UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
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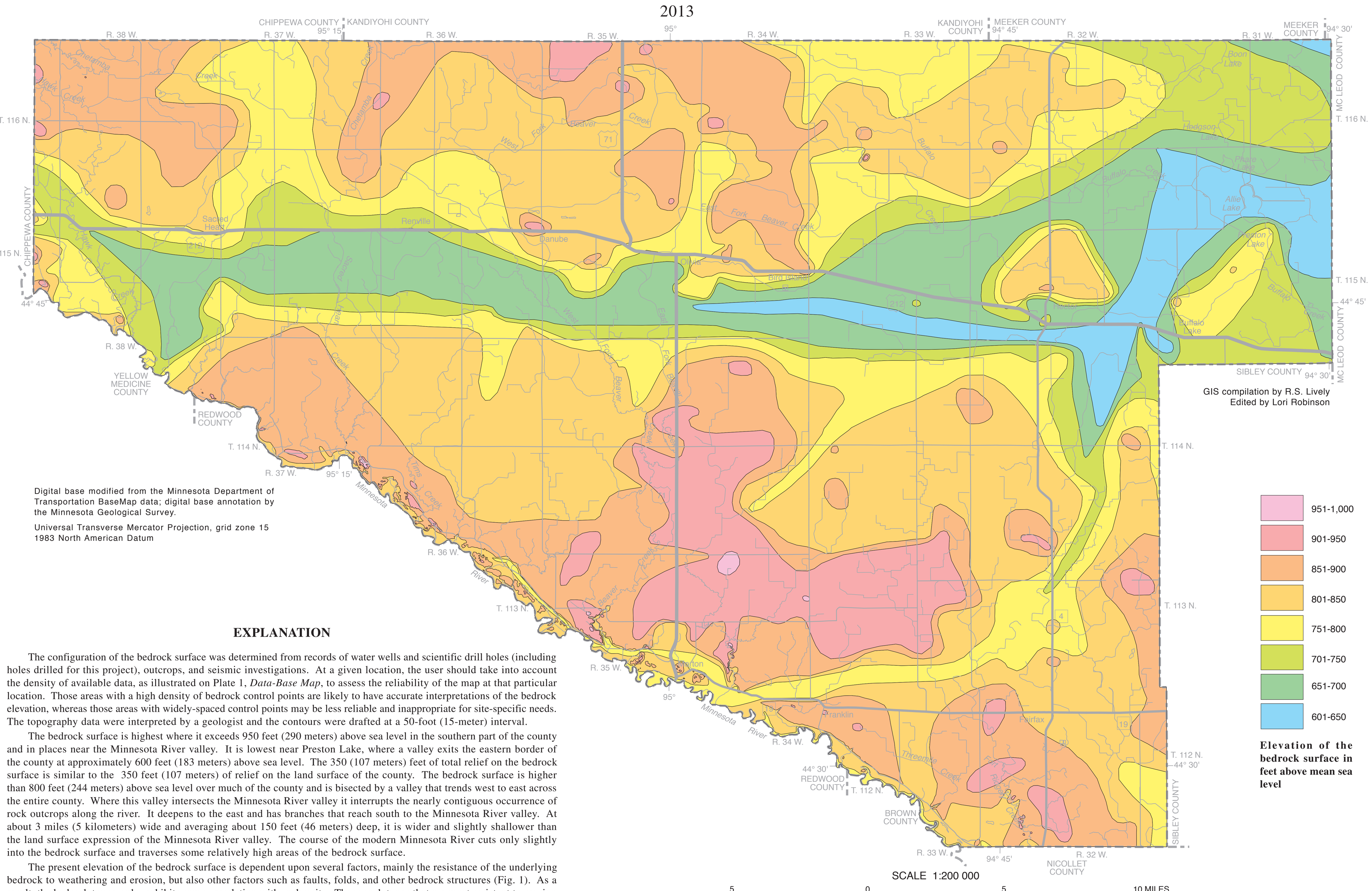
COUNTY ATLAS SERIES
ATLAS C-28, PART A
Renville County
Plate 5—Depth to Bedrock, Bedrock Topography, *and* Sand Distribution Model

# BEDROCK TOPOGRAPHY

By

Dale R. Setterholm

2013

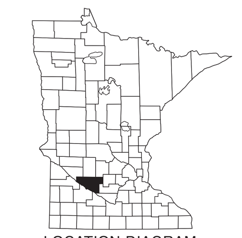



## EXPLANATION

The configuration of the bedrock surface was determined from records of water wells and scientific drill holes (including holes drilled for this project), outcrops, and seismic investigations. At a given location, the user should take into account the density of available data, as illustrated on Plate 1, *Data-Base Map*, to assess the reliability of the map at that particular location. Those areas with a high density of bedrock control points are likely to have accurate interpretations of the bedrock elevation, whereas those areas with widely-spaced control points may be less reliable and inappropriate for site-specific needs. The topography data were interpreted by a geologist and the contours were drafted at a 50-foot (15-meter) interval.

The bedrock surface is highest where it exceeds 950 feet (290 meters) above sea level in the southern part of the county and in places near the Minnesota River valley. It is lowest near Preston Lake, where a valley exits the eastern border of the county at approximately 600 feet (183 meters) above sea level. The 350 (107 meters) feet of total relief on the bedrock surface is similar to the 350 feet (107 meters) of relief on the land surface of the county. The bedrock surface is higher than 800 feet (244 meters) above sea level over much of the county and is bisected by a valley that trends west to east across the entire county. Where this valley intersects the Minnesota River valley it interrupts the nearly contiguous occurrence of rock outcrops along the river. It deepens to the east and has branches that reach south to the Minnesota River valley. At about 3 miles (5 kilometers) wide and averaging about 150 feet (46 meters) deep, it is wider and slightly shallower than the land surface expression of the Minnesota River valley. The course of the modern Minnesota River cuts only slightly into the bedrock surface and traverses some relatively high areas of the bedrock surface.

The present elevation of the bedrock surface is dependent upon several factors, mainly the resistance of the underlying bedrock to weathering and erosion, but also other factors such as faults, folds, and other bedrock structures (Fig. 1). As a result, the bedrock topography exhibits some correlation with rock units. Those rock types that are most resistant to erosion (see Plate 2, *Bedrock Geology*) typically tend to occupy higher parts of the topography and less resistant rock types are associated with low areas. However, there is only a weak correlation between bedrock types and bedrock topography in Renville County. This may indicate that faults in the bedrock and glacial dynamics were the dominant factors in shaping the bedrock surface.



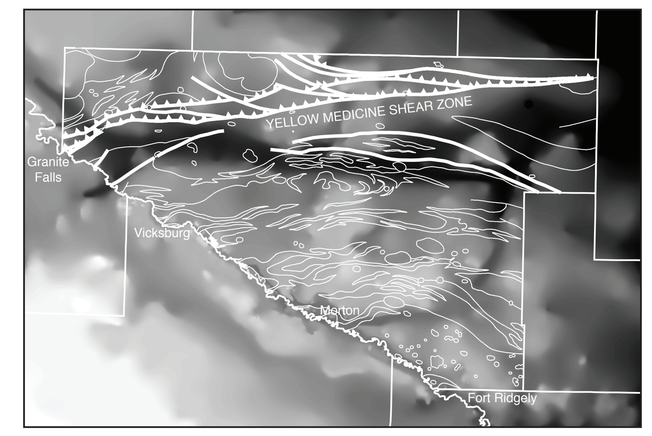




**Figure 1.** Shaded image of bedrock topography showing geologic contacts and faults (white lines; from Plate 2, *Bedrock Geology*). Darker shades represent lower elevations of the bedrock surface. Note that the prominent east-trending valley in the central part of the county (dark) corresponds in part with the Yellow Medicine shear zone and faults south of it (slightly bolder white lines). This valley may be the result of glacial and pre-glacial scouring of bedrock that was weakened by shearing and associated deeper weathering.



# DEPTH TO BEDROCK

By

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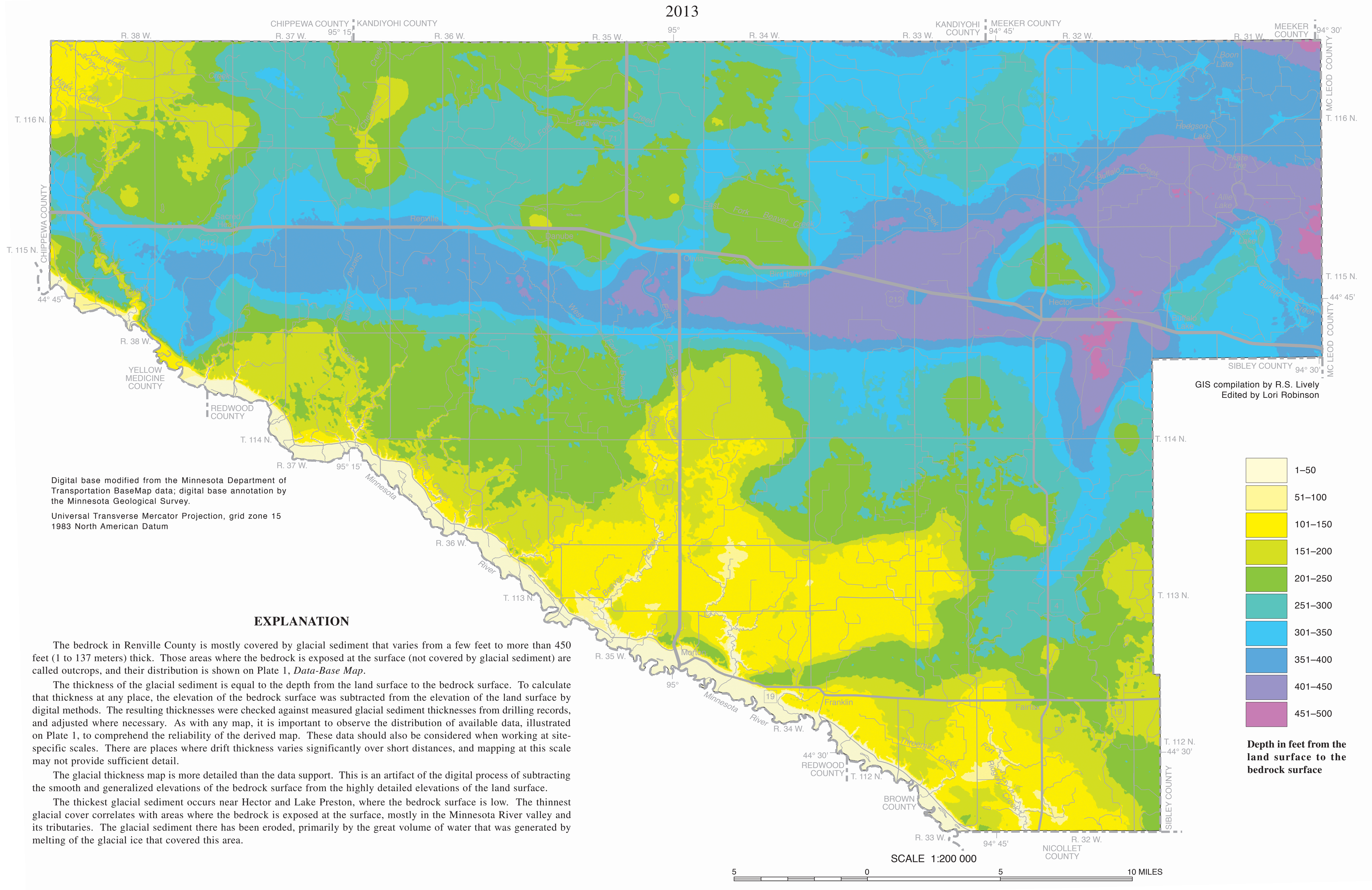
2013




## EXPLANATION

The bedrock in Renville County is mostly covered by glacial sediment that varies from a few feet to more than 450 feet (1 to 137 meters) thick. Those areas where the bedrock is exposed at the surface (not covered by glacial sediment) are called outcrops, and their distribution is shown on Plate 1, *Data-Base Map*.

The thickness of the glacial sediment is equal to the depth from the land surface to the bedrock surface. To calculate that thickness at any place, the elevation of the bedrock surface was subtracted from the elevation of the land surface by digital methods. The resulting thicknesses were checked against measured glacial sediment thicknesses from drilling records, and adjusted where necessary. As with any map, it is important to observe the distribution of available data, illustrated on Plate 1, to comprehend the reliability of the derived map. These data should also be considered when working at site-specific scales. There are places where drift thickness varies significantly over short distances, and mapping at this scale may not provide sufficient detail.

The glacial thickness map is more detailed than the data support. This is an artifact of the digital process of subtracting the smooth and generalized elevations of the bedrock surface from the highly detailed elevations of the land surface.

The thickest glacial sediment occurs near Hector and Lake Preston, where the bedrock surface is low. The thinnest glacial cover correlates with areas where the bedrock is exposed at the surface, mostly in the Minnesota River valley and its tributaries. The glacial sediment there has been eroded, primarily by the great volume of water that was generated by melting of the glacial ice that covered this area.

# SAND DISTRIBUTION MODEL

By

Alan R. Knaeble, Robert G. Tipping, and R.S. Lively

2013

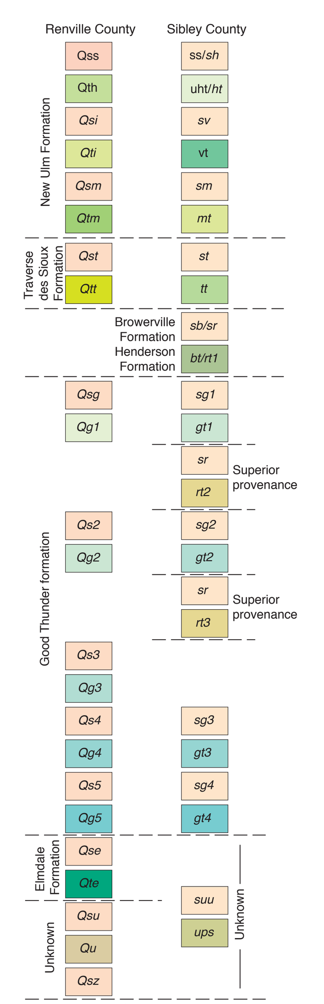



**Figure 2.** Stratigraphic position of sand and gravel bodies shown on the sand distribution diagrams (Figs. 3 through 12) for Renville County. Units are compared with equivalent bodies mapped to the east in Sibley County (Lusardi and others, 2012).

## INTRODUCTION

Establishing the location and characteristics of sand and gravel as aggregate resources and as aquifers is an essential step toward their wise use and protection. This project employed a process that combined the understanding of a geologist with the data-handling capability of a geographic information system (GIS) to create three-dimensional models of sand and gravel bodies. The resulting figures show the distribution of Quaternary sand and gravel deposits that may be aquifers in Renville County. The distribution of sand, which in the following text implies sand and gravel, at the land surface was mapped by the geologist from exposures, shallow drill holes, soil maps, and landforms. In contrast, interpreting sand distribution in the subsurface relied primarily on well records, scientific drill core, and drill cuttings (see cross sections on Plate 4, *Quaternary Stratigraphy*, for locations). Sand distribution models are based on the assessment of these data, consideration of the processes that deposited the glacial sediment, and an understanding of the glacial history.

The unconsolidated Quaternary sediments that overlie the bedrock in Renville County vary greatly in character and thickness. These deposits are largely the result of numerous distinct ice advances during the Pleistocene Epoch (see Plate 3, *Surficial Geology*, Summary of Glacial History, and Plate 4, Fig. 3). Most of the aquifers within the mapping area consist of sand and gravel beds laid down in meltwater streams that flowed from these glaciers. Sand bodies are typically bracketed above and below by confining layers (aquitards) composed of unsorted sediment deposited directly from the ice (till) or of fine-grained clay- and silt-rich bedded sediment deposited in ponded meltwater. The ice sheets typically covered broad areas of the landscape and deposited widespread layers of till during each ice advance. On the other hand, meltwater stream deposits were generally confined to narrow drainages at lower elevations on the evolving land surface. Advancing ice may erode some or all of its own proglacial sand and gravel outwash deposits, as well as underlying sediments from previous glacial events. As ice retreats or stagnates, it covers the landscape with till, which in turn may be eroded and/or covered by sand and gravel associated with postglacial meltwater streams. As a result, sand and gravel between till units may represent postglacial outwash from one or more ice lobes, proglacial outwash associated with the ice that deposited the overlying till, or a combination of both. For simplicity, the sand body naming convention associates the sand and gravel units on the cross sections with the underlying till or lake sediment (Fig. 2).

Because glacial ice and meltwater not only deposit sediment, but also erode older, underlying sediment, their actions create a complex stratigraphy. New layers of sand or till could fill depressions eroded into older layers or completely replace older layers, if enough erosion occurs. The net effect of erosion and deposition in discrete drainage depressions is that sand and gravel bodies that provide water to wells in glacial terrain tend to be discontinuous both vertically and horizontally.

In order to model the subsurface, 50 closely spaced cross-section lines were generated in a west–east direction (Plate 4, Fig. 1). The results from the cross section analyses are available digitally as raster data sets for the top and bottom elevation surfaces and thicknesses of each interpreted unit of till and sand. Examples of the interpretations along six of these lines are shown in cross sections A–A' through F–F' on Plate 4. Descriptions and samples from a combination of water well records, rotary-sonic core, scientific cutting sets, and auger borings were used to identify contacts between units in the subsurface along each cross section. The geologist provides an interpretation of materials that occur in the areas between wells or at depths not penetrated by wells, based primarily on an understanding of geologic processes. The distribution of data greatly affects the resolution and accuracy of the models. For example, if wells are widely-spaced, they may not intersect sand and gravel deposits that have limited extent. In another situation, shallow bodies of sand and gravel may provide enough water for most uses so that deposits deep below the surface are typically intersected by few wells. With less information, the geologist may only be able to interpret deep sediments as glacially derived but undifferentiated, and suggest the possibility that sand bodies are present, and that more complete data are required to map them.

Each water well record describes the vertical sequence of earth materials at the location of the well. Although sand and gravel can occur within a till, they occur more commonly at the contact between two tills. Where two till layers related to different depositional events are not separated by sand and gravel, the contact can commonly be recognized by a change in the driller's description of material, texture, density, or color. Using the available data, contact lines were drawn along each cross section, with each line representing the base of a unit of sand or till. GIS software extracted elevation values from vertices along each unit line, and converted those into raster data representing the elevation surface and aerial distribution of the unit. The till surfaces were iteratively modified until the geologist was confident that they adequately represented the stratigraphic interpretation for the majority of water well data. A similar process was followed for the surfaces of the sand and gravel bodies to ensure they conformed with till and water well data. When both till and sand surface grids were complete, they were processed through GIS raster calculations to create a set of top and bottom surfaces and thickness for each geologic unit. The result is a three-dimensional geologic model of tills and sands for the county.

Till and sand and gravel units from Plate 4 are listed in Figure 2 by stratigraphic order, youngest to oldest, along with equivalent units from adjacent Sibley County to the east. The areal distribution and thickness of the sands are shown in Figures 3 through 11 and indicate where major sand bodies in the subsurface are likely to occur. The surface sand (unit Qss), modeled as a single unit, was compiled from individual surficial sands (units Qa, Qf, Qc, Qsw, Qs, and Qsc) shown on Plate 3. Peat (unit Qp) and modern lake sediment (unit Qhl), which locally overly the surface sands, are included in the areal extent and thickness of unit Qss (Fig. 3). Sands other than unit Qss are subsurface units because any exposures are limited to bluffs of the Minnesota River and its tributaries and are too small to be mapped (Figs. 4 through 10). Units *Qs5* (Fig. 9) and *Qsu* (Fig. 10) in northeastern Renville County represent most of the larger sand bodies in Renville County. They show an east–west elongated pattern along cross-section lines. This is because bordering cross sections lacked data, or sand and gravel that could be connected with a specific sand body. Thus, a sand and gravel body appears only on the one section, giving it an east–west orientation. This type of pattern illustrates both that data in the region are sparse and that sand distribution is likely to be highly discontinuous. Sand bodies may be more extensive along the cross-section lines than shown. In contrast, the linearity of unit *Qsz* (Fig. 11) shows an east–west trend resulting from identified sand and gravel deposits along the bottom of an east-trending bedrock valley (indications of these sands were seen previously in regional Minnesota Department of Natural Resources subsurface mapping in 2006; J. Berg, unpub. data). Enough wells encountered these deposits just above the bedrock surface to indicate that they could be more extensive than the modeled sand units at higher elevations. The Good Thunder formation has five sand units (Fig. 2). Sand units *Qs2* and *Qs4* have distribution patterns similar to unit *Qsg* and therefore are not shown. Additionally, sand unit *Qse* (Fig. 2) was not extensive enough to be shown on this plate.

The till/sand geologic model does not guarantee that sand and gravel will be found at all places and depths shown, nor does it preclude them from being found in areas where they are not shown. It does indicate where sand features with a large areal extent and significant thickness are more likely to be encountered. Where data are limited, geologic interpretations relating to the extent of sand and gravel bodies and their thickness tend to be conservative, and suggest less material than may actually be present. To compound the limited data, most ice advances entered the area from the northwest without incorporating much sand and gravel. Additionally, erosion by ice and meltwater during subsequent glacial events may have removed portions of older sand bodies. Together these factors account for the generally spotty nature of the subsurface sand bodies in Renville County. Where incomplete data did not allow for interpretations, sediments were categorized as Pleistocene undifferentiated deposits (Fig. 12). Additional sand bodies, or extensions of those shown, are undoubtedly present in these areas.

The geologic model provides a generalized interpretation of the distribution and type of geologic units encountered in the subsurface. Due to its interpretive nature and data limitations, the model should be used as a guide and should not preclude site-specific investigation.

## REFERENCE

Lusardi, B.A., Meyer, G.N., Knaeble, A.R., Gowan, A.S., and Jennings, C.E., 2012, Quaternary stratigraphy, pl. 4 *of* Setterholm, D.R., project manager, Geologic atlas of Sibley County, Minnesota: Minnesota Geological Survey County Atlas C-24, 6 pls.

CONTOURS FOR FIGURES 3 THROUGH 11

**Thickness of a sand and gravel unit contoured at 20 foot (6 meter) intervals.**

20
40
60
80
100
120
140

**Note:** Contour lines may not close at the edges of mapped areas. This is an artifact of the digital processing.

DEPTH FOR FIGURES 4 THROUGH 12

0–50
51–100
101–150
151–200
201–250
251–300
301–350
351–400

**Depth in feet from the land surface to the top of a sand and gravel unit** (depth from the land surface to the top of undifferentiated sediment is shown on Figure 12).

SCALE 1: 400 000

10 0 10 20 MILES

10 0 10 20 30 KILOMETERS

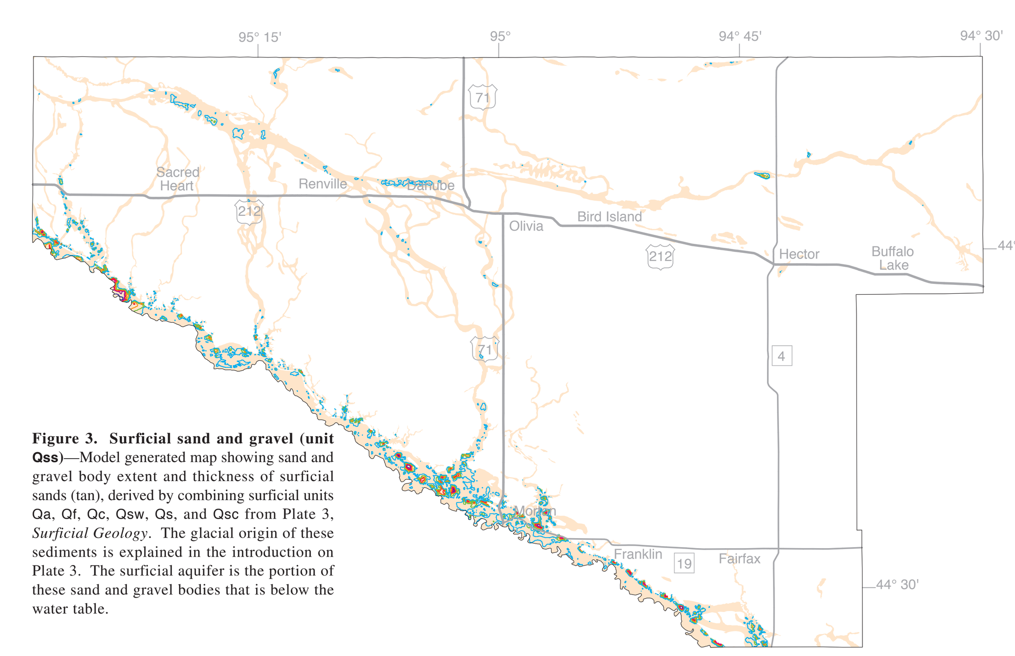


**Figure 3. Surficial sand and gravel (unit Qss)**—Model generated map showing sand and gravel body extent and thickness of surficial sands (tan), derived by combining surficial units Qa, Qf, Qc, Qsw, Qs, and Qsc from Plate 3, *Surficial Geology*. The glacial origin of these sediments is explained in the introduction on Plate 3. The surficial aquifer is the portion of these sand and gravel bodies that is below the water table.

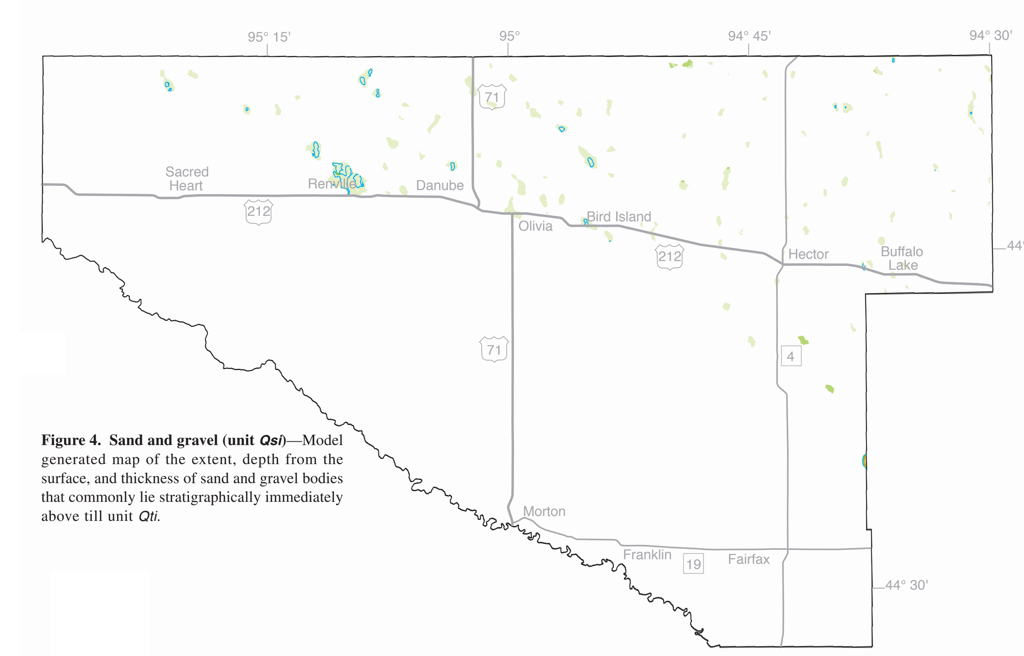


**Figure 4. Sand and gravel (unit *Qsi*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies that commonly lie stratigraphically immediately above till unit *Qti*.

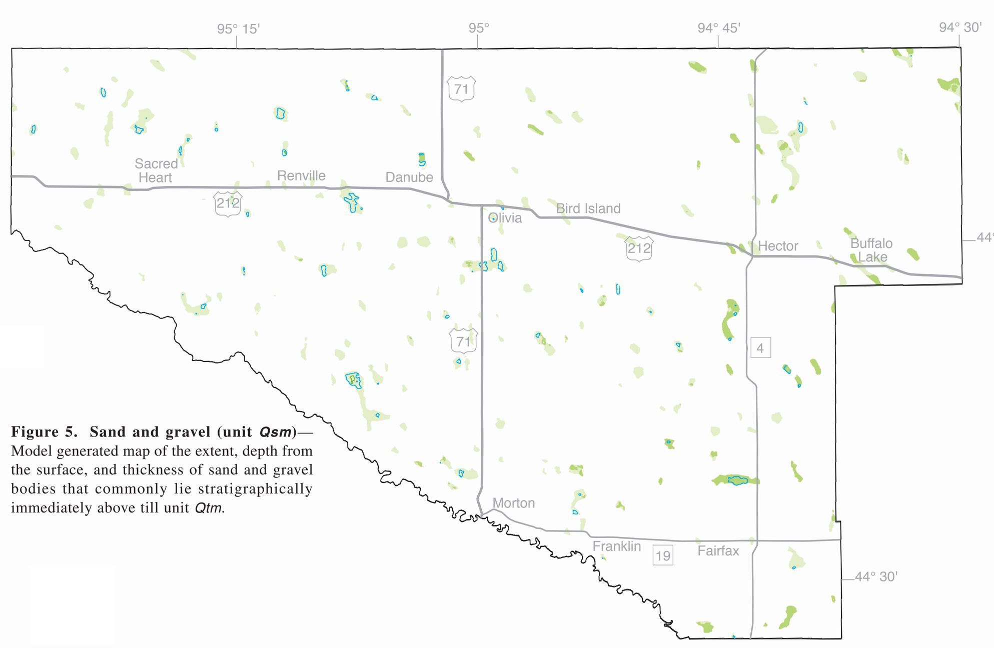


**Figure 5. Sand and gravel (unit *Qsm*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies that commonly lie stratigraphically immediately above till unit *Qtm*.

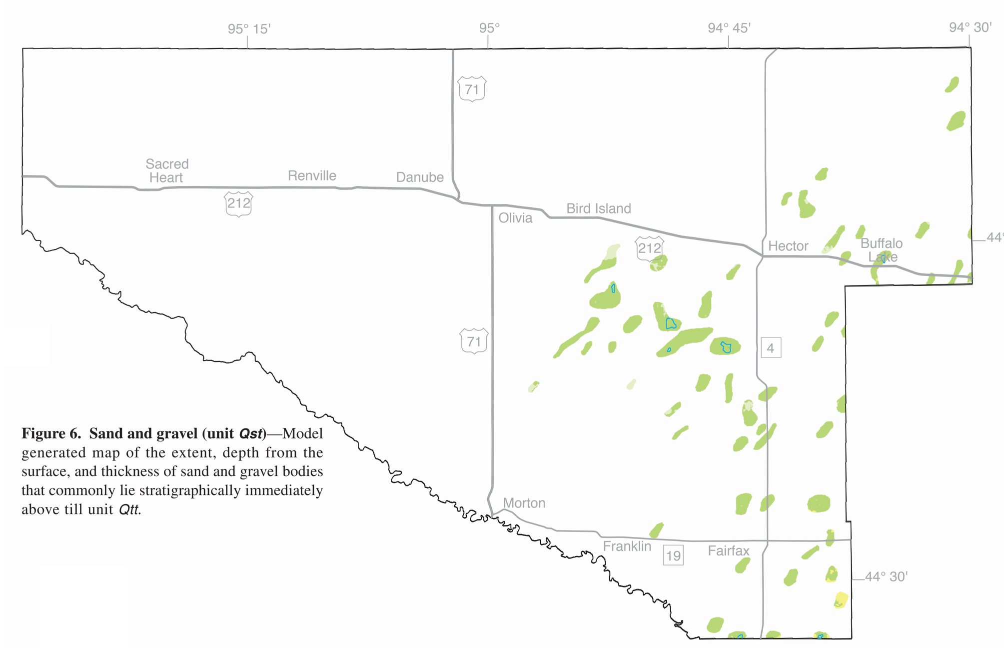


**Figure 6. Sand and gravel (unit *Qst*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies that commonly lie stratigraphically immediately above till unit *Qtt*.

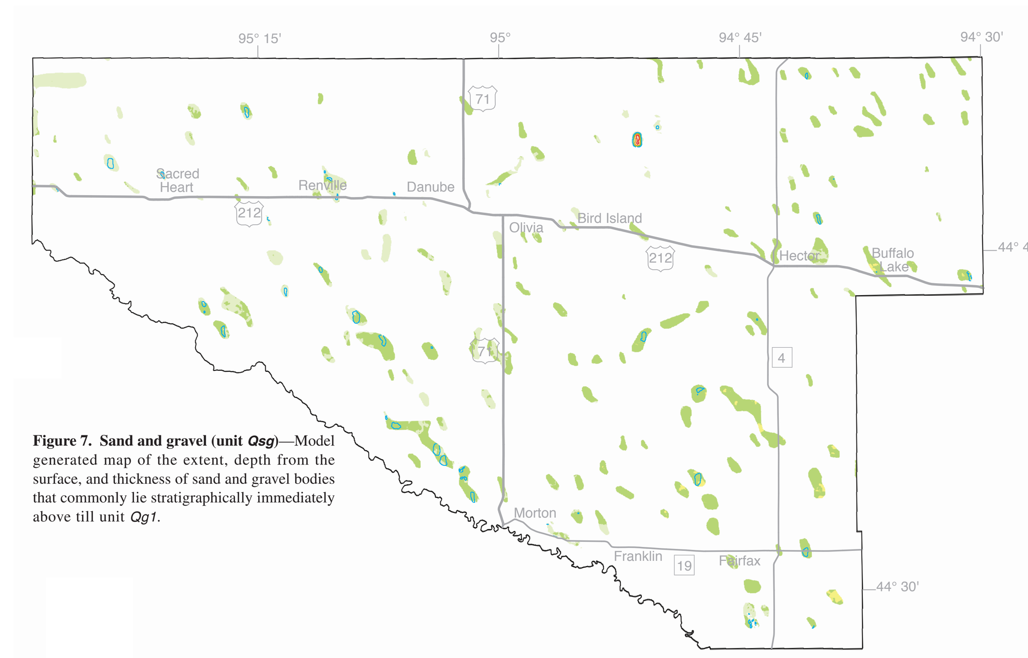


**Figure 7. Sand and gravel (unit *Qsg*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies that commonly lie stratigraphically immediately above till unit *Qg1*.

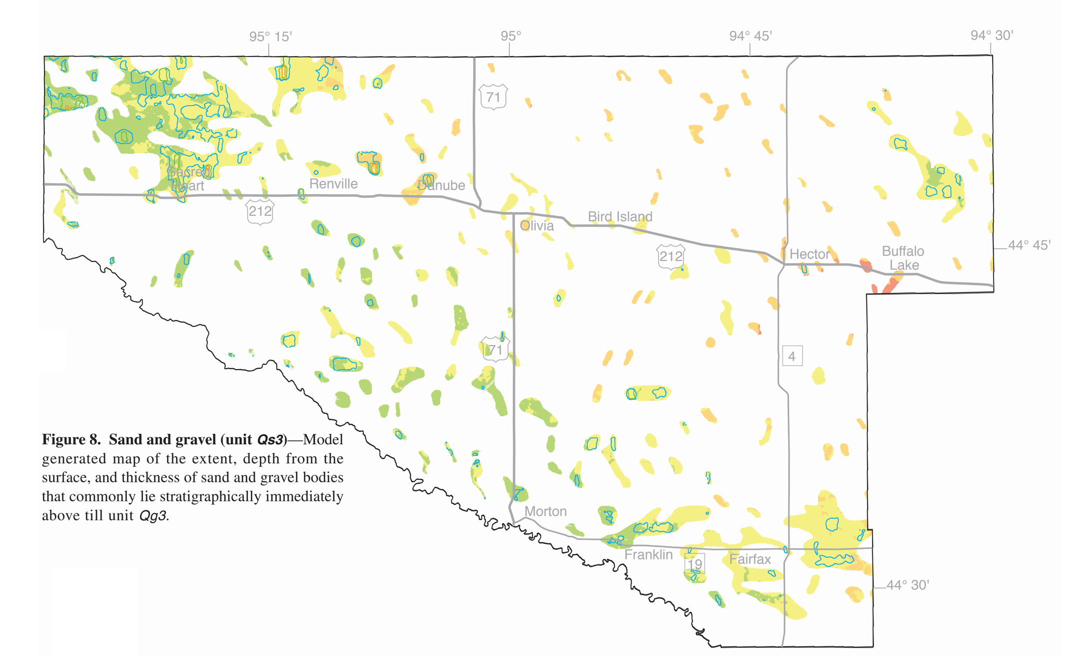


**Figure 8. Sand and gravel (unit *Qs3*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies that commonly lie stratigraphically immediately above till unit *Qg3*.

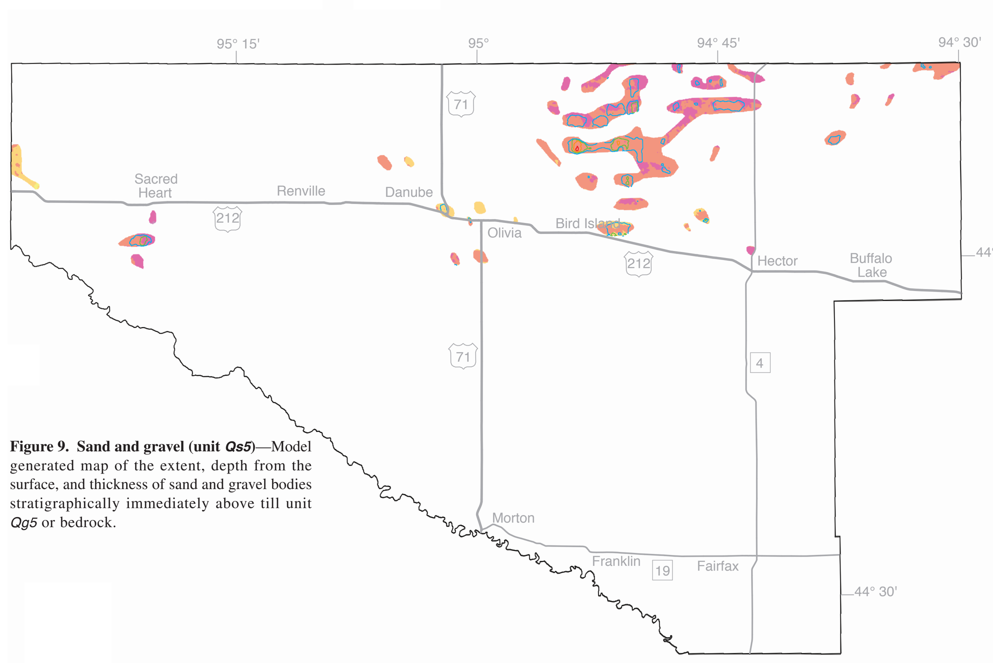


**Figure 9. Sand and gravel (unit *Qs5*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above till unit *Qg5* or bedrock.

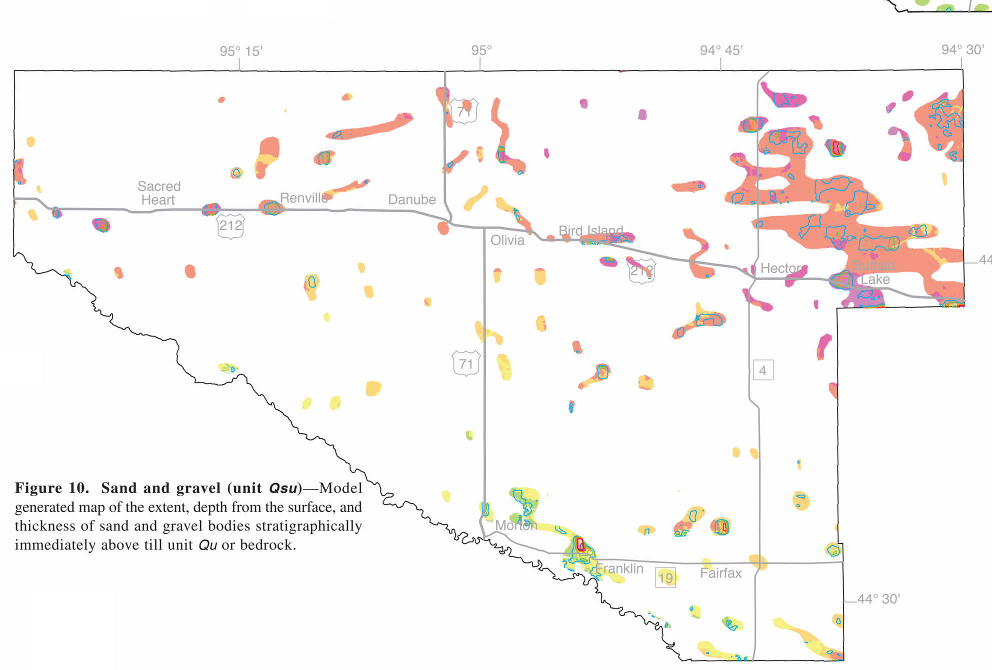


**Figure 10. Sand and gravel (unit *Qsu*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above till unit *Qu* or bedrock.

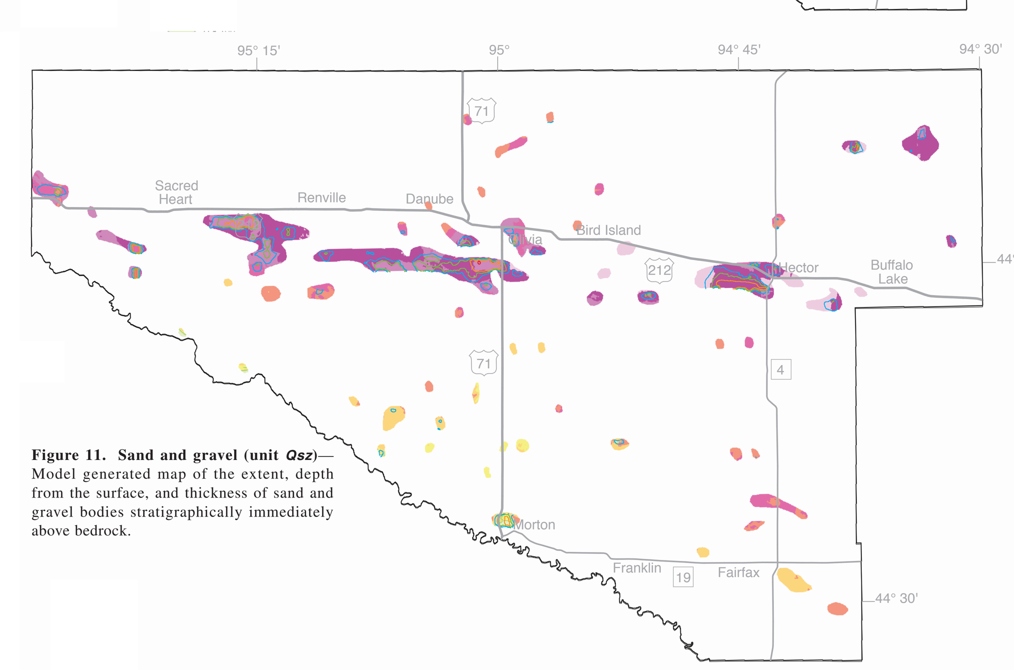


**Figure 11. Sand and gravel (unit *Qsz*)**—Model generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above bedrock.

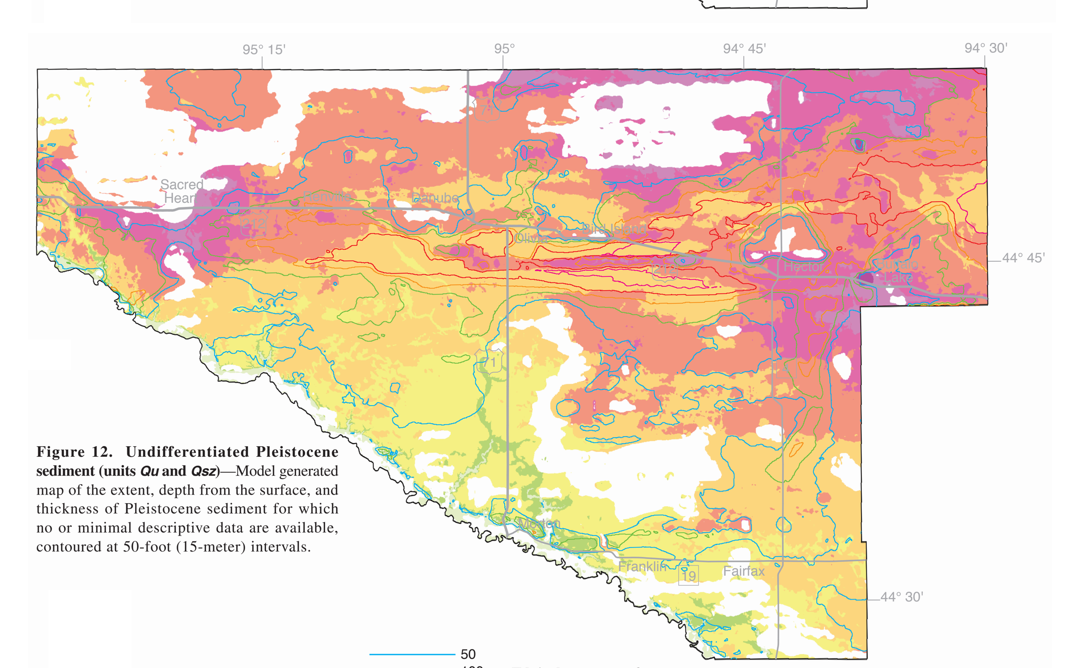



**Figure 12. Undifferentiated Pleistocene sediment (units *Qu* and *Qsz*)**—Model generated map of the extent, depth from the surface, and thickness of Pleistocene sediment for which no or minimal descriptive data are available, contoured at 50-foot (15-meter) intervals.