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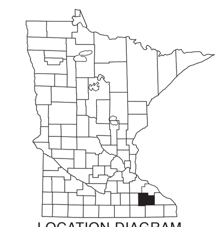

SAND-DISTRIBUTION MODEL

By

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2020

INTRODUCTION

The Quaternary sand and gravel deposits of Minnesota are the products of a long and complex history of multiple glacial events that make subsurface mapping of these potential water-bearing units difficult. In general, the Quaternary deposits in Olmsted County tend to be thicker in the western part of the county and thin and patchy in the east. Identifying the location and characteristics of the sand and gravel units and understanding the extent and thickness of the intervening diamicton units (unsorted sediments) is an important step towards appropriately protecting the underlying Paleozoic bedrock aquifers.

In Olmsted County, this project employed a process that combined the geologic contextual understanding of a geologist and the expertise of a geologic information specialist with the data-handling capability of a geographic information system (GIS) to create the three-dimensional models of the Quaternary sand and gravel deposits. These three-dimensional models relate sand and gravel-bearing units (potential aquifers) to the glacial events that formed them. Although the models and interpretations are based on the best available data, they are unavoidably incomplete due to lack of data in some areas. The surface distribution of sand and gravel is mapped by a geologist based on exposures, shallow drill holes, soil maps, and landforms (see Plate 3, *Surficial Geology*). In contrast, subsurface mapping of sand and gravel is limited to well records, bedrock topographic interpretation, scientific drill core, and drill cuttings. The unit extent, thickness, stratigraphic correlation, and material mapped in the subsurface relies heavily on the geologist's interpretations, especially in areas with less data constraint and where units are extrapolated beyond and interpolated between data points.

Unconsolidated Quaternary sediments that overlie the bedrock in Olmsted County vary greatly in character, distribution, and thickness. The deposits are largely the result of many distinct glacial ice advances during the Pleistocene Epoch (Plate 4, *Quaternary Stratigraphy*). These Quaternary units consist of sand and gravel beds that are interbedded between low-permeability layers of unsorted sediment, deposited directly from glacial ice (till). The sand and gravel units were deposited by meltwater streams that flowed from these glaciers. Till layers are more continuous than the sand and gravel layers because ice sheets typically covered widespread areas, whereas meltwater drainage was typically restricted to channels or channel networks. By convention, sand and gravel bodies depicted on this plate are named and associated with their underlying till (except for those at the land surface and those that stratigraphically overlie the lowermost unknown unit).

Glacial ice and meltwater not only transport and deposit sediments, but also are strong instruments of erosion of underlying materials. The new layer of sand and gravel or till could fill a void eroded into an underlying layer or could completely take the place of the underlying layer, given sufficient erosion. The varying degrees of erosion and deposition over distances in a glacial setting create complex systems of discontinuous sand and gravel bodies. In order to create an accurate geologic representation of the subsurface, 40 closely spaced (0.6 mile [1 kilometer]) cross-section lines were generated in a west–east direction (Fig. 1). Water wells and scientific and engineering test holes within 0.3 mile (0.5 kilometer) of each side of the cross-section line were projected onto that line and used by a geologist to identify contacts between geologic units in the subsurface.

On water-well records, till is generally described as "clay" by drillers. Although sand and gravel beds can occur within a till, deposits that are more extensive tend to occur at the contact between two till sheets. Where two till layers related to different depositional events are not separated by a sand and gravel layer, their contact may be recognized by a change in the driller's description of the clay's texture, density, or color. Using the available data, contact lines between geologic units were drawn along each cross section and modified until the geologist was confident in the spatial and stratigraphic representation of each geologic unit. Each line represents the base of a unit of sand and gravel or till. GIS software was used to extract elevation values from vertices along each unit line. Each vertex was then used to create an elevation-surface grid identifying the distribution of the unit in the county. Final interpretations along five of these cross sections are shown on Plate 4, and results from all cross sections are available digitally, as vector and raster datasets, for the top and bottom elevation surface and thickness of each interpreted unit. From the raster datasets, a three-dimensional geologic model of tills and sand was built for the county. The more extensive sand and gravel bodies are shown in Figures 3 through 11, from youngest sand at the surface to older, more deeply buried sand and gravels, and a lower unit of sediment that is undifferentiated (unit *Qup*) due to lack of data.

Sand and gravel within the model is considered an aquifer when the unit is saturated and able to readily transmit water to a well. A unit's capacity for water yield depends on a number of factors including its extent and thickness, sediment coarseness, degree of sorting, consolidation, potential for recharge, and connectivity within the unit. Potability of the water from an aquifer is determined by water quality. The maps and reports produced by the Minnesota Department of Natural Resources, as Part B of the Olmsted County Geologic Atlas, consider these and other factors in characterizing hydrogeologic conditions.

The geologic model should be considered a probability map for the occurrence and approximate thickness of major sand bodies. The model does not guarantee sand and gravel will be found at all places shown, nor does it preclude them from being found in areas where they are not shown. Where clusters of wells exist in cross sections, lines drawn represent generalized interpretations of the cluster of data instead of representing each individual well. Sand layers that were too thin or did not extend to neighboring cross sections commonly were eliminated during processing. Lastly, because of the unique geologic setting of the Quaternary sediments in Olmsted County (see Plates 3 and 4 for a more detailed explanation), the unconsolidated sediments are commonly thin and patchy over the underlying bedrock. This thin depth to bedrock made modeling these units in the subsurface challenging. In many places, the unit surfaces represented on Figure 3 do not directly match the extent of the units mapped on the surficial geology map (Plate 3). Where depth to bedrock was less than 10 feet (3 meters) and along steeply sloping bedrock valleys, it is difficult to portray multiple geologic units. For example, the Quaternary units were commonly drawn as continuous units extending down valley walls, when in reality these units may be topped by colluvium. For this reason, the colluvium unit (*Qco*) is not depicted as extensively in the sand-body model as it shown on the surficial geology map.

In Olmsted County, wells commonly target the Paleozoic bedrock aquifers, meaning the complete thickness of the Quaternary stratigraphy is penetrated. However, because the target of the well was commonly the bedrock, drillers' logs may lack detailed descriptions of the Quaternary sediments and the sand-body thicknesses may be underreported. As a result, some of the sands shown on the cross sections (Plate 4) and modeled here may be thicker and more widespread than they are portrayed. At increasing depths in the stratigraphic section, data availability diminishes and delineated sand bodies could be more or less continuous than shown.

In some parts of Olmsted County, water wells do not extend through the full thickness of the Quaternary deposits. Cross section D–D' on Plate 4 indicates that the characteristics of deeper deposits cannot be differentiated in some places, and are therefore assigned to units *Qus* (Fig. 10) and *Qup* (Fig. 11). Despite these limitations, the geologic model provides a realistic interpretation of where and what kind of geologic units would be encountered in the subsurface of Olmsted County. However, given the limits of the data, as noted above, the model should be used as a guide and should not preclude further site-specific investigations or inspection of individual well logs.

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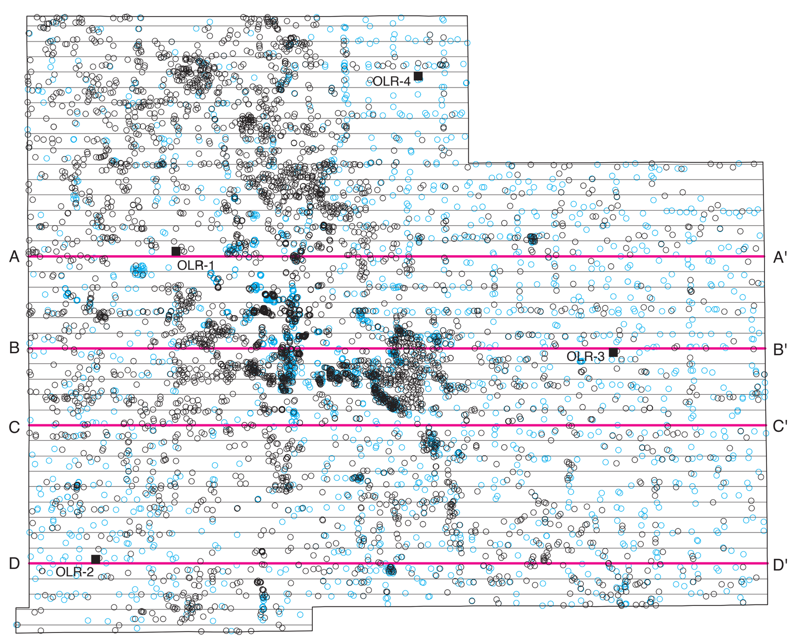

Figure 1. Map of Olmsted County showing cross-section lines, drill sites (blue circles), rotary-sonic core locations (squares), and drill sites to bedrock (black circles). Cross sections A–A' through D–D' are illustrated on Plate 4, *Quaternary Stratigraphy*.

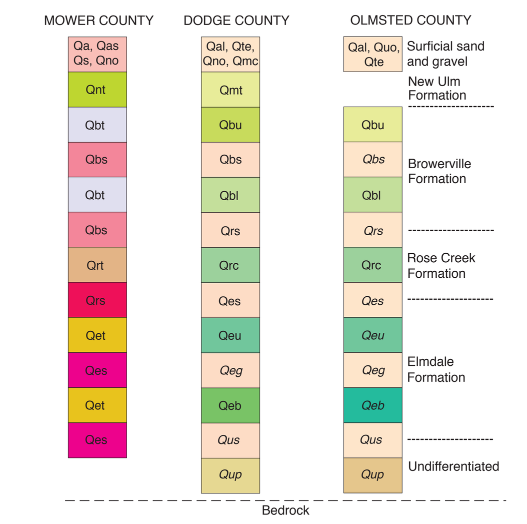

Figure 2. Correlation of stratigraphic units encountered in Olmsted County with units identified in adjacent Mower (Meyer, 2000) and Dodge (Meyer and others, 2019) Counties. Note that this body of work follows the framework of Johnson and others (2016), which supersedes the work done in Mower County, making some correlations across these maps uncertain.

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 and greater

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 11

0–50
51–100
101–150
151–200
201–250

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 11).

SCALE 1:300 000

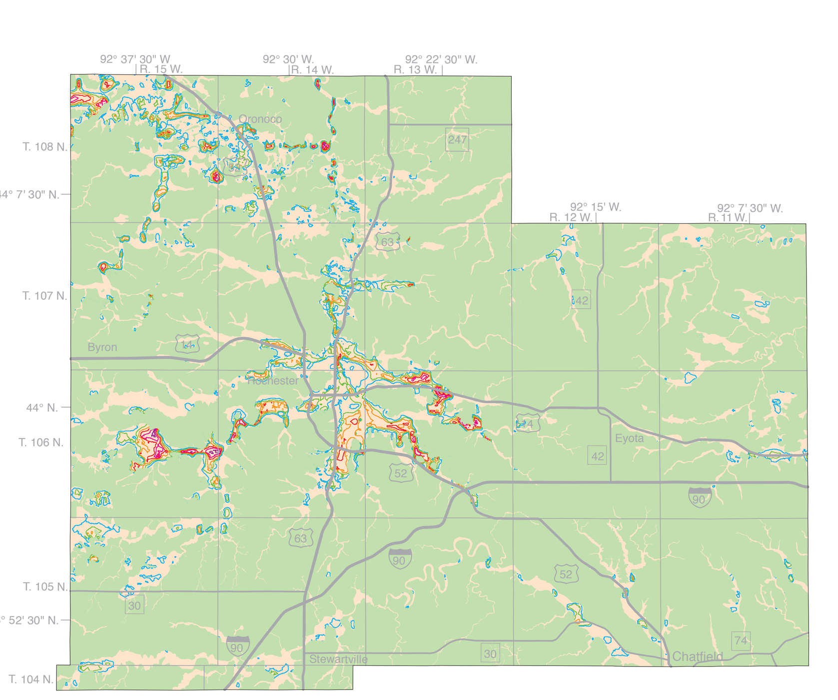

Figure 3. Surficial sand and gravel—Model-generated map showing the extent and thickness of sand and gravel bodies (cream) generally occurring at or near the land surface (all other sediments are green). Includes units Qal, Qte, and Quo from Plate 3, *Surficial Geology*. Where the surficial sand and gravel is below the water table and not overlain by more than 10 feet (3 meters) of fine-grained sediment, it is the potential surficial aquifer for Olmsted County.

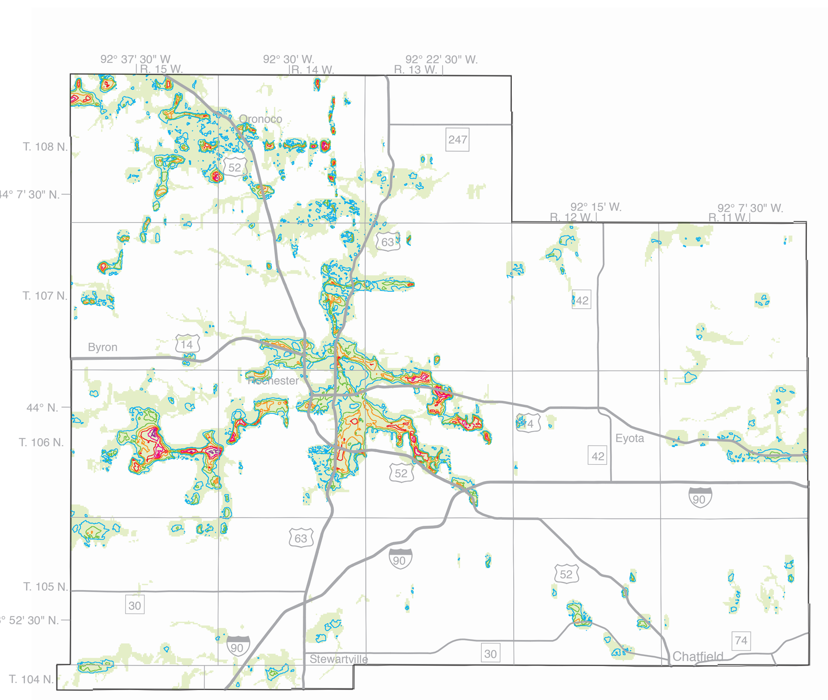

Figure 4. Sand and gravel unit Qte—Model-generated map of the extent, depth from the surface, and thickness of terrace alluvium. This unit generally coarsens to cobbly gravel and may be capped by loamy, fine-grained sand; deposited during higher stages of river flow.

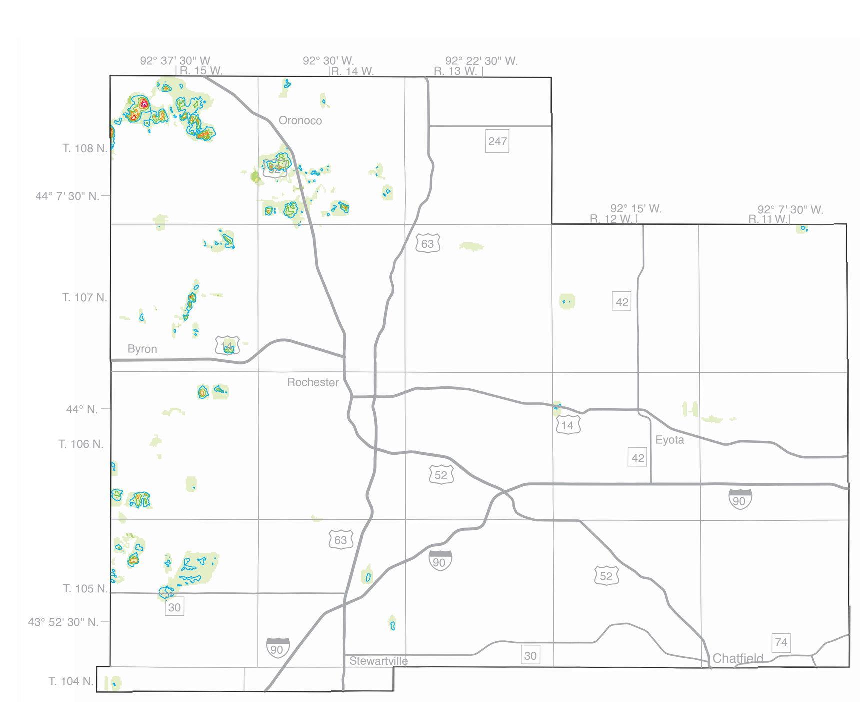

Figure 5. Sand and gravel unit Quo—Model-generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above till and/or lake sediment of unit Qbu.

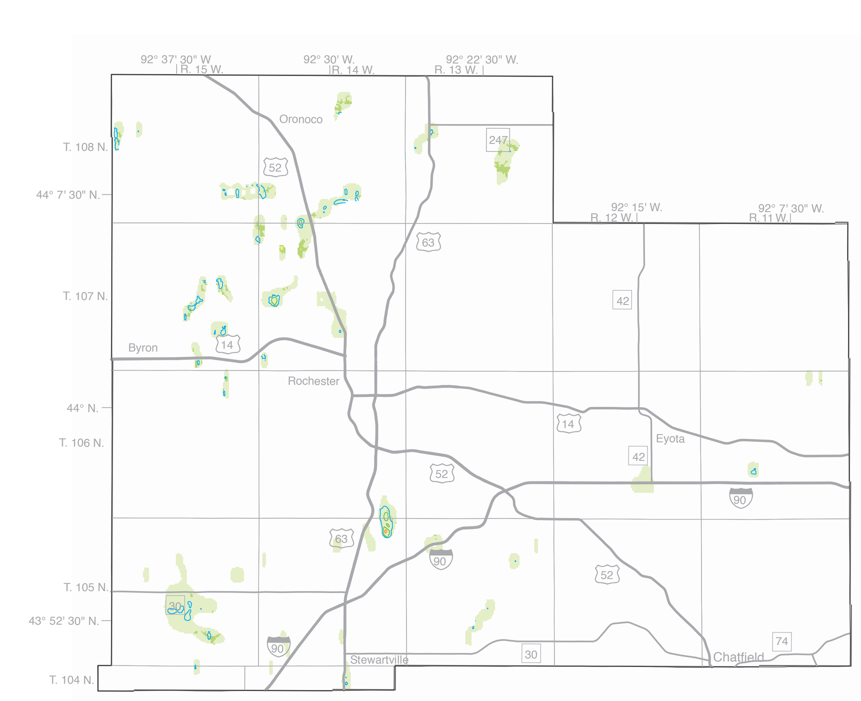

Figure 6. Sand and gravel unit Qbs—Model-generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above till and/or lake sediment of unit Qbl.

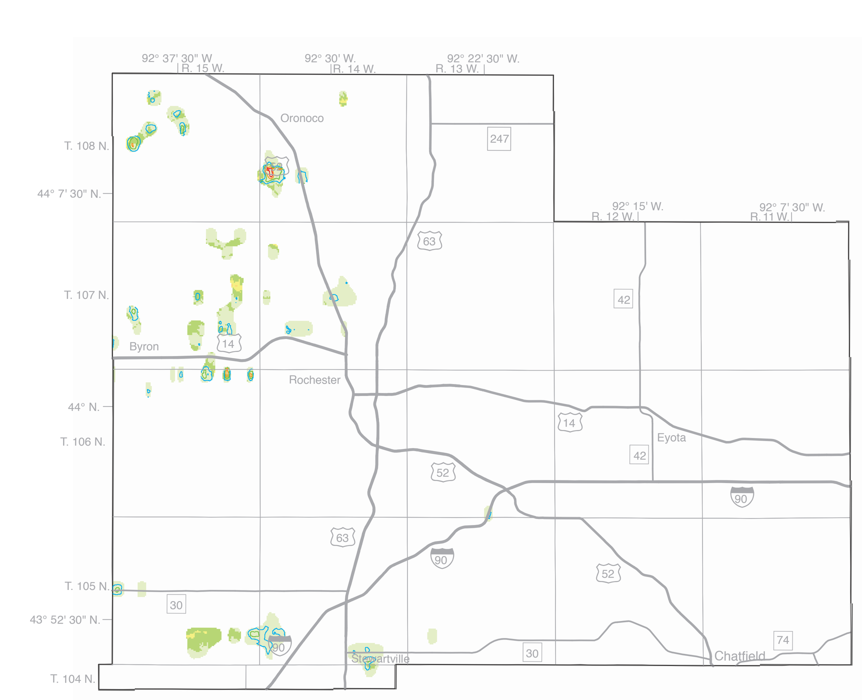

Figure 7. Sand and gravel unit Qrs—Model-generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above till and/or lake sediment of unit Qrc.

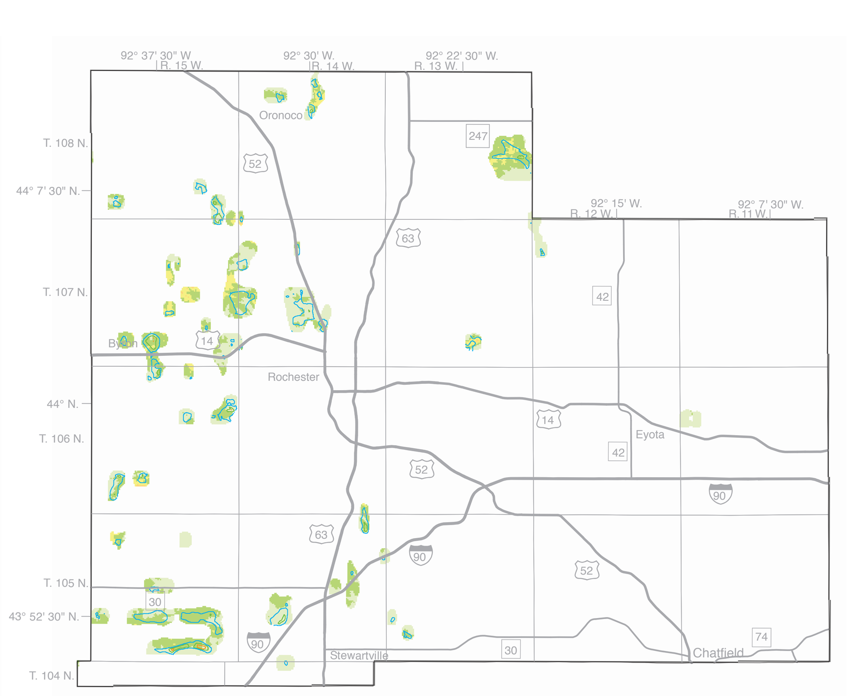

Figure 8. Sand and gravel unit Qes—Model-generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above till and/or lake sediment of unit *Qeu*.

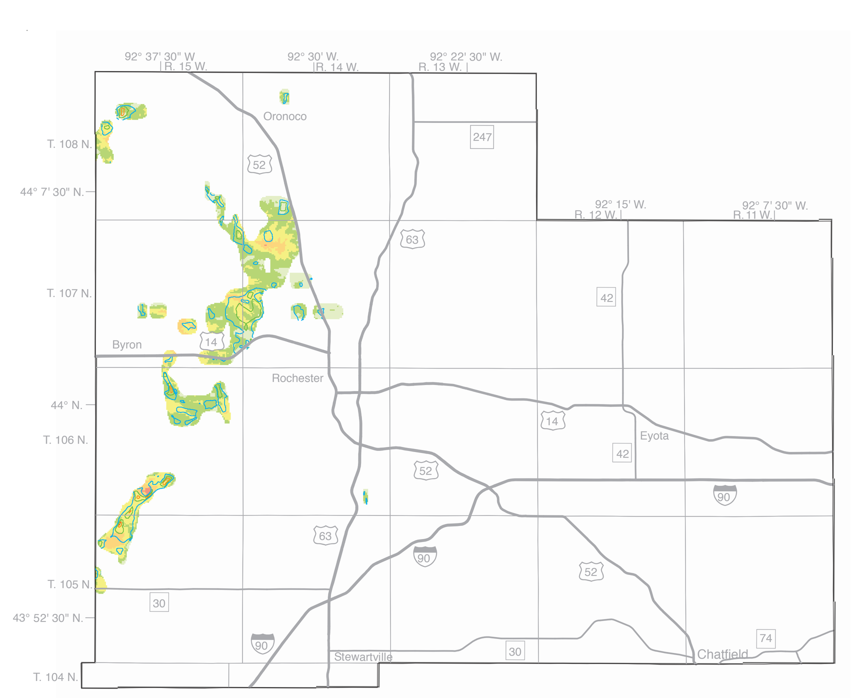

Figure 9. Sand and gravel unit Qeg—Model-generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above till and/or lake sediment of unit *Qeb*. Lack of data at depth likely reduces the mapped extent.

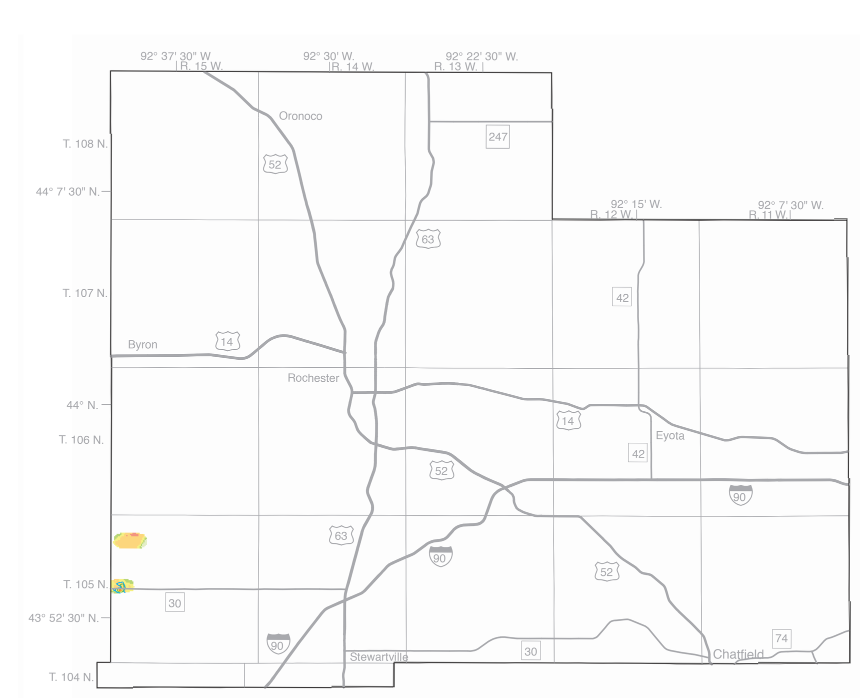

Figure 10. Sand and gravel unit Qus—Model-generated map of the extent, depth from the surface, and thickness of sand and gravel bodies stratigraphically immediately above undifferentiated Pleistocene sediment or bedrock. Deposited by meltwater from pre-Wisconsinan ice of unknown provenance. Thicker in places and more laterally extensive than depicted due to a lack of data at depth.

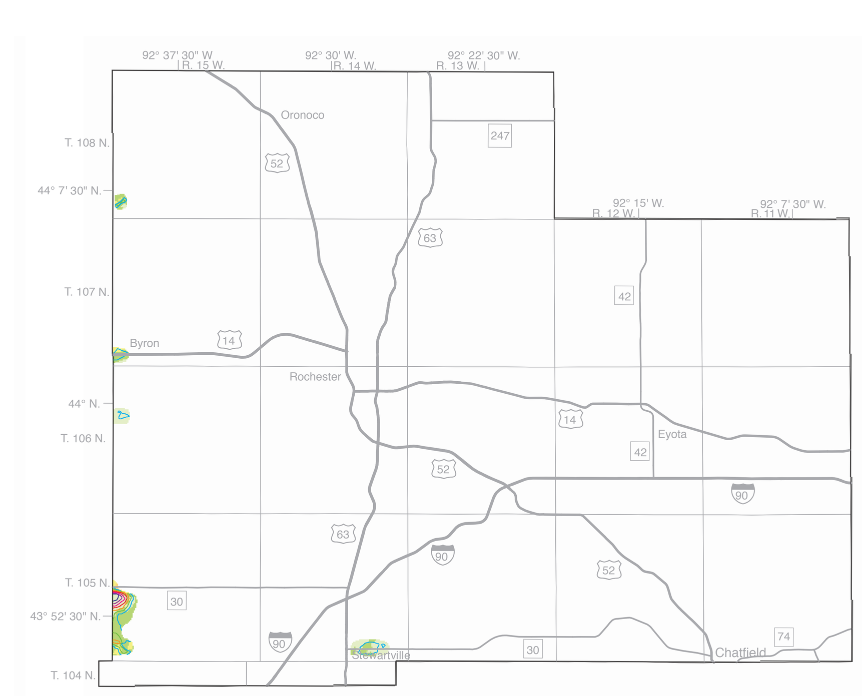

Figure 11. Undifferentiated Pleistocene sediment (unit Qup)—Model-generated map of the extent, depth from the surface, and thickness of Pleistocene sediment for which little or no descriptive data are available.

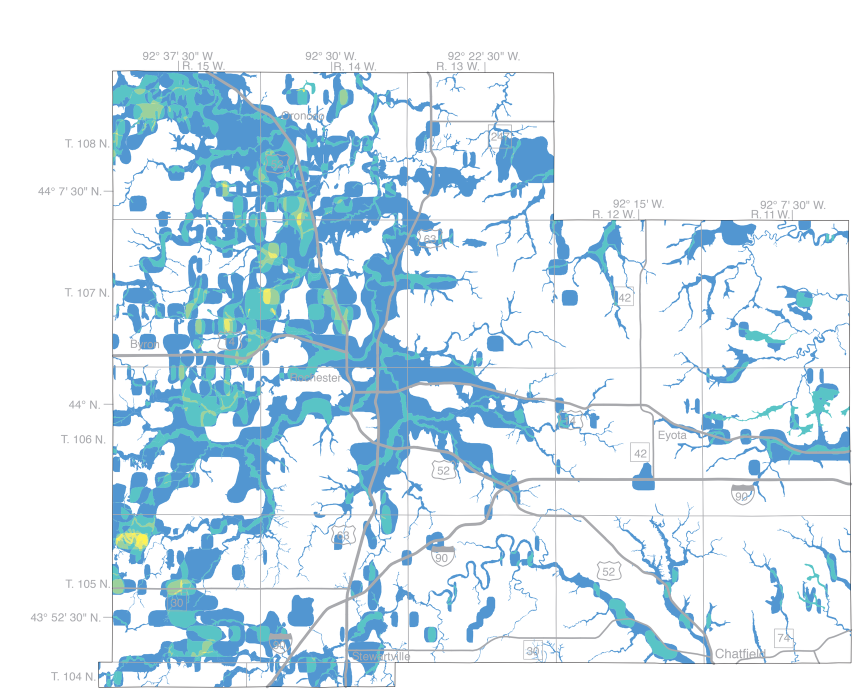

Figure 12. Number of sands below a given point—Model-generated map of the extent and number of Quaternary sand bodies (as defined in the model) encountered between the land surface and bedrock. The individual sand bodies are not necessarily interconnected. White areas have no mapped sand units.

NUMBER OF SAND UNITS
1
2
3
4
5
6

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