

**Update and Revision of Regional 1x2 Degree Water-Table  
Configuration Maps for the State of Nebraska**

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## **Introduction**

On May 19, 1999, the Nebraska Department of Environmental Quality (NDEQ) and the Conservation and Survey Division (CSD) of the University of Nebraska-Lincoln (UNL) signed a cooperative agreement to conduct a hydrogeologic study that would research, update and publish water-table contour maps. The purpose of the study is to provide updated and accurate water-table elevation maps to the NDEQ Source Water Assessment Program. Information from the maps is utilized in the delineation of Wellhead Protection Areas (WHPAs) for public water supplies in Nebraska. The last time water-table maps were produced at a 1:250,000 scale for most of Nebraska was in 1979 (Nebraska Department of Environmental Control [NDEC] and CSD, 1980a-i), while it has been since 1971 for the panhandle (Souders and Freethey, 1975a,b). The 1979 maps were also made under an agreement between CSD and NDEC (Carlson and others, 1980). These new water-table maps reflect more recent, accurate, and comprehensive water-level data, as well as a current understanding of ground water in Nebraska.

## **Data Sources and Data Acquisition Procedures**

The water-level data used in the project were acquired from a number of sources, processed and then compiled into a project-specific database. The primary source of the data is the water-level database maintained by the U. S. Geological Survey (USGS). The database is comprised of water-level measurement information originally made in the field by the Nebraska natural resources districts (NRDs), the USGS, the CSD, the U. S. Bureau of Reclamation (BOR), and other entities. The data is routinely sent to the USGS Lincoln office for quality assurance and control checks prior to compilation into the database. Electronic files of the data were transferred to the CSD from the USGS. This water-level data are also accessible via the Internet at Nebraska Department of Natural Resources web site: <http://www.dnr.state.ne.us/>

To the data obtained from the USGS, the CSD added a large volume of water-level information that was acquired directly from the BOR's Denver and Grand Island offices. The Bureau oversees the measurement of ground-water levels in observation wells associated with its irrigation and flood-control facilities and projects. Most of the bureau's water-level data is not part of the database maintained by the USGS. In addition, the CSD gathered data from some NRDs that also are not part of the USGS database.

The water-level information obtained and compiled for this project is maintained at the CSD in either WordPerfect text files or Microsoft Access/Excel database or spreadsheet files. This data contains records of over 5,000 wells from which water-level measurements were made during the spring of 1995. Spring 1995 data were chosen because they were the most comprehensive and quality-checked data available when the project was initiated during the winter of 1998-1999. Spring water-level data was used over fall data because water levels have had time to recover from seasonal pumping to their near-static or non-pumping levels. In addition to the spring 1995 water-level readings, these well records contain other information vital to the project such as location and surface elevation above mean sea level (MSL). Additional location and surface-elevation data were obtained from some NRDs, utilities, and irrigation districts that had recently used surveying techniques and global positioning technology to provide more accurate information for their observation wells. In addition, CSD project researchers revised some



location and surface-elevation data that were deemed inaccurate based on the availability of more recent topographic maps and registered well information in our office. Revisions were also made for wells where there were obvious errors in surface elevations in the original data or where there was not any elevation at all specified in the database. The revised location and surface-elevation data is in the process of being submitted to the USGS so that their database can be revised as well.

Ground-water elevations were calculated from the spring 1995 depth-to-water readings and the surface-elevation records. The calculated ground-water elevations from the 5,000 observation wells were used as the "control points" in the contouring procedures outlined below. In addition to these control points, perennial stream, spring, and lake-elevation data from the 7.5-minute maps were also used to form the basis of the contouring methodology used to prepare the water-table maps. In areas where stream reaches were suspected to have changed from perennial to intermittent (or vice versa) since the date of the topographic maps, this information was supplemented by data from more recent field work such as the USGS low-flow investigations in the Republican River basin. In areas where ground water in the principle aquifer occurs mainly under confined conditions, potentiometric-surface contours were generally drawn without using surface water and topographic features.

Where significant gaps in the coverage were evident, the water-level data were supplemented at the investigator's discretion with depth to static water-level information from recent well registrations (typically from years 1994-1996) from the Nebraska Department of Water Resources. In areas where ground-water levels fluctuate significantly on a seasonal basis (for example, irrigation pumping from confined aquifers), water-level data obtained during the irrigation season was not used.

### **Map Preparation Methodology**

Project methodology for preparing the water-table maps varied slightly from quadrangle to quadrangle based on the researcher(s) involved and the hydrogeologic characteristics of the region. The following are the eleven 1:250,000-scale quadrangles and their respective project researcher(s)

Alliance	Vince Dreeszen
Broken Bow	Steve Hartung and Scott Summerside
Fremont-Omaha	Scott Summerside
Grand Island	Michael Ponte
Lincoln-Nebraska-City	Vince Dreeszen
McCook	Michael Ponte
North Platte	Michael Ponte
O'Neill	Steve Hartung
Scottsbluff	Vince Dreeszen
Sioux City	Steve Hartung and Scott Summerside
Valentine	Scott Summerside and Joe Szilagyi



For each observation-well “control point” and supplemental DWR registered-well data point, the location of the well was plotted on 7.5-minute maps, along with the surface elevation of the well, the depth to static water level, the calculated ground-water elevation and the date of the measurement. These ground-water elevation points were contoured on the 7.5-minute work maps utilizing elevation of surface water features where applicable. In general, contours were produced at 50-foot intervals, with supplementary 10-foot contours in the Platte Valley area. Some areas of 25- or 100-foot contours were produced. Topographic characteristics of the land surface were also taken into account. The contouring of data points is strongly influenced by the surface topography and surface-water features. For example, ground-water contours cannot be higher than the surface topography (Fetter, 1994). Contours were transferred from 7.5-minute maps to 1:250,000 (1x2-degree) work maps. In areas of extremely sparse data, ground-water elevation points and contouring were done directly on the 1x2 degree maps. Work maps compiled at 7.5-minute and/or 1x2-degree scales for selected areas of the state are on file at our office. The primary authors are available for interpretation and explanation of map content. Work maps can be used to identify areas where further activities may be needed to meet data gaps (additional research, field activities, hiring of consultants, etc.) in SWAP and wellhead-delineation activities.

Maps were then drafted by a cartographer on a stable mylar base. Project researchers and the cartographer reviewed consistency between the 1x2-degree quadrangle maps so that contours matched at map interface boundaries. After maps were drafted by cartography, they were reviewed again for any errors that may have occurred during drafting. After any additional changes were made, the finished maps were sent out for offset printing.

For the Grand Island, North Platte, and McCook maps, the methodology was varied slightly as follows. The well data was plotted on 7.5-minute topographic maps to confirm the latitude/longitude coordinates and surface elevations from the database. These data points were then plotted onto 1:100,000-scale digital line graphs used with the Wellhead Analytical Element Model (WhAEM2000) groundwater modeling program; latitude/longitude coordinates used in the USGS database were converted to UTM coordinate system used in WhAEM. In the WhAEM modeling program, water-table contours are generated at intervals the user designates; for this project, 50-foot contours were chosen, except in the Platte River valley, where 10-foot contours were chosen. The contours generated by the program were based on water-level data entered into the program: the elevation differences along perennial streams and rivers, as well as the elevation differences between wells. Using the maps generated by the program as a guide, the water-level contours were then hand drawn on a 1:250,000 topographic base prior to being submitted to a cartographer for formal drafting and publication.

For the Valentine map, the researcher used ESRI ArcView/Arcinfo software to produce water table contours from the database. He used stream and lake elevations from digital elevation models (DEMs). However, the quality of the output was not up to the standard of the hand drawn contours. In some areas of sparse data, highly irregular contour patterns developed using the computer. Also, there were problems of where the computer incorrectly produced water-table elevation contours above the land surface. The map was redone according to the traditional approach outlined above with the inclusion of additional data from BOR; but, the computer-



generated map was utilized as a guide in areas where sufficient data and no topographic control problems occurred.

All of the published water-table maps will be reproduced in electronic format in the near future to provide for CSD statewide geographic information system (GIS) coverage. Access to the digital forms of the maps should be available on CSD web site in the near future.

### **Discussion of Methodology Related to Eastern Nebraska Hydrogeology**

Because of the greater degree of hydrogeologic complexity within the ground-water system in eastern Nebraska, the water-table contours tend to be less reliable east of the dashed line on the Sioux City, Fremont-Omaha, and Lincoln-Nebraska City maps. The dashed line of the 1979 maps was left in essentially the same location on the new maps. Although not quite the outer limit of Pleistocene glacial advance or stillstand, the dashed line marks the approximate location of terminal moraines of one or more undifferentiated Pre-Illinoian glacial maxima (Swinehart and others, 1994). For hydrogeologic considerations, the dashed line generally represents the western boundary of predominately fine-grained glacial deposits (for example, till) referred to as the Nebraska glacial drift of groundwater regions 10 and 11 in *The Groundwater Atlas of Nebraska* (Flowerday and others, 1998). Significant vertical groundwater flow gradients are common within the aquifer system in eastern Nebraska. They are caused by contrasts in hydraulic conductivity between aquifer zones within the principle aquifer system (and Dakota aquifer), as well as recharge and discharge area relationships. It should be noted that in the Platte, Missouri, and "Todd" valley areas, as well as some portions of other major stream valleys in eastern Nebraska, the glacial drift deposits have been largely removed and replaced by more recent alluvial and terrace deposits.

The area on the maps east of the dashed line should be considered a ground-water *level* contour map rather than a ground-water *table* contour map. This is because the water levels from most observation and production wells in this area represent composite levels, rather than the top of the zone of saturation. Most of these wells are screened in coarse-grained deposits that often occur as confined aquifers (for example, paleovalley aquifer systems). These wells are often poorly sealed and usually gravel packed and/or screened over multiple hydrostratigraphic zones, if not the entire principal aquifer system. Consequently, composite water levels result from the integration of various pressure heads within the aquifer system. According to Saines (1981), composite water levels usually do not indicate the surface of the water table. In summary, most of the available water-level data east of the dashed line is from observation and production wells that do not reliably reflect the water table.

The water table is often within 50 feet of the land surface and frequently occurs within low-permeability sediments such as loess, glacial till and fine-grained alluvium/colluvium. If a water-table map was constructed for the area east of the dashed line, it would depict a topographically driven phreatic surface where the contours of the water table would mirror the land surface at a slightly lower elevation above mean-sea level. According to Fetter (1994), the relief of the water table is usually less than the topographic relief. The surface of the water table occurs where the pore water pressure is equal to the atmospheric pressure. Lohman and others, 1972, state that it



### **Limitations and Intended Uses of Maps**

Efforts have been made to ensure the accuracy of the factual data on which these water-table maps are based. Users may want to verify critical information. In addition, efforts have been made to ensure that the interpretations used to make the maps conform to sound geologic, hydrologic, and cartographic principles

These reconnaissance-scale maps are intended to be used for regional understanding of hydrologic conditions (that is, approximate groundwater flow directions, gradients and depth to water) and should not be used for detailed site-specific decision-making activities with economic or legal implications. They can be used as a “first-cut” of information prior to local site-specific hydrogeologic investigations. For example, they can be used to help formulate a preliminary conceptual model of the hydrogeology of a site during an initial site assessment and prior to the actual site-specific fieldwork. In summary, the water-table maps should not be used to guide regulatory and engineering-scale decisions without site-specific verification.

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