrigation well near Verdel, NE.

Water Use	Active
Irrigation	94,882
Domestic	26,596
Livestock	17,059
Monitoring (groundwater quality)	16,358
Public Water Supply	3,024
Commercial/Industrial	1,668
Other	11,866
TOTAL	171,453

Table 1. Registered water wells and use as of November 2013. (Source: Nebraska Department of Natural Resources Registered Well Database, 2013)

Groundwater Monitoring

The previous information clearly shows that groundwater is vital to the well-being of all Nebraskans. Fortunately, our state has a long tradition of progressive action in monitoring, managing, and protecting this most precious resource. Several agencies perform monitoring of groundwater for a variety of purposes.

Those entities include:

- Natural Resources Districts (23)
- Nebraska Department of Agriculture
- Nebraska Department of Environmental Quality
- Nebraska Department of Health and Human Services
- University of Nebraska-Lincoln
- United States Geological Survey

Groundwater monitoring performed by these organizations meets a variety of needs, and therefore is not always directly comparable. For instance, the state's 23 Natural Resources Districts (NRDs) perform groundwater monitoring primarily to address contaminants over which they have some jurisdiction; mainly nitrates and agricultural chemicals. In contrast, the state's 1306 public water suppliers monitor groundwater for a large number of possible pollutants which could impact human health. These include basic field parameters, agricultural compounds, and industrial chemicals. Not only are these samples analyzed for many different parameters, the methods used for sampling and analysis vary widely as well.

Lower Platte South Natural Resources District staff sampling an irrigation well.

Partly in response to this situation, the Nebraska Departments of Agriculture (NDA) and Environmental Quality and the University of Nebraska - Lincoln (UNL) began a project in 1996 to develop a centralized data repository for groundwater quality information that would allow comparison of data obtained at different times and for different purposes. The result of this project is the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater (referred to as the Database in this publication). The Database brings together groundwater data from many different sources and provides public access to this data.

The Database serves two primary functions. First, it provides to the public the results of groundwater monitoring for agricultural compounds in Nebraska as performed by a variety of entities. At present, agricultural contaminants (mainly nitrate and pesticides) are the focus of the Database because of their widespread use, and also because historical data suggests that these compounds pose the greatest threat to the quality of groundwater across Nebraska. Second, the Database provides an indicator of the methodologies that were used in sampling and analysis for each of the results. UNL staff examine the methods used for sampling and analysis to assign a quality "flag" consisting of a number from 1 to 5 to each of the sample results. The flag depends upon the amount and type of quality assurance/quality control (QA/QC) that was identified in obtaining each of the results. The higher the "flag" number, the better the QA/QC, and the higher the confidence in that particular result.

During the past several years, UNL staff have worked vigorously to establish contact with all the entities performing groundwater monitoring of agricultural chemicals (nitrates and pesticides) in Nebraska. Groundwater data is submitted to UNL by these entities each year, where it is assigned a quality "flag" and entered into the Database. The updated information is then forwarded to the Nebraska Department of Natural Resources (NDNR), which places the data on its website (http://www.dnr.ne.gov/ or more specifically http://dnrdata.dnr.ne.gov/clearinghouse/). The Database can be accessed and searched at NDNR's website for numerous subsets of data, sorted by county, type of well, Natural Resources District, etc.

Groundwater Quality Data

Groundwater quality data presented in the remainder of this report reflect the data present in the Database as of October 1, 2013. The dates for these data range from mid-1974 to 2012. Groundwater results from some of the agencies working in Nebraska have not been submitted to UNL to be entered into the Database, but NDEQ is confident that the information presented represents the majority of sample results available. Table 2 lists each agency producing groundwater quality data for this report.

Agency	
Central Platte NRD	Nebraska Department of Health and Human Services
Hastings Utilities	
Lewis & Clark NRD	Nemaha NRD
Little Blue NRD	North Platte NRD
Lower Big Blue NRD	Papio-Missouri River NRD
Lower Elkhorn NRD	South Platte NRD
Lower Loup NRD	Tri-Basin NRD
Lower Niobrara NRD	Twin Platte NRD
Lower Platte North NRD	U.S. Geological Survey
Lower Platte South NRD	University of Nebraska
Lower Republican NRD	Upper Big Blue NRD
Middle Niobrara NRD	Upper Elkhorn NRD
Middle Republican NRD	Upper Loup NRD
Nebraska Department of Agriculture	Upper Niobrara-White NRD
Nebraska Department of Environmental Quality	Upper Republican NRD

Table 2. Various agencies providing groundwater analyses in Nebraska to be used in the Database. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

Types of Wells Sampled

The data summarized in Table 3 represent the quantity of water samples analyzed from a variety of well types. Historically, most wells that have been sampled are irrigation or domestic supply wells. Irrigation and domestic wells are constructed to yield adequate supplies of water, not to provide water quality samples. However, in recent years, monitoring agencies have been installing increasing numbers of dedicated groundwater monitoring wells designed and located specifically to produce samples. By utilizing such varied sources, groundwater data from a wide range of geologic conditions can be obtained.

Well Type	Number of Analyses
Monitoring	251,136
Irrigation	99,801
Domestic	74,216
Public Water Supply	27,465
Commercial/Industrial	2,214
Livestock/Other	1,818
Total	456,650

Table 3. Total number of groundwater analyses by well type. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

Lower Loup Natural Resources District staff utilizing a passive diffusion sampler to sample a monitoring well near Duncan, NE.

Monitoring Parameters

As already mentioned, numerous entities across Nebraska have been monitoring groundwater quality for many years, for a wide variety of possible contaminants. However, much of this monitoring has been for area-specific (part of an NRD), or at most, regional purposes (entire NRDs), and it has been difficult to assess data on a statewide basis for more than a short period of time. Creation of the Database has provided an important tool for such analysis. Appendix A lists the compounds for which groundwater has been sampled and analyzed since 1974. Table 4, found on page 11 lists the compounds from Appendix A for which at least 50 samples collected exceeded the **Reporting Limit***. This comparison gives an indication of which compounds are more prevalent than others in Nebraska's groundwater. Only 12 of the 241 compounds sampled met the criteria.

> ***Reporting Limit** refers to the concentration a laboratory has indicated their analysis method can be validated. For example, if a contaminant were at a level below the reporting limit, the laboratory's analysis method could not detect it and the concentration would be reported as "below the reporting limit".*

Throughout this report, the number of sample analyses for any one contaminant refers only to the number of analyses as reported **in the Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater**, and not for the total number of analyses for that contaminant taken in the state. As already mentioned, data which are currently in the process of being submitted to UNL to be entered into the database are not reflected in this report. In addition, there are undoubtedly samples for various contaminants taken by entities other than the agencies referred to in this report (for instance, private consulting firms, or other programs within some of the reporting agencies), which are not included in this database.

The table in Appendix A shows a wide variety of compounds for which groundwater samples have been analyzed, all of which are used in agricultural production. As mentioned previously, there is a significant effort in monitoring groundwater for other, non-agricultural contaminants. Examples of such compounds include petroleum products and additives, industrial chemicals, hazardous wastes, contaminants associated with landfills and other waste disposal sites, and effluent from wastewater treatment facilities. Such issues are beyond the scope of §46-1304, and information about such monitoring data is not contained in any centralized database at present.

Compound	Total Samples Collected	Number of Samples that exceed the Reporting Limit	Percent of Samples that exceed the Reporting Limit
nitrate-N	98,278	91,043	92.64%
alachlor ethane sulfonic acid	127	66	51.97%
deethylatrazine	5,236	1,566	29.91%
atrazine	10,087	2,249	22.30%
metolachlor	9,156	1,044	11.40%
deisopropylatrazine	4,795	377	7.86%
cyanazine	9,656	422	4.37%
alachlor	9,691	305	3.15%
propazine	5,128	119	2.32%
simazine	5,665	125	2.21%
prometon	5,482	54	0.99%
metribuzin	9,557	59	0.62%

Table 4. Compounds more commonly found in wells monitored in Nebraska. More than 50 samples analyzed for each compound were greater than the reporting limit. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

Discussion and Analysis

The information presented previously in this report shows that a considerable amount of effort has gone into groundwater quality monitoring in Nebraska since the mid-1970s, especially in areas that are heavily farmed. **It is worth noting that the majority of samples taken during this period show that groundwater in the State is of very high quality.** A comparison of Appendix A and Table 4 shows that only a small percentage of parameters analyzed have been detected. However, these same data show that several contaminants have been detected in numerous samples throughout the monitoring period. Levels and distribution of these compounds are issues of concern to Nebraskans.

As Table 4 shows, the compounds that have been detected more than just a few times throughout the period of record include nitrate-nitrogen (nitrate-N), atrazine, metolachlor, and degradation products of atrazine, alachlor, and metolachlor. Nitrate is a form of nitrogen common in human and animal waste, plant residue, and commercial fertilizers. Atrazine, alachlor, and metolachlor are herbicides used for weed control in crops such as corn and sorghum while deethylatrazine, deisopropylatrazine, and metolachlor ethane sulfonic acid are degradation products, or metabolites of atrazine and metolachlor. Cyanazine is a trizine herbicide similar to atrazine, but its use has been discontinued.

In addition to atrazine and metolachor, the Nebraska Department of Agriculture identified two other priority compounds (alachlor and simazine) for development of pesticide State Management Plans, following guidance produced by the U.S. Environmental Protection Agency. While these compounds (alachlor and simazine) were not identified in any significant quantities in Nebraska's groundwater, (alachlor ethane sulfonic acid is a degradation product of alachlor) they will be discussed later in this report.

University of Nebraska Conservation and Survey Division staff installing a monitoring well near Clearwater, NE.

Taylor-Ord canal, property of North Loup Public Power and Irrigation District, located north of Elyria, NE.

Occurrence of elevated levels of nitrate and herbicides in groundwater has been associated with the practice of irrigated agriculture, especially corn production. A good summary of this can be found in Exner and Spalding (1990). The Natural Resources Districts have instituted Groundwater Management Areas (GWMAs) over all or parts of nearly all of the 23 districts based on NRD and NDEQ groundwater sampling. The NRDs' institution of these GWMAs indicates a concern and recognition of nonpoint source groundwater contamination. Additionally, NDEQ's Groundwater Management Area program (Title 196, 2002) has completed 20 studies across the state since 1988 identifying areas of nonpoint source contamination from the widespread application of commercial fertilizer and animal waste.

The State of Nebraska is a large geographic area, over 77,000 square miles. Accurately showing the quality of Nebraska's groundwater is becoming an easier task, but this highly complex system is still difficult to characterize. The acquisition of more data is making a trend analysis more viable. However, practices of sampling the "problem" areas still skew the data and make it very difficult to show the areas in Nebraska where the contaminant levels are decreasing through better management and farming practices.

Another difficulty is obtaining the resources and the logistics of collecting groundwater samples. There are approximately 171,000 active registered wells in Nebraska and only enough resources to collect samples from 3,100 (1.9%) to 4,500 (2.6%) annually (since 2000). Also, not all water well owners are receptive to having their well sampled. Figure 7 is a map showing all active registered water wells in Nebraska as of November 2013. As discussed earlier in this document, not all water wells are registered and these will not show up on this map.

Nitrate Trends Utilizing the Database

Nitrate monitoring data from wells have been collected for many years, and the purpose of collection varies by the agency or organization performing the work. For instance, public water supply operators sample their drinking water wells to ensure that the public is offered good quality water through the municipal system. Natural Resources Districts have been tasked by the Nebraska legislature to manage groundwater quality and quantity and preserve its usefulness into the future. Additionally, shallow groundwater may have much different natural chemical characteristics than deep groundwater and is more easily and quickly affected by things happening on the surface than its deeper counterpart.

The database makes accessing and reviewing data relatively simple. One must use caution, though, when utilizing the vast database because differences in wells may result in differences in the data. Deep wells may not necessarily be compared to shallow wells, nor irrigation wells (potentially screened across multiple aquifers) to dedicated monitoring wells (with perhaps only 10 feet of screen), nor wells used for measuring water levels (piezometers) for water quality. All of these issues have been considered and not necessarily well-addressed. The data are being used to present what we believe to be the most interesting and useful information available, but other interpretations are possible.

Several different methods have been used to present and interpret the nitrate data collected since the early 70s. In past reports there have been many discussions on the adequacy of the data, with respect to determining the quality of the State's groundwater quality. It is known that a majority of the sampling was done in "problem" areas (elevated nitrate) and that data would skew the values toward higher means. In fact, one site sampled between 1991 and 1996 skewed the data so much that it was removed from our analysis. Additionally, due to the nature of the data, the median (center of the data set) as opposed to the mean (average) was more representative of the data. The tables presented in past reports have been updated again and presented in Figures 9 and 10.

In the past, maps were generated using the entire Database data set in an attempt to show "current" statewide groundwater quality (see Figure 11) from the most recent time the well had been sampled (aiming to show the most current water quality at that location). Unfortunately, there are numerous wells that haven't been sampled for 10 or more years but represented the most recent sample collected in that location. As an example, there are four wells in Adams County that were only sampled once in 1991. These wells show up as green dots (<7.5 mg/L) on the statewide map (Figure 11) and it is assumed that after 21 years, the groundwater quality is still the same. There is no recent data to either verify or falsify this assumption.

One of the best ways to use the entire data set is to refer to the maps found in Appendix B, which shows the results of sampling done each year, and compare the annual monitoring data. The 2012 map is also presented below as Figure 12. This gives the reader an idea of where there are reoccurring "problem" areas. For example, the reader is directed to look at the samples collected over the years in parts of Phelps, Kearney, Merrick, Nance, Platte, Holt, and Antelope Counties. These are all locations with sandy soils, shallow groundwater, and high nitrate.

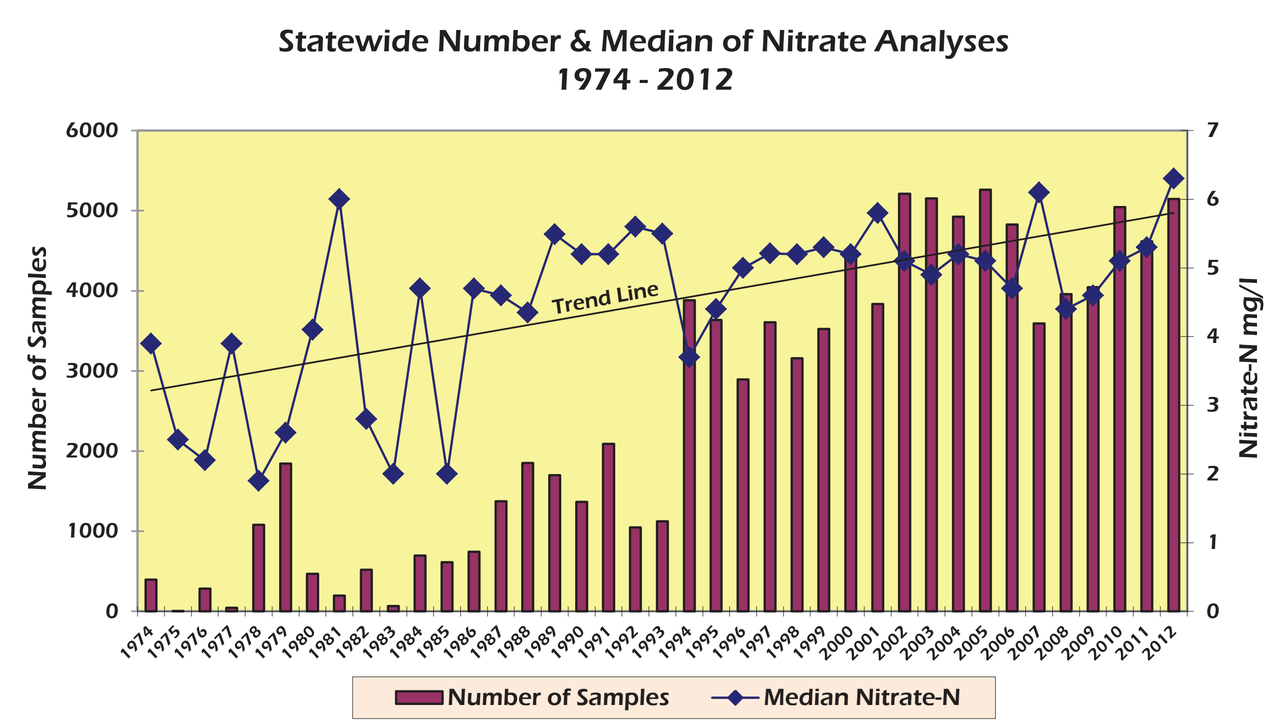


Figure 9. All 98,278 analyses and median nitrate-nitrogen levels for Nebraska, 1974-2012. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

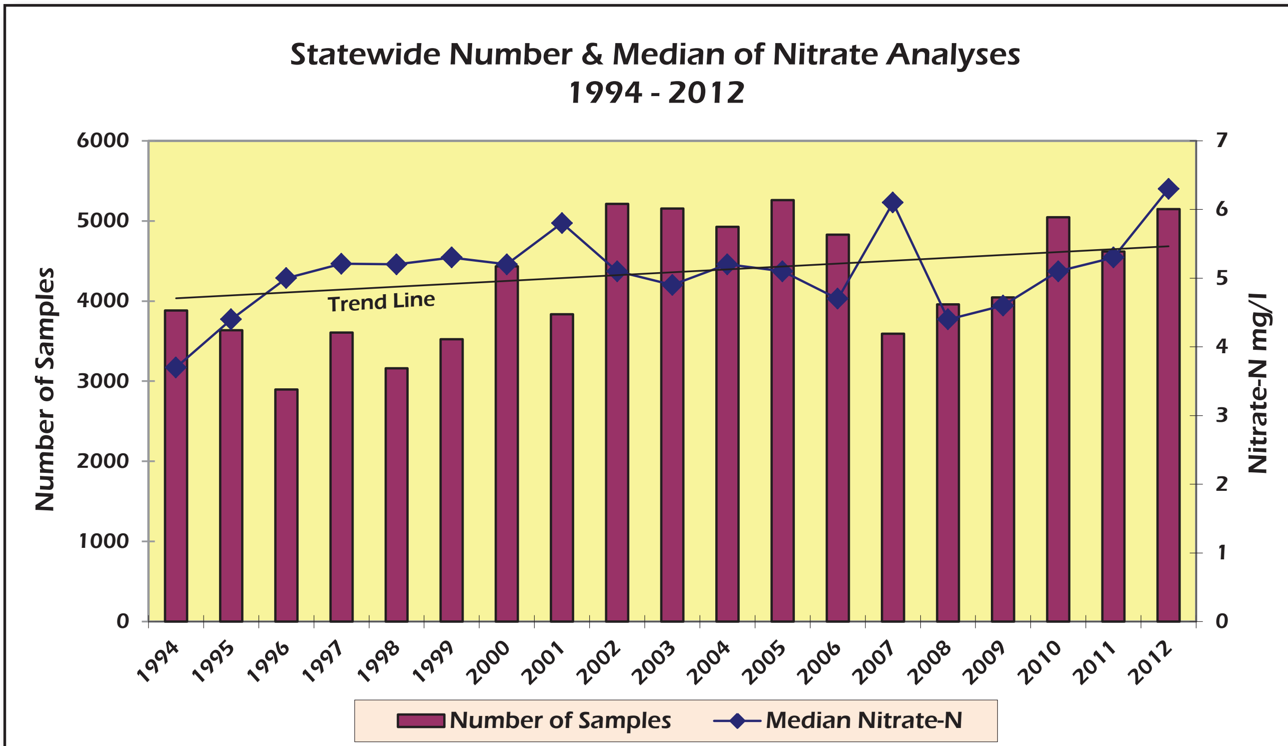


Figure 10. All 80,773 analyses and median nitrate-nitrogen levels for Nebraska, 1994-2012. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

Most Recent Nitrate-N Concentrations

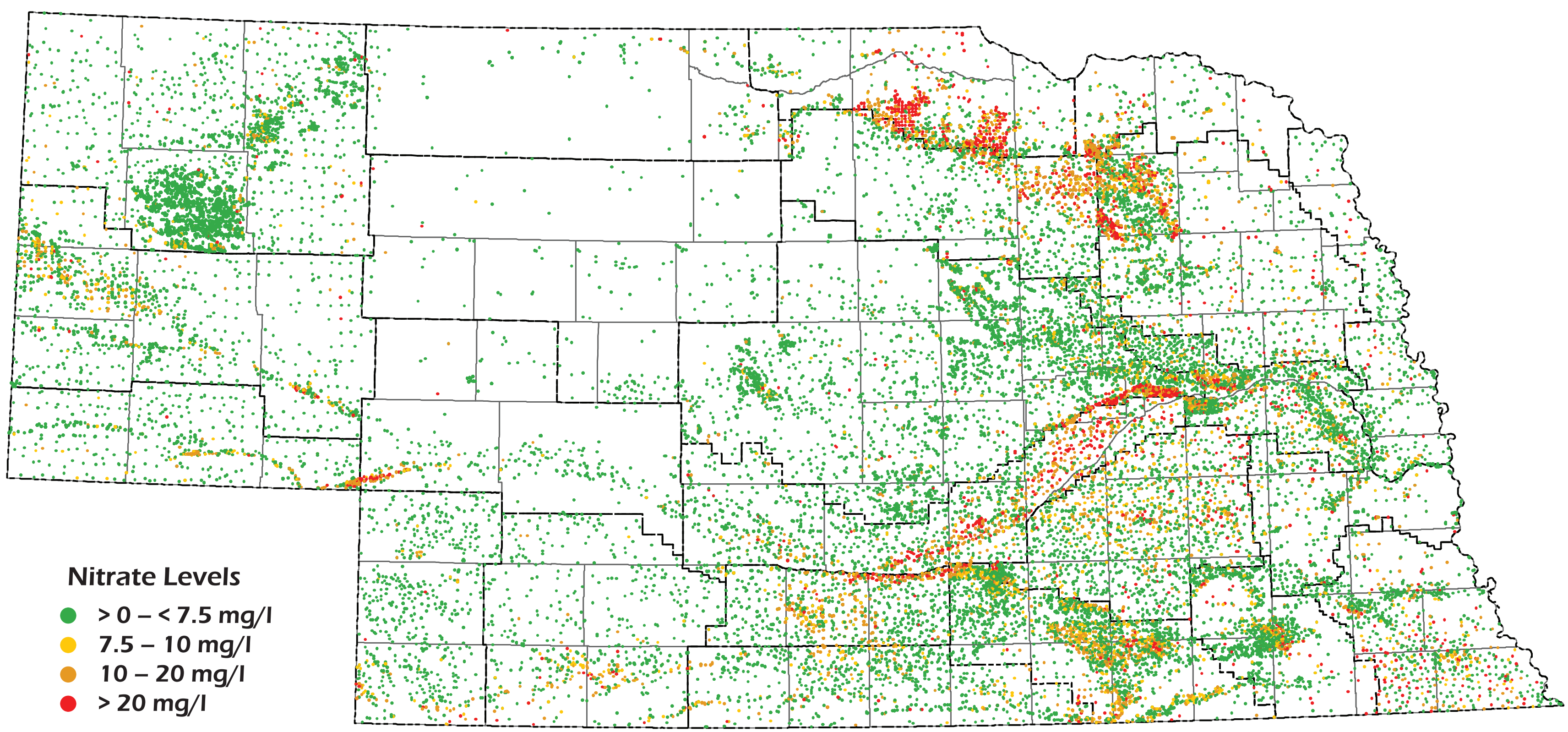


Figure 11. Most recent recorded concentration of nitrate from 1974 - 2012.
(Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.

Nitrate-N Concentrations of Wells Sampled in 2012

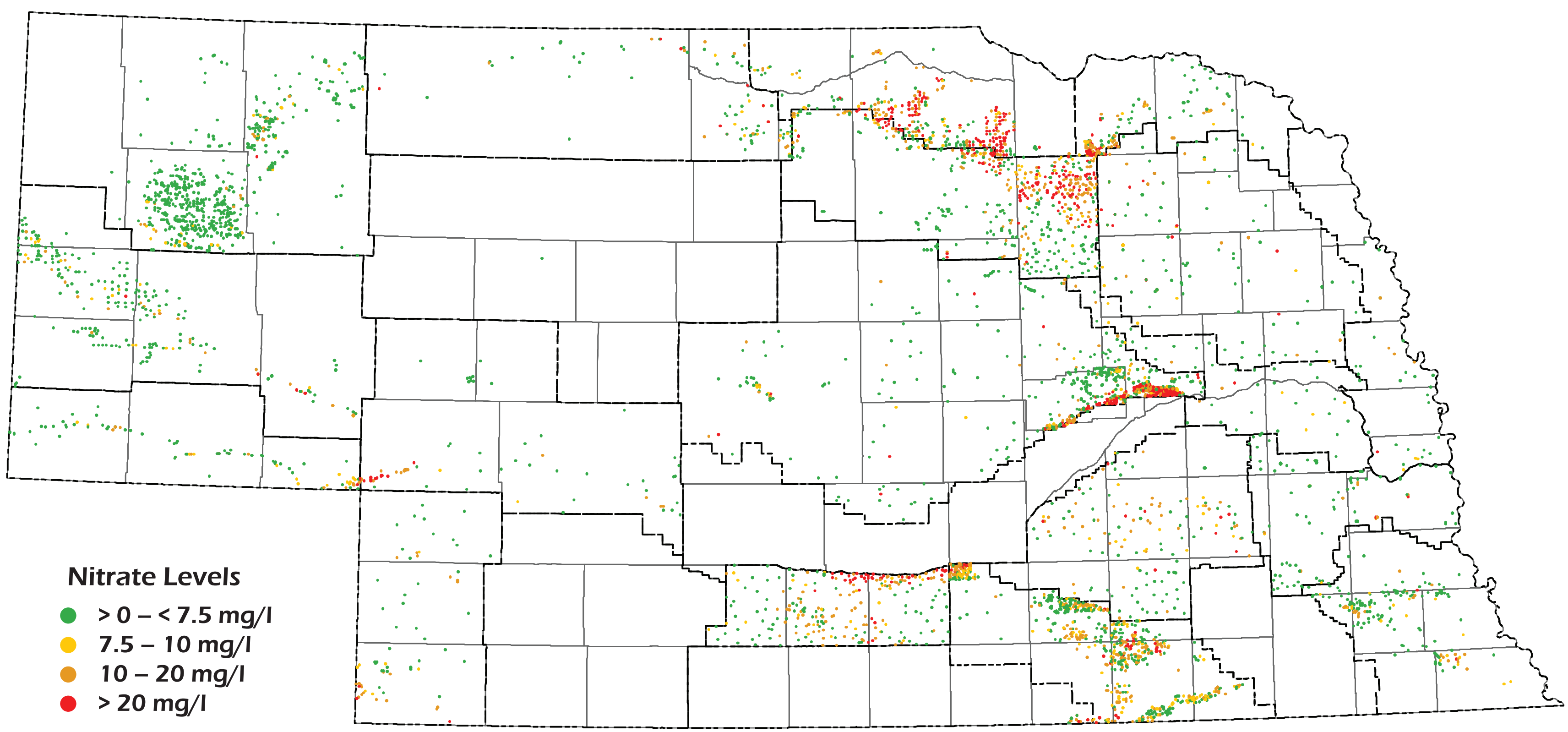


Figure 12. Nitrate concentrations of wells sampled in 2012.
(Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.

In 2002 the NRDs began discussing a Statewide Monitoring Network (a defined subset of wells from the Database) with regularly sampled wells to help better assess Nebraska's groundwater quality and better develop and analyze trends for this report. The first data for this network were assessed in the 2005 Groundwater Quality Monitoring Report using 1280 wells that were scheduled to be sampled in 2004. The 2006 report used 1437 network wells, followed by 1427 wells in 2007, 1404 wells in 2008 and 2009, and 1386 wells from 2010 through present for the Statewide Network trend analysis. A current map of the network wells is presented in Figure 13.

The network wells were set up to be sampled on an annual basis to make data assessment more reliable and to complete trend analyses. Unfortunately, resources were not always available to the NRDs and not all of the wells were sampled on an annual basis. The data that were collected are still very useful and can still be used for trend analysis. Data from network wells sampled in 2012 are presented on in Figure 14.

It is important to keep some qualifications in mind when interpreting these maps. Since each NRD has its own schedule for monitoring, individual samples may not have been taken at the same time as other samples within the same District or between Districts. Thus, at this point, each map does not necessarily represent a "snapshot" in time of nitrate levels or nitrate concentration changes, but they do give a very general indication of how nitrate levels are changing over time. It is also important to remember that aquifer systems and nitrate levels within them are very dynamic, complex, and variable. Although care was taken to select wells that were fairly representative of the geologic conditions present in various areas of the state, it is impossible to extrapolate conditions in a given well to a large area. Therefore, the several hundred wells in the statewide network give a general indication of how nitrate levels are changing over time across the state as a whole, but it would be inappropriate to use one or a few wells in the network to try to analyze nitrate levels in a specific part of the state.


Little Blue Natural Resources District


Little Blue Natural Resources District

Location of Statewide Groundwater Monitoring Network Wells

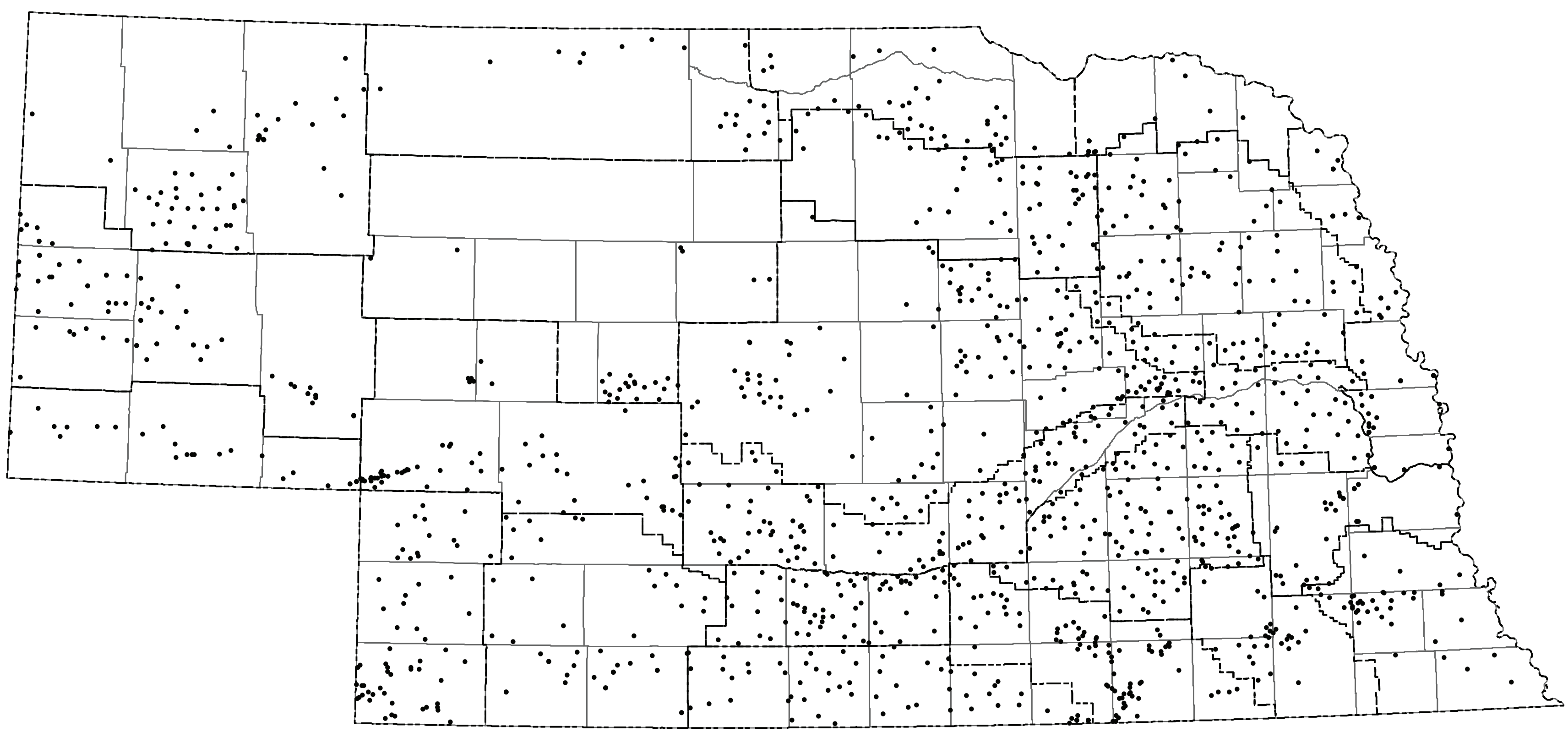


Figure 13. Location of all 1386 statewide groundwater monitoring network wells.
(Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.

Nitrate-N Concentrations of Network Wells Sampled in 2012

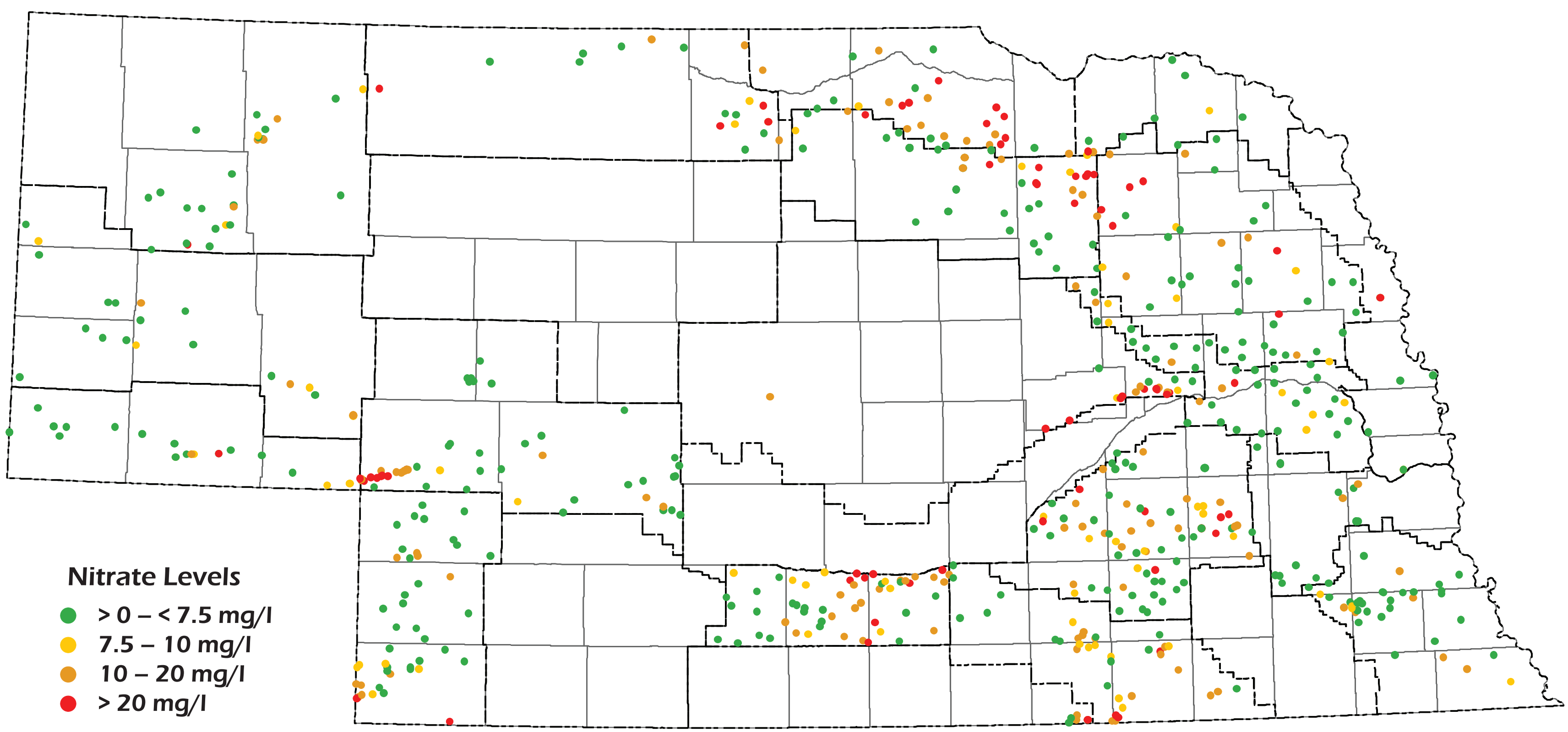
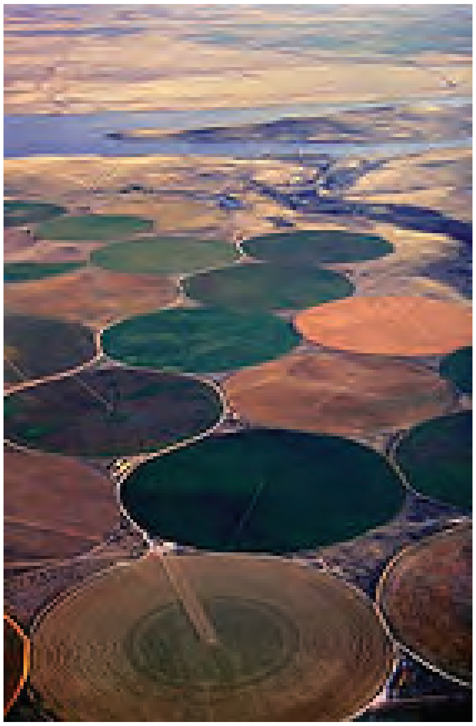


Figure 14. Nitrate concentrations of statewide groundwater monitoring network wells sampled in 2012. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)
Empty areas indicate no data reported, not the absence of nitrate in groundwater.



Before a trend analysis was completed on all the network well data from 2000 to 2012, a few factors had to be considered. First, the data were reviewed at to see if the depth of the well had any effect on the concentration. Figure 15 clearly shows that the deeper the well, the lower the nitrate concentration. Next, the nitrate data were analyzed to determine if an obvious increase or decrease can be seen over time in the network wells. Figure 16 shows essentially no change in the aggregated data.

The data was then separated by NRD to do trend analysis with data from the network wells going back as far as 1980. No clear trends were indicated. Comparing the trend analysis done on the network wells (Figure 16) to the simple trends of all the data conducted in previous reports (Figure 10) is a good indication that the nitrate concentration of Nebraska's groundwater is holding pretty steady. However, there are several places in Nebraska where the median concentration is approaching 10 mg/L.

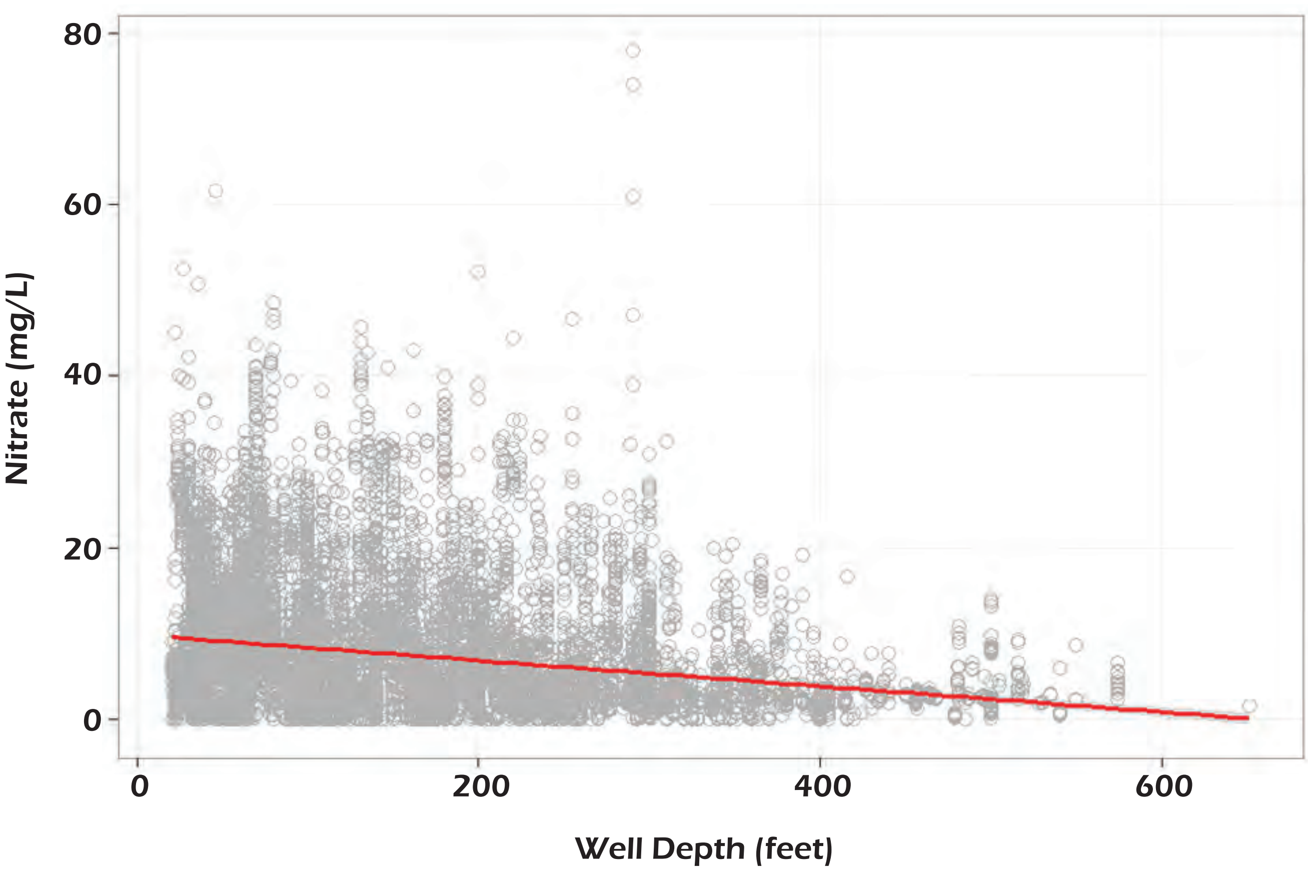


Figure 15. Comparison between nitrate concentration and total depth of well using the statewide groundwater monitoring network wells. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

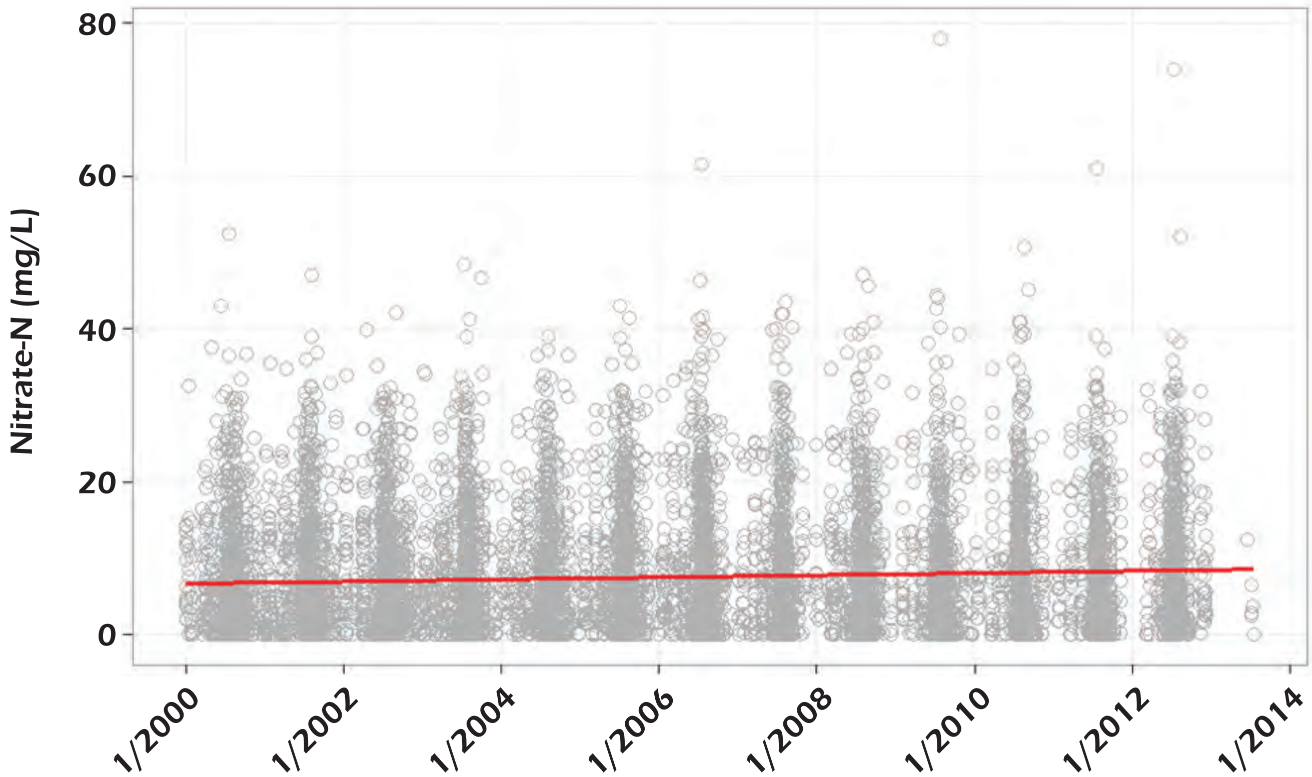


Figure 16. Comparison of nitrate concentrations over time using the statewide groundwater monitoring network wells. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

Nitrate in Public Water Supplies

Reverse Osmosis treatment plant to remove nitrate (Seward, NE).

Public water supply systems are required to test for a variety of potential contaminants in the drinking water that they serve to the public. When a contaminant in the drinking water is over the federal Safe Drinking Water Act limit (also known as the maximum contaminant level [MCL]), the water system will receive an Administrative Order for that contaminant from the Nebraska Department of Health and Human Services (DHHS) and must somehow 'fix' the problem. The MCL for nitrate-nitrogen is 10 mg/l, but public water supply systems with wells or intakes testing over 5 mg/l may be required to perform quarterly sampling. Of the nearly 550 groundwater based community public water supply systems in Nebraska that supply their own water, 66 of those must perform quarterly sampling for nitrate. Common methods to solve a nitrate Administrative Order include drilling a new or deeper well, hooking on to a neighboring water system, or building a treatment plant. Figure 17 shows the location of active community public water supply systems with their own wells. Colors differentiate administrative order for nitrate, systems required to preform quarterly sampling, and systems treating for nitrate. Please note that the public water supply system data from DHHS is not in the Database. Also note that nitrate Administrative Orders do not necessarily fall in the areas of highest nitrate problems, as indicated in Figures 11 and 12 and the figures in Appendix B.

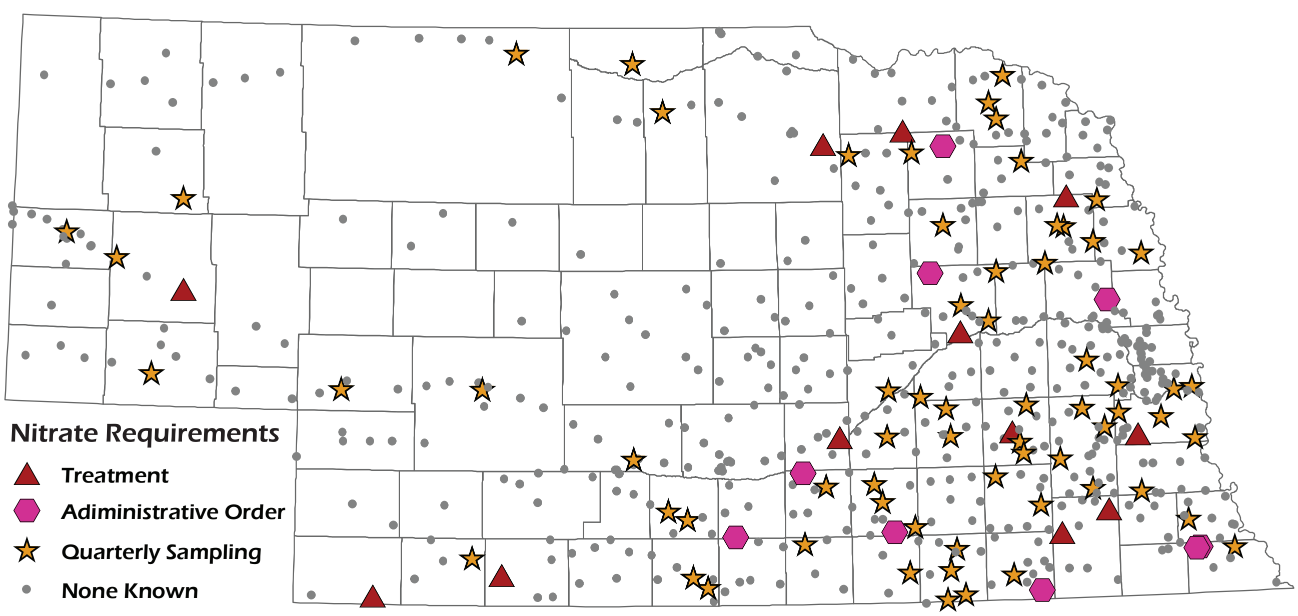


Figure 17. Community public water supply systems with requirements for nitrate. (Source: DHHS, November 2013)

Several studies have been completed over the last several years on the relationship of nitrate leaching into the subsurface and uranium concentrations found in groundwater. Research indicates that the natural uranium in the subsurface may be oxidized and mobilized as the nitrate (in many forms) moves past the root zone and eventually to groundwater.

More public water supply systems are now finding themselves not only treating for nitrate, but also uranium. The MCL for uranium is 0.030 mg/L. Figure 18 shows the location of active community public water systems treating for uranium.

Ion Exchange plant to remove uranium (McCook, NE).

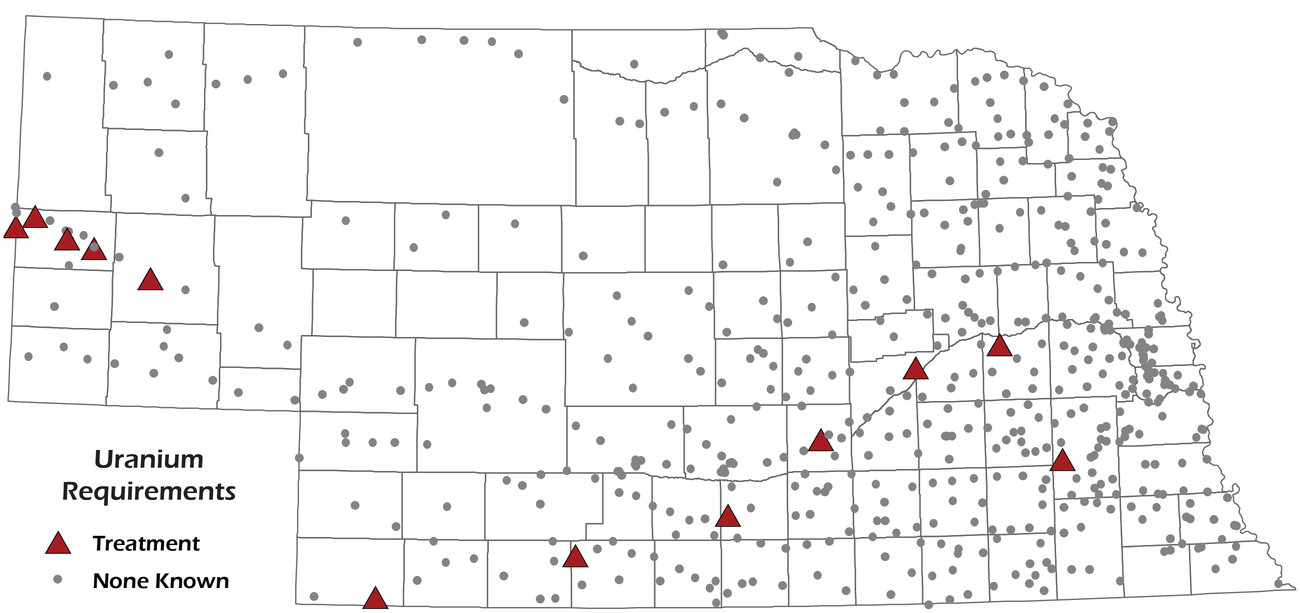


Figure 18. Community public water supply systems with requirements for uranium. (Source: DHHS, November 2013)

HERBICIDES

Atrazine

The locations of all wells sampled for atrazine from 1974 to 2012 and then the most recent recorded concentration of that herbicide are presented in Figures 19 and 20. Atrazine is used as an herbicide to eradicate broad leaf weeds. Common commercial trademark names include, but are not limited to Aatrex and Bicep.

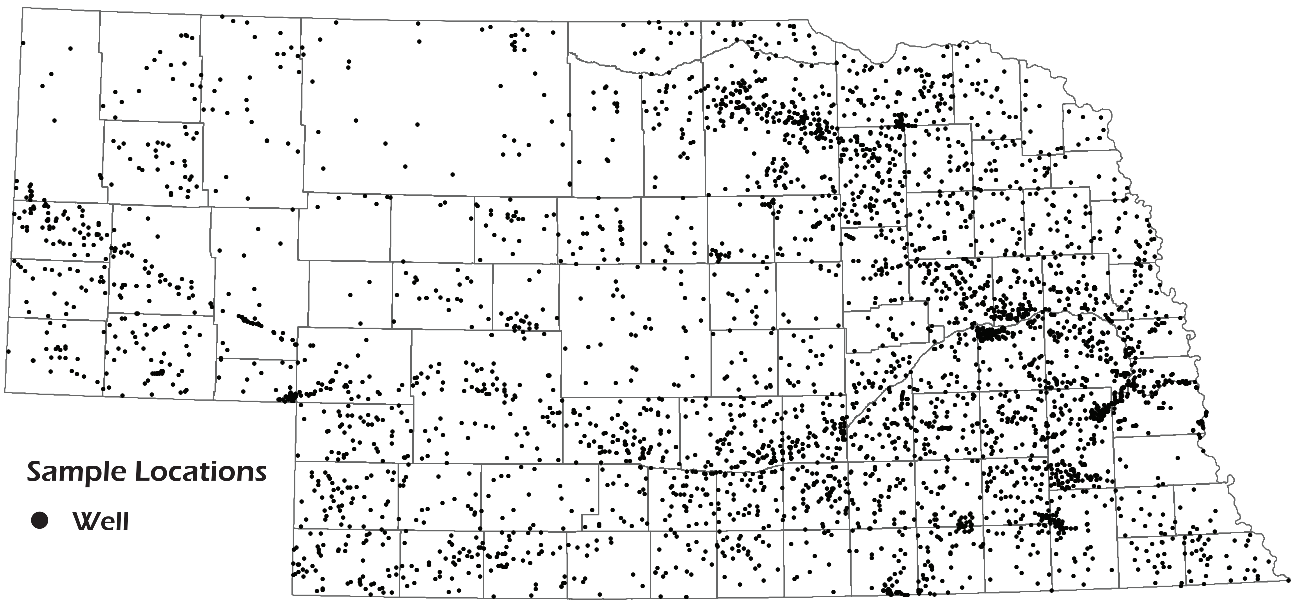


Figure 19. Location of 4,243 wells sampled for atrazine from 1974 – 2012. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

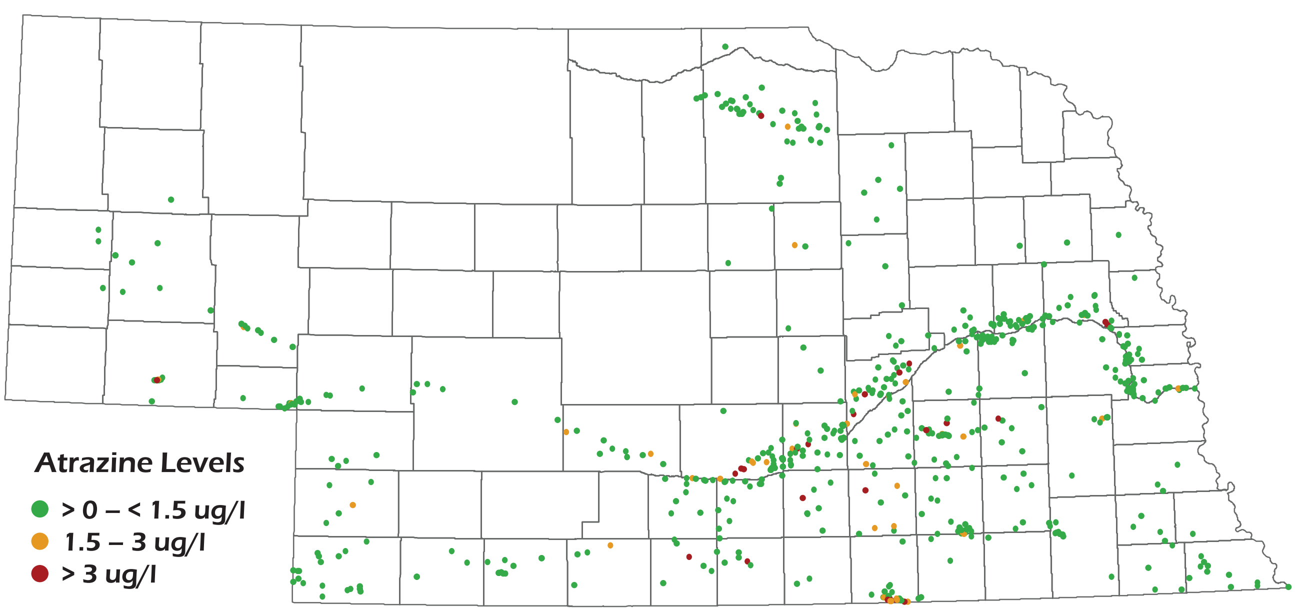


Figure 20. Most recent recorded detected concentration of atrazine from 1974 – 2012. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

The locations of all wells sampled for atrazine in 2012 are presented in Figure 21, there were no detections of atrazine in the 2012 sampling.

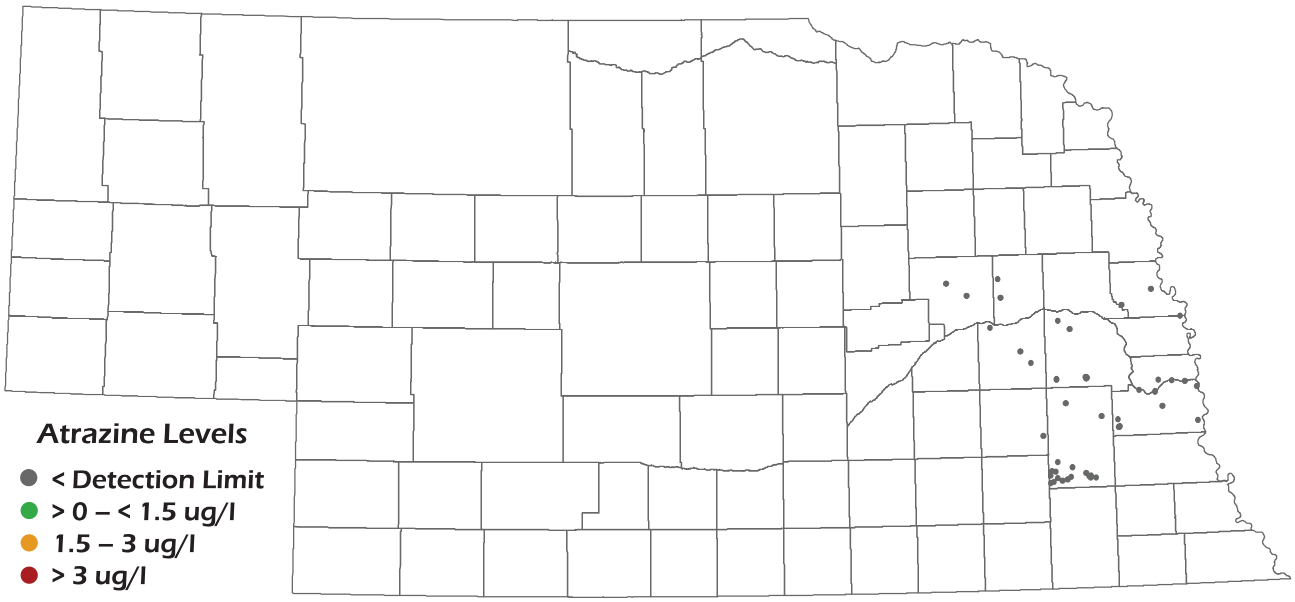


Figure 21. Location of 67 wells sampled for atrazine in 2012. (Source: Quality-Assessed Agrichemical Database for Nebraska Groundwater, 2013)

The mean atrazine concentration calculated from the Database has been less than 1 µg/L since 1979, compared to the USEPAs MCL of 3 µg/L.

Twin Platte Natural Resources District

Alachlor

Alachor is used as an herbicide to eradicate broad leaf weeds and grasses. Common commercial trademark names include, but are not limited to, Lasso, Bullet, and Lariat. There have been 9,691 samples collected since 1974 and no reported concentrations of Alachlor in the 1,156 samples collected since 2004.

The mean alachlor concentration calculated from the Database for the entire record from 1974 is 0.008 µg/L, compared to the USEPAs MCL of 6 µg/L. Fourteen of the 23 NRDs are currently using the in-house analysis described on page 29, but that data is not yet in the Database.

Metolachlor

Metoloachlor is used as an herbicide to eradicate broad leaf weeds. Common commercial trademark names include, but are not limited to, Bicep and Dual. There have been 9,156 samples collected since 1974 and only one sample above the reporting limit for Metolachlor in the 636 samples collected since 2007.

The mean metolachlor concentration calculated from the Database for the entire record from 1974 is 0.037 µg/L. There is no USEPA MCL for metolachlor. Fourteen of the 23 NRDs are currently using the in-house analysis described on page 29, but that data is not yet in the Database.

Simazine

Simazine is used as an herbicide to eradicate broad leaf weeds. Common commercial trademark names include, but are not limited to, Princep and Aladdin. There have been 5,666 samples collected and no reported concentrations of Simazine in the 1,157 samples collected since 2004.

The mean simazine concentration calculated from the Database for the entire record from 1974 is 0.0035 µg/L, compared to the USEPAs MCL of 4 µg/L.

Alternative Laboratory Methods

In mid-2004, the NRDs, working with NDEQ and the Nebraska Department of Agriculture (NDA), began two new monitoring efforts. Using funding from USEPA Region 7, NDEQ, and NDA placed in-house equipment for the analysis of priority herbicides (atrazine, alachlor, metolachlor, and acetochlor) in several NRD offices. In 2005, NDEQ obtained additional funding from USEPA to place herbicide units in other NRD offices for a total of 14.

Monitoring for these parameters using these in-house methods continues as resources allow. The herbicide data received from this project can be considered qualitative or semi-quantitative, and the results have been roughly similar to the pattern of detections from the Database.

The herbicide data has been compiled by the NDA and will soon be available at: http://dnrdata.dnr.ne.gov/clearinghouse/

Herbicide Trends

An in-depth analysis of statewide trends for any of the herbicides has not been attempted this year because the number of detections in separate wells for these compounds was too small to permit a reliable trend analysis. Many of the detections for these compounds were in the same wells or a series of closely spaced wells. Therefore, an analysis for trends in these parameters would not be valid. In general, the greater numbers of detections of herbicides in groundwater follows the same overall pattern of higher nitrate in groundwater.

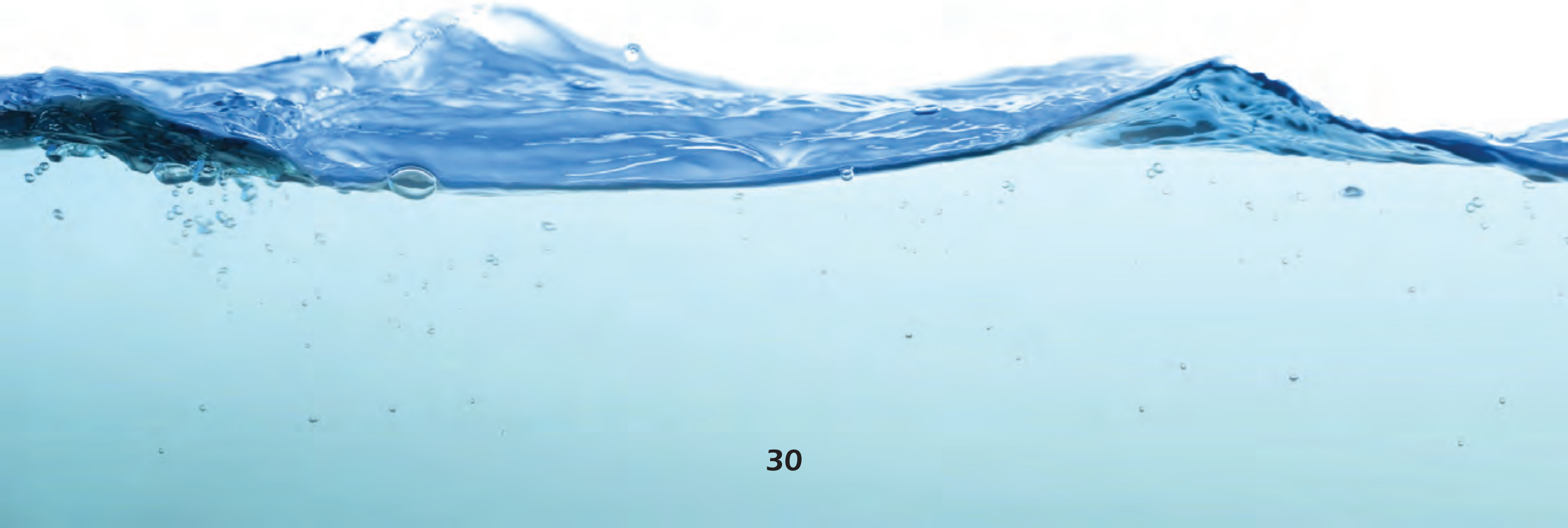
As mentioned previously in this report, 14 of the 23 NRDs continue to sample for atrazine, metolachlor, and acetochlor and analyze on a case-by-case basis using the in-house technology described above. The Nebraska Department of Agriculture (NDA) has authority to manage pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The NDA can be contacted at (402) 471-2351.

CONCLUSIONS

Groundwater is a valuable resource for Nebraska. The majority of Nebraska's residents rely on groundwater for drinking water, agriculture, and industry. Most public water supplies that utilize groundwater do not require any form of treatment for drinking water before serving it to the public. There are some limited areas in Nebraska where the nitrate concentration is greater than the drinking water standard of 10 mg/L. The state's reliance on groundwater alone makes it important to continue to monitor groundwater quality and to coordinate and share monitoring techniques, to enable decision makers to make more informed management decisions.

The Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater has been invaluable to decision makers in managing Nebraska's groundwater resource. This report authorized by Neb. Rev. Stat. § 46-1304 (LB 329, 2001) would be extremely difficult, if not impossible, to prepare were it not for the existence of the Database. More importantly, the Database has made it possible to quickly and confidently retrieve both recent and historic groundwater quality data for the entire state. These data not only are utilized to make regulatory decisions to protect groundwater quality, but can also be used by the private sector to identify alternate sources of groundwater for drinking water purposes. Most of the 23 NRDs and several state and federal agencies are conducting or analyzing groundwater monitoring, resulting in a large number of analyses spread across the entire state. It is imperative that the Database continue to be implemented and updated for the foreseeable future.

Nebraska's Natural Resources Districts are conducting extensive groundwater quality monitoring, focusing on nitrate and pesticides and have instituted many Groundwater Management Areas (GWMAs). Most of the NRDs have submitted groundwater quality monitoring data to the Database. The other NRDs are submitting data through a cooperative agreement with USGS. In addition, the NRDs have also developed a Statewide Groundwater Monitoring Network that has been sampled for eight years. Not only are the NRDs data vital to the Database, but their implementation of GWMAs is essential in the protection of groundwater quality in Nebraska. NRDs with GWMAs have instituted farm operator certification, soil testing for nitrogen, irrigation water management, and other best management practices. It will be through these GWMA and related practices that Nebraskans will see a decrease in contaminants such as nitrate over the next several decades.



Concentrations and trends of contaminants. This is the first year that the data from the Statewide Groundwater Monitoring Network was utilized to show trends of nitrate detected in the states groundwater. These data indicate that nitrate concentrations tend to decrease with depth of the well. Also, there is no clear trend in the nitrate concentrations in groundwater for the data gathered from 2000 to the present. Looking back at previous reports where the median nitrate concentration in groundwater for each year was utilized in a simple trend analysis, these data also indicated that there was no clear trend after 2000. However, there are still areas in Nebraska where the median nitrate concentration in groundwater is approaching the drinking water MCL of 10 mg/l. There is not enough recent data statewide for atrazine, alachlor, metolachlor, or simazine to conduct any trend analyses.

The Future. There has been a significant amount of time and effort expended to populate the Database and the importance of its merits cannot be emphasized enough. The NRDs' Statewide Groundwater Monitoring Network has been very useful and consists of many dedicated monitoring wells. However, in the past, the NRDs' network had limitations and the resources were not available to improve the dedicated monitoring well network or maintain the necessary yearly sampling routine. Efforts are being made to improve the Statewide Groundwater Monitoring Network with new dedicated monitoring wells with strict well construction and screen placement, and emphasizing standards for sample collection and reporting. Also, dedicated pumps will be added to current network monitoring wells to make sampling more efficient. Continued attention and resources (i.e. local and state time, funding, and staff) directed toward monitoring to implement the Statewide Groundwater Monitoring Network will be crucial for the successful management of Nebraska's valuable natural resource, groundwater.

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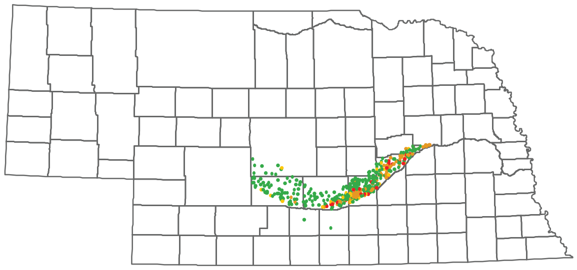
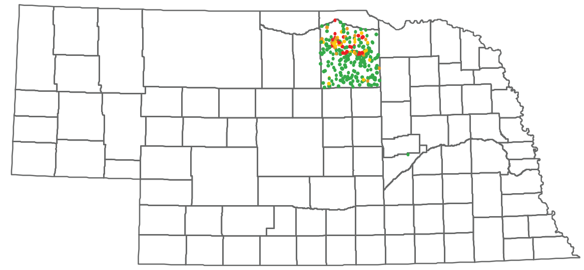
Compound	Compound	Compound
1,1,1-trichloroethane	aldicarb sulfoxide	dechloroacetochlor
1,2,4-trichlorobenzene	aldrin	dechloroalachlor
1,2-dibromo-3-chloropropane	alpha-HCH	dechlorodimethenamid
1,2-dibromoethane	ametryn	dechlorometolachlor
1,2-dichlorobenzene	atrazine	deethylatrazine
1,2-dichloroethane	azinphos-methyl	deethylcyanazine
1,2-dichloropropane	azinphos-methyl oxon	deethylcyanazine acid
1,3-dichloropropane	bendiocarb	deethylcyanazine amid
1,4-dichlorobenzene	benfluralin	deethylhydroxyatrazine
1-naphthol	benomyl	deisopropylatrazine
2,4,5-T	bensulfuron-methyl	deisopropylhydroxyatrazine
2,4,6-trichlorophenol	bentazon	delta-HCH
2,4-D	benzo(a)pyrene	demethylfluometuron
2,4-D methyl ester	beta-HCH	desulfinylfipronil
2,4-DB	bromacil	desulfinylfipronil amide
2,4-dinitrophenol	bromomethane	di(2-ethylhexyl)adipate
2,6-diethylaniline	bromoxynil	di(2-ethylhexyl)phthalate
2-[(2-ethyl-6-methylphenyl) amino]-1-propanol	butachlor	diazinon
	butylate	diazoxon
2-[(2-ethyl-6-methylphenyl) amino]-2-oxoethane sulfonic acid	carbaryl	dicamba
	carbofuran	dichlobenil
2-chloro-2',6'-diethylacetanilide	carbon disulfide	dichlorprop
2-ethyl-6-methlyaniline	carbon tetrachloride	dichlorvos
3,4-dichloroaniline	carboxin	dicrotophos
3,5-dichloroaniline	chloramben methyl ester	didealkyl atrazine
3-hydroxycarbofuran	chlordane	dieldrin
4,6-dinitro-o-cresol	chlorimuron-ethyl	dimethenamid
4-chloro-2-methylphenol	chloroform	dimethenamid ethane sulfonic acid
4-chloro-3-methylphenol	chlorothalonil	
4-nitrophenol	chlorpyrifos	dimethenamid oxalinic acid
acenaphthene	chlorpyrifos oxon	dimethoate
acetochlor	cis-1,3-dichloropropene	dinoseb
acetochlor ethane sulfonic acid	cis-permethrin	diphenamid
acetochlor oxanilic acid	clopyralid	disulfoton
acetochlor sulfynilacetic acid	cyanazine	disulfoton sulfone
acifluorfen	cyanazine acid	diuron
acrylonitrile	cyanazine amide	endosulfan I
alachlor	cycloate	endosulfan II
alachlor ethane sulfonic acid	cyfluthrin	endosulfan sulfate
alachlor ethane sulfonic acid, secondary amide	cypermethrin	endrin
	cyprazine	endrin aldehyde
alachlor oxanilic acid	DCPA	EPTC
alachlor sulfynilacetic acid	DCPA monoacid	esfenvalerate
aldicarb	DDD	ethalfluralin
aldicarb sulfone	DDT	ethion

Appendix A. Compounds for which groundwater samples have been analyzed

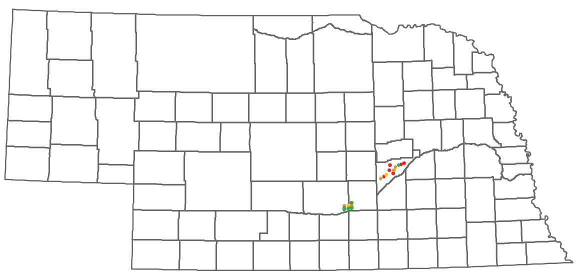
Compound	Compound	Compound
ethion monoxon	lindane	phorate
ethoprop	linuron	phorate oxon
ethyl parathion	malathion	phosmet
fenamiphos	malathion oxon	phosmet oxon
fenamiphos sulfone	MCPA	picloram
fenamiphos sulfoxide	MCPB	prometon
fenuron	metalaxyl	prometryn
fipronil	methidathion	propachlor
fipronil sulfide	methiocarb	propachlor ethane sulfonic acid
fipronil sulfone	methomyl	propachlor oxalinic acid
flufenacet	methoxychlor	propanil
flufenacet ethane sulfonic acid	methyl paraoxon	propargite
flufenacet oxalinic acid	methyl parathion	propazine
flumetsulam	methylene chloride	propham
fluometuron	metolachlor	propiconazole
fonofos	metolachlor ethane sulfonic acid	propoxur
fonofos oxon		propyzamide
heptachlor	metolachlor oxalinic acid	siduron
heptachlor epoxide	metribuzin	silvex
hexachlorobenzene	metsulfuron-methyl	simazine
hexachlorocyclopentadiene	molinate	simetryn
hexazinone	myclobutanil	sulfometuron-methyl
hydroxyacetochlor	naphthalene	tebuthiuron
hydroxyalachlor	napropamide	terbacil
hydroxyatrazine	neburon	terbufos
hydroxydimethenamid	nicosulfuron	terbufos oxon sulfone
hydroxymetolachlor	nitrate-N	terbuthylazine
hydroxysimazine	norflurazon	terbutryn
imazaquin	oryzalin	tetrachloroethene
imazethapyr	oxadiazon	thiobencarb
imidacloprid	oxamyl	toxaphene
iodomehtane	oxyfluorfen	trans-1,3-dichloropropene
iprodione	p,p'-DDE	triallate
isofenphos	pebulate	trichloroethene
isoxaflutole	pendimethalin	triclopyr
isoxaflutole benzoic acid	pentachlorophenol	trifluralin
isoxaflutole diketonitrile	permethrin	vernolate



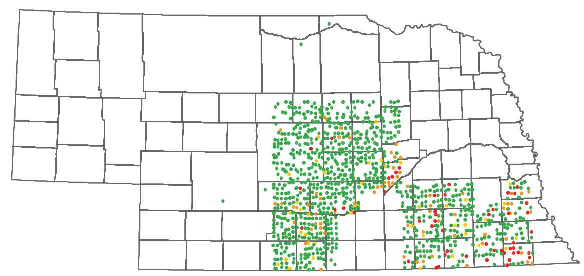
1974 - 1975 (397 wells, 397 analyses)



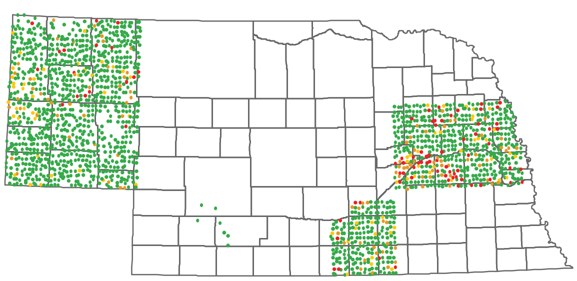
1976 (283 wells, 283 analyses)



1977 (45 wells, 45 analyses)



1978 (1057 wells, 1082 analyses)

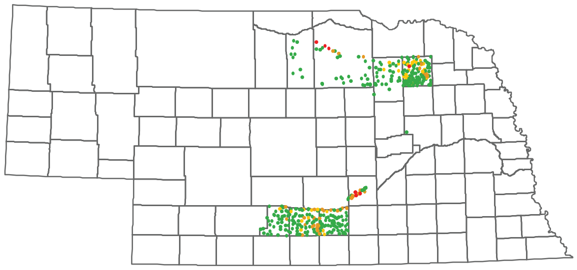


1979 (1843 wells, 1844 analyses)

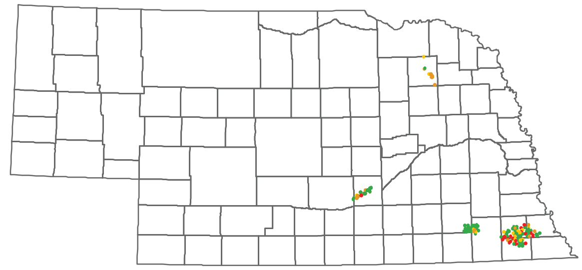
Figure B-1
Nitrate analyses for years 1974 - 1979
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- **< 7.5 mg/l**
- **7.5 – 10 mg/l**
- **10 – 20 mg/l**
- **> 20 mg/l**

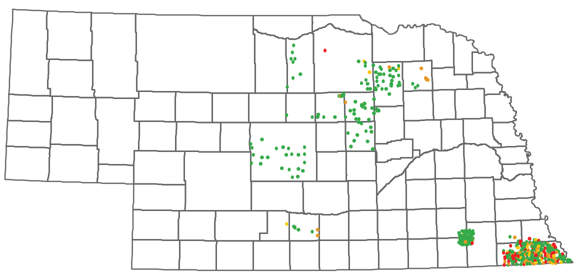
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



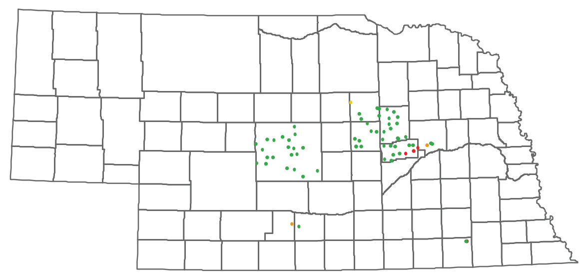
1980 (403 wells, 470 analyses)



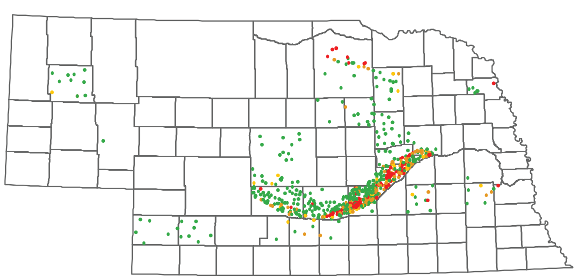
1981 (143 wells, 197 analyses)



1982 (506 wells, 519 analyses)



1983 (65 wells, 67 analyses)

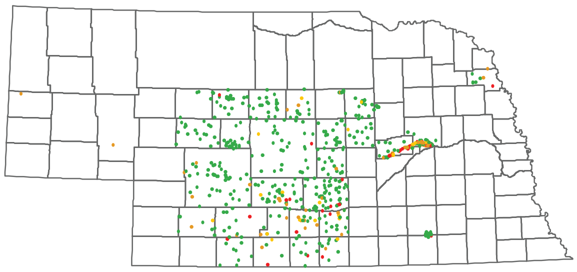


1984 (691 wells, 695 analyses)

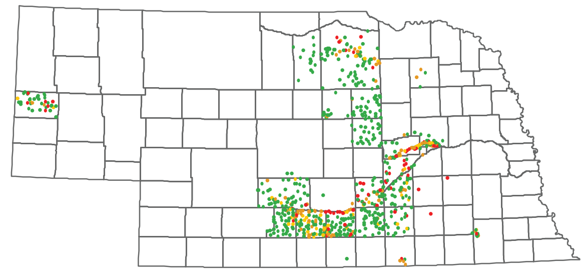
Figure B-2
Nitrate analyses for years 1980 - 1984
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

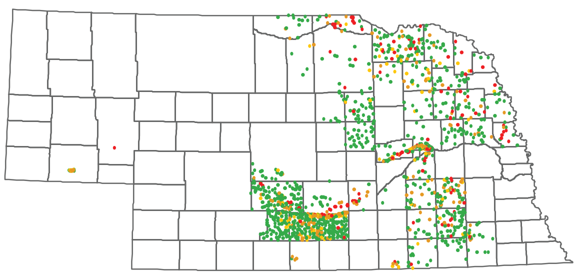
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



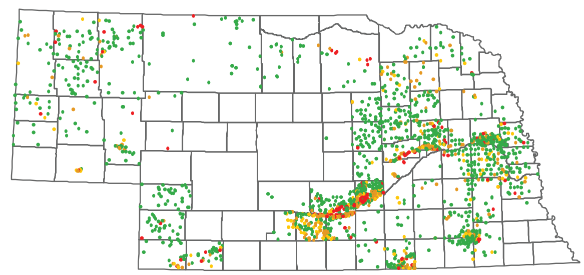
1985 (615 wells, 615 analyses)



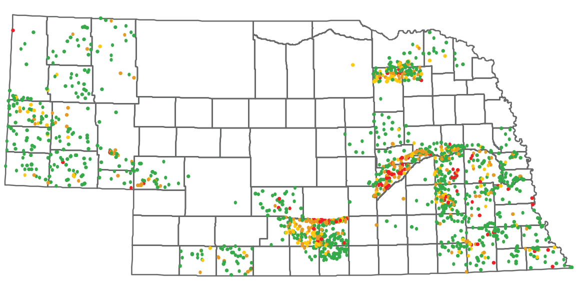
1986 (742 wells, 742 analyses)



1987 (1324 wells, 1372 analyses)



1988 (1794 wells, 1850 analyses)

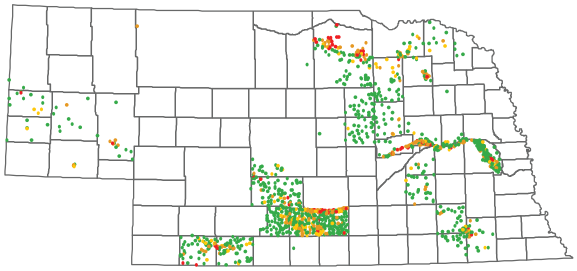


1989 (1664 wells, 1699 analyses)

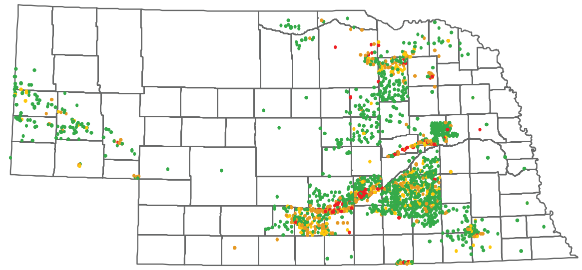
Figure B-3
Nitrate analyses for years 1985 - 1989
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

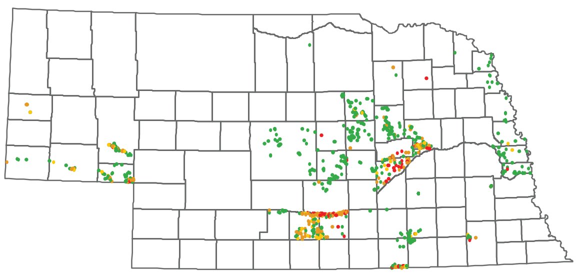
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



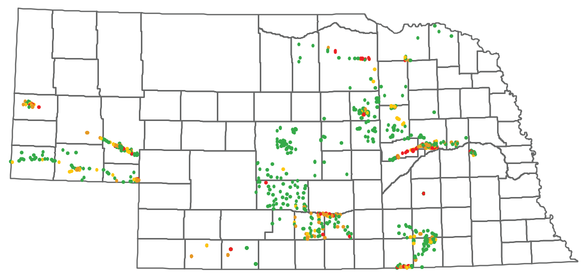
1990 (1336 wells, 1365 analyses)



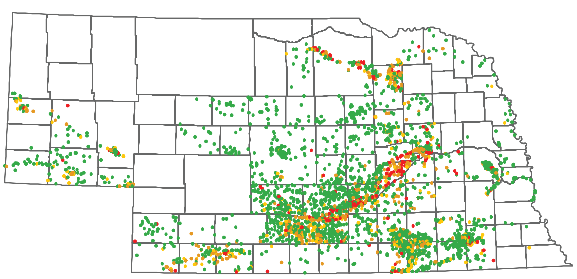
1991 (1918 wells, 2089 analyses)



1992 (803 wells, 1049 analyses)



1993 (809 wells, 1124 analyses)

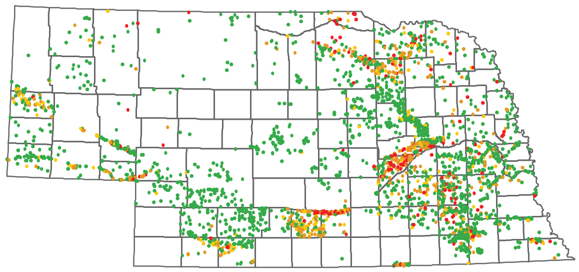


1994 (3149 wells, 3881 analyses)

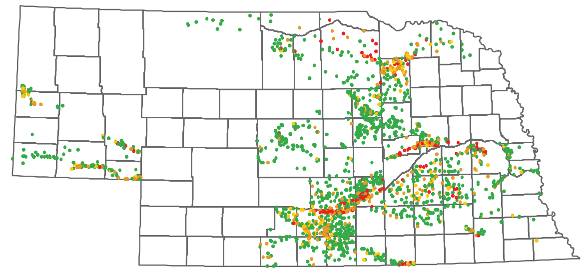
Figure B-4
Nitrate analyses for years 1990 - 1994
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

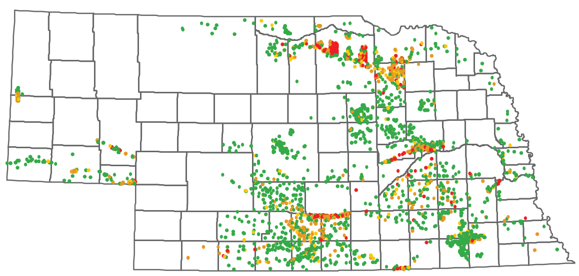
Empty areas indicate no data reported. These Maps were provided to give you a snapshot of the data. To see them better, view the report on NDEQ's web site (http://deq.ne.gov) and use your Adobe Acrobat reader to enlarge individual maps.



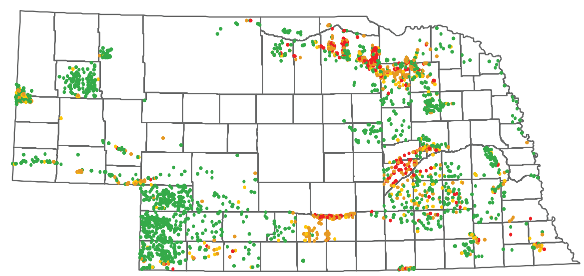
1995 (2939 wells, 3635 analyses)



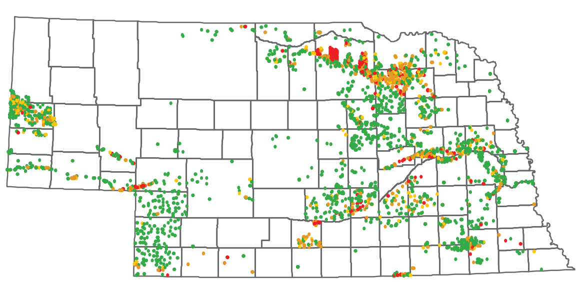
1996 (2124 wells, 2895 analyses)



1997 (2626 wells, 3607 analyses)



1998 (2428 wells, 3160 analyses)



1999 (2883 wells, 3525 analyses)

Figure B-5
Nitrate analyses for years 1995 - 1999
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

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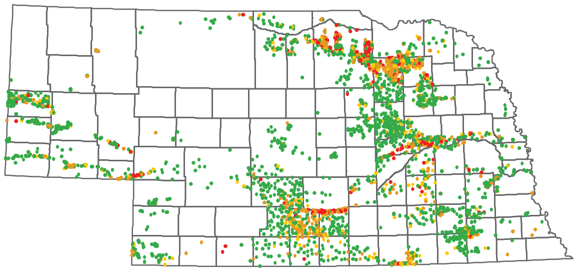
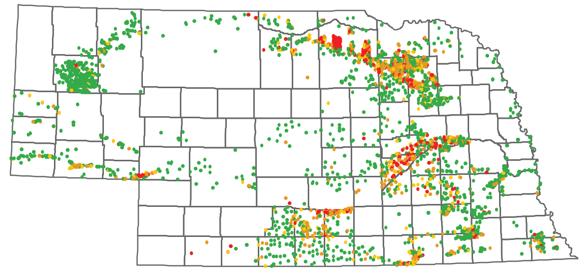
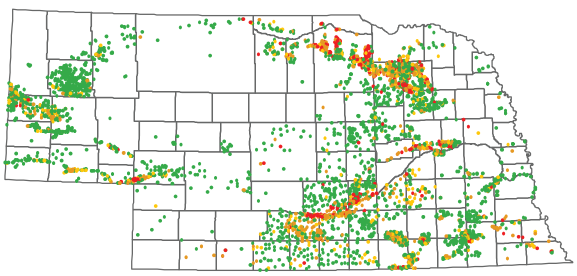


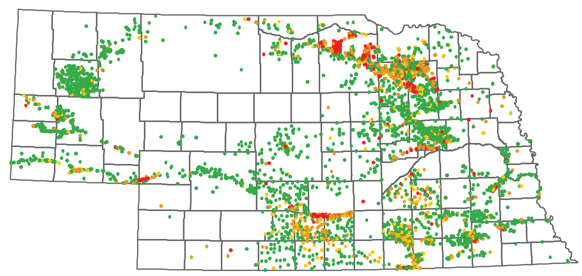
2000 (3504 wells, 4434 analyses)



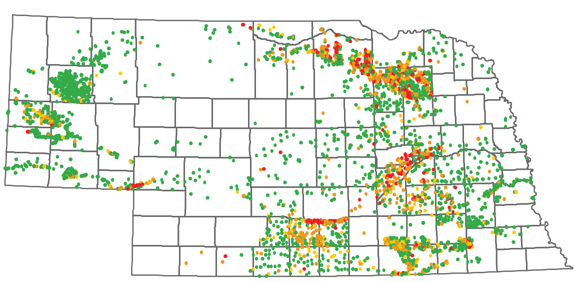
2001 (3243 wells, 3834 analyses)



2002 (4318 wells, 5213 analyses)



2003 (4420 wells, 5154 analyses)



2004 (3976 wells, 4926 analyses)

Figure B-6
Nitrate analyses for years 2000 - 2004
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- **< 7.5 mg/l**
- **7.5 – 10 mg/l**
- **10 – 20 mg/l**
- **> 20 mg/l**

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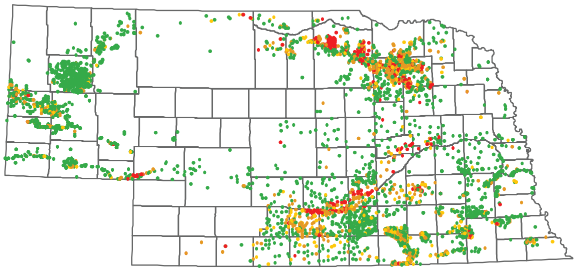
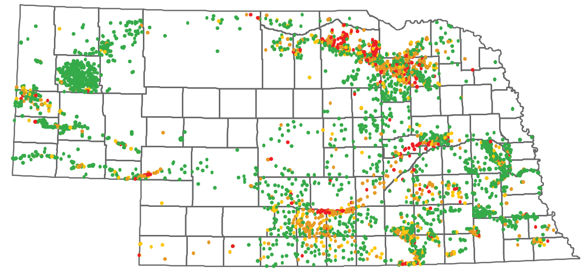
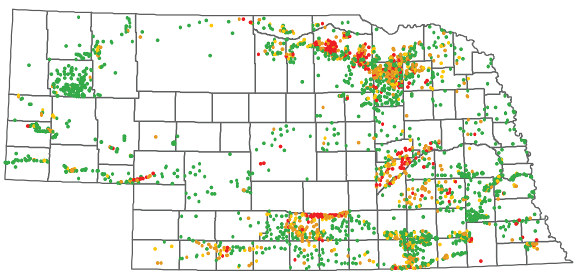


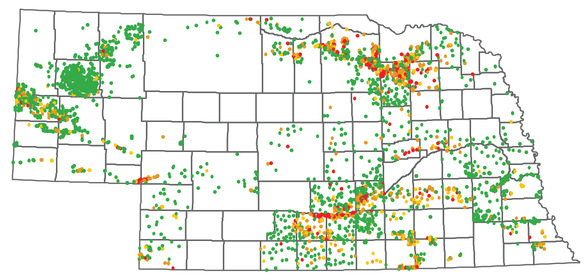
2005 (4274 wells, 5261 analyses)



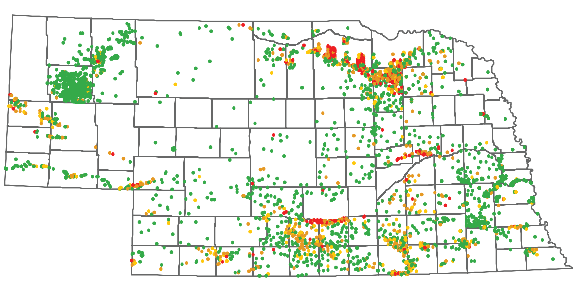
2006 (3892 wells, 4829 analyses)



2007 (3198 wells, 3593 analyses)



2008 (3460 wells, 3960 analyses)



2009 (3429 wells, 4044 analyses)

Figure B-7
Nitrate analyses for years 2005 - 2009
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels
- **< 7.5 mg/l**
- **7.5 – 10 mg/l**
- **10 – 20 mg/l**
- **> 20 mg/l**

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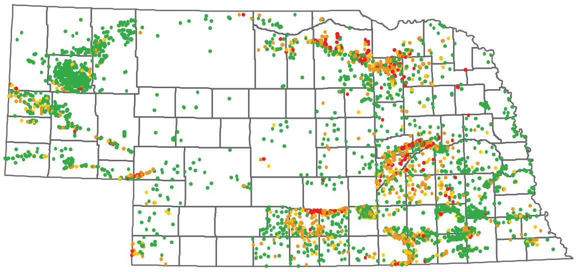
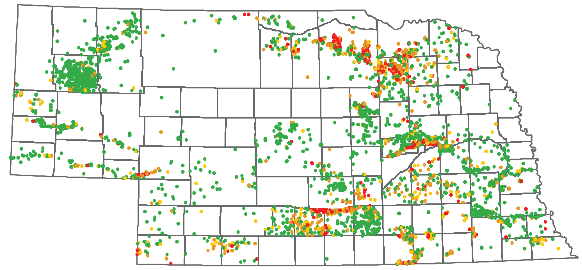
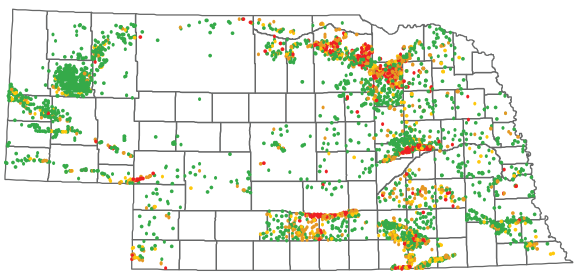


2010 (4492 wells, 5044 analyses)



2011 (4119 wells, 4618 analyses)



2012 (4472 wells, 5147 analyses)

Figure B-8
Nitrate analyses for years 2010 - 2012
(Source: Quality-Assessed Agrichemical Contaminant Database for Nebraska Groundwater)

Nitrate Levels

- < 7.5 mg/l
- 7.5 – 10 mg/l
- 10 – 20 mg/l
- > 20 mg/l

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