Draft* Surficial Geology and Geomorphology of the Middle Minnesota River Watershed

December 2009

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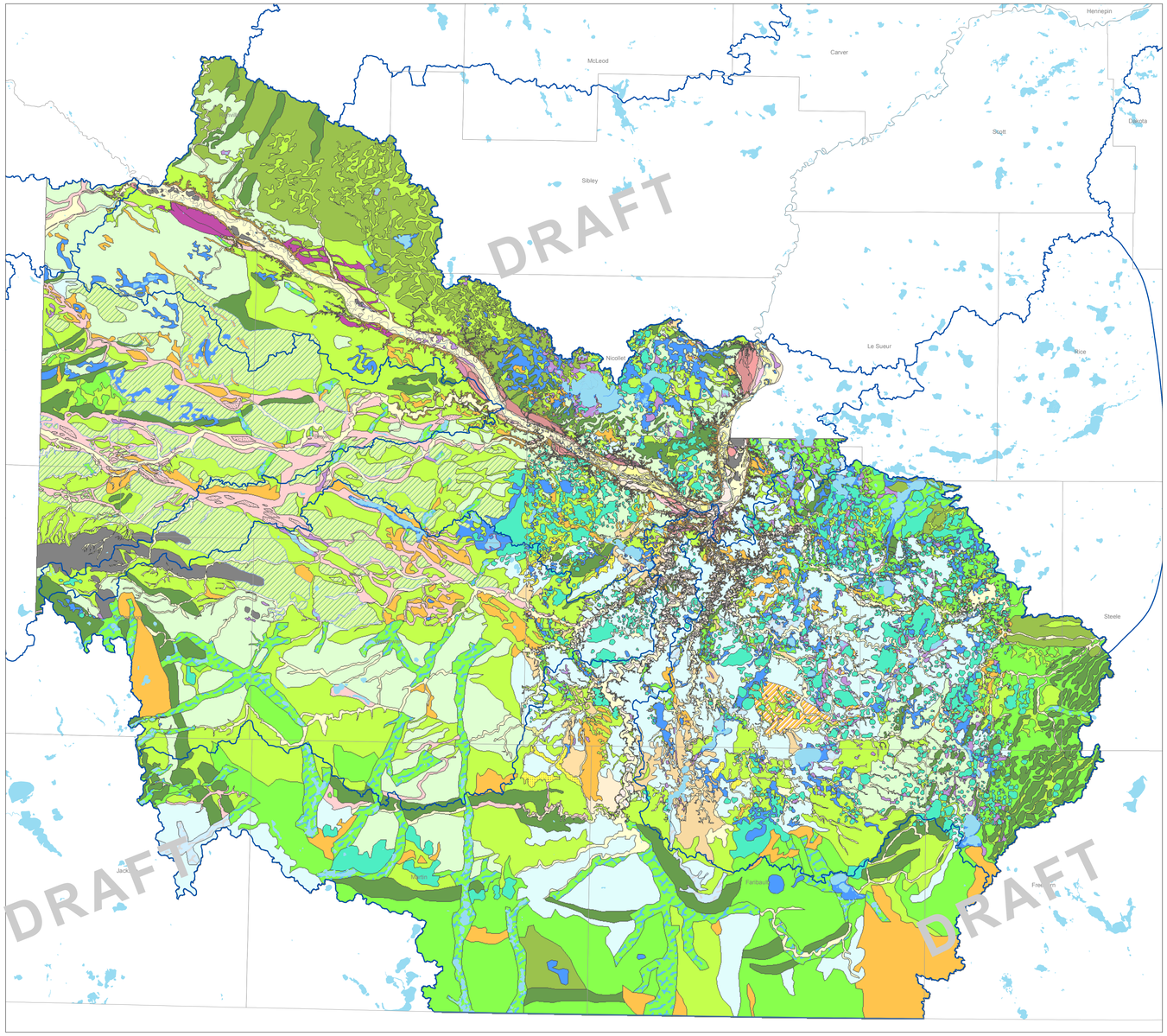
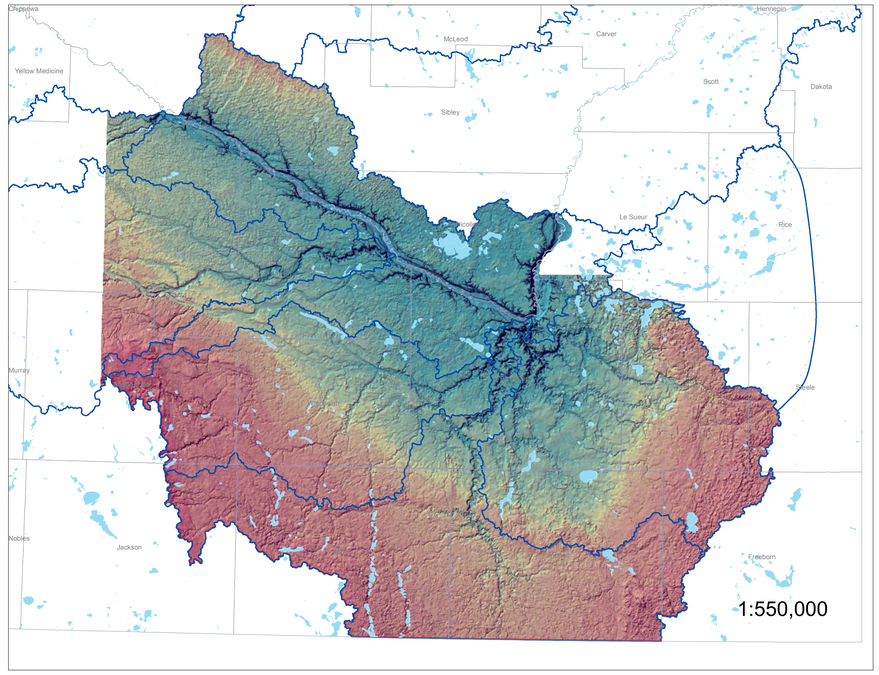
*This draft map does not meet MGS publication standards. The map represents only the initial stages of surficial map production followed by reconnaissance field-checking.

1:300,000



0 4.5 9 18 Miles

0 10 20 40 Kilometers



Hillshade Relief Map of Study Area Derived from USGS NED

Legend

- Mn Counties
- Watershed outlines
- Lakes

Surficial Geology Units

Unit

- Ha
- Hb
- Hc
- Hf
- Hfp
- Hl
- Hp
- Ht
- Ht760
- Ht800
- Ht830
- Ht850
- Ht900
- Ht940
- Ht950
- Ht980
- Ht990
- Prk
- Qb
- Qcss
- Qcssb
- Qfb
- Ql
- Qlc
- Qliw
- Qlw
- Qs
- Qsb
- Qsd
- Qt
- Qtc
- Qth
- Qtm
- Qtr
- Qtsz
- Qtw

Unit description

Sediment deposited during the Holocene—

Post-glacial to pre-settlement sediment derived from loose, initially unvegetated glacigenic sediment is portrayed in this map. Profound landscape-altering events such as the incision of the deep, glacial River Warren channel immediately after ice withdrawal were followed by slower fluvial and slope processes owing to the warm and dry conditions of the mid-Holocene (approximately 9,000-5,000 radiocarbon years before present). From 5,000 radiocarbon years ago until the European settlement period, climate and therefore geomorphic processes were much like today. However, intensive landscape and drainage modifications by humans since European settlement has altered the land surface in a way that is not reflected in this map.

Ha Predominantly sand but including pebbly sand to mud (silt and clay, organic-rich in places), deposited in horizontal layers by modern streams in channels. Many modern streams re-occupy glacial channels so unit may be coarser in places owing to reworking of glacial stream sediment. May also include areas of decomposing organic material and fine sediment deposited by slack water. *Holocene alluvium.*

Hb Predominantly sand with some gravel in low bars or ridges. Interpreted as deposited in shallow, moving water along a lake shore or in a river. If in a river, found at a higher elevation than the general alluvial surface and in a streamlined form. *Holocene bar or beach.*

Hf Sand and gravel forming a fan-shaped mound at the mouth of a modern stream where it enters a less-steep area, typically a terrace or floodplain. *Holocene alluvial fan.*

Hfp Predominantly sand but including fine sediment deposited by slack water (silt and clay, organic-rich in places), deposited in horizontal layers by modern streams during high-water events. Also includes areas of decomposing organic material that accumulates in this setting. *Holocene floodplain sediment.*

Ht and Ht xxx Sand and gravel, well sorted, forming a nearly level surface with some areas of streamlined bars and shallow channels, lying above the modern floodplain; general elevation of surface given in feet and expressed in slightly different color. Terraces with various elevations are interpreted as having formed during the incision of glacial River Warren. The river was created during one or possibly two, catastrophic discharge events from glacial Lake Agassiz. Terraces in each spillways do not typically represent long-term stability of the system but rather, reflect the complicated internal dynamics of a rapidly cutting spillway. Terraces on tributaries to the glacial River Warren channel are not subdivided by elevation (**Ht**). They began evolving after the initial glacial River Warren channel incision, 11,500 reph (13,400 calendar years) as knickpoints migrated upstream on the tributaries. *Holocene alluvial terrace.*

Hl Silt to clay with sand and organics near shore; laminated in places. Deposited in ponded water in modern or drained lakes. *Holocene lake sediment.*

Hp Partially to fully decomposed organic matter infilling shallow depressions and water bodies such as seasonal or ephemeral ponds, lakes (peat mats typically form near shore and grow into deeper water), along low-gradient modern and glacial streams. The low infiltration capacity of the fine-grained glacial sediment and irregular topography of ice stagnation landscapes created many isolated depressions that seasonally held standing water. *Holocene organic deposits.*

Hc Varying amounts of sediment and rock fragments deposited on steep slopes by wet and dry gravitational failure. May resemble glacial sediment or locally exposed rock on steep slopes or may have been sorted by gravity and water resulting in material with a different texture than the parent material. *Colluvium.*

Sediment associated with the northwest-source Des Moines lobe ice—Color of glacial sediment is typically olive-brown (Munsell Soil color 2.5y 4/4) where oxidized and dark gray (Munsell soil color 2.5 Y 4/1) where unoxidized. Sorted sediment has the color associated with the dominant grain size (2.5 Y 3/1, very dark gray for clay; 2.5y 6/4, light yellowish brown for silt and variable for sand depending on the mineral assemblage).

Qt Unsorted sediment with a loam matrix and containing clasts of gravel (diamicton); compact; forms a low relief surface. *Subglacial till.*

Qth Unsorted sediment with a loam matrix and containing clasts of gravel (diamicton). Undulating with isolated depressions and irregular hills. Interpreted as originating in an unstable, supraglacial sediment layer that differentially insulated stagnant ice resulting in uneven downwasting, reconfiguration of the surface slope and redeposition of the material. May be sorted in places as a result of resedimentation by moving or still water. *Supraglacial, hummocky till.*

Qtc As above but commonly forming a broad, linear, irregular low indicating that the ice surface collapsed over an ice cavern ; interpreted as a subglacial drainage way called a tunnel valley; *Collapsed till.*

Qliw Silt and clay layers, bedded sand, and loamy, vaguely bedded glacial sediment (diamicton); interpreted as lake and debris flow deposits confined within growing holes in stagnant ice surface resulting in flat-topped, circular hills. Associated with unit **Qth.** *Ice-walled-lake plain deposits.*

Qtm Ridge of poorly sorted glacial sediment (diamicton); interpreted as demarcating margin of active ice and formed through a combination of ice-marginal processes including meltout of a basal debris layer, thrusting, and debris flows. *Moraine.*

Qtw Unsorted deposit of loamy glacial sediment with gravel (diamicton); surface expression is subdued and commonly streamlined. Interpreted as having been washed by water (rivers and lakes). Has the potential to be capped with a coarse lag resulting from the removal of finer particles by water and a drape of fine sediment deposited by waning flows. *Washed till.*

Qtr Poorly sorted glacial sediment with low ridges oriented transverse to the inferred ice-flow direction. *Subglacial till with superimposed crevasse-fill deposits.*

Qtsz Complex terrain with low to moderate relief. Lows are commonly a loamy, dense diamicton (unit **Qt**); irregular uplands are commonly unsorted deposits (unit **Qth)** with inclusions of sand (unit **Qts);** the complex forms a broad, southeaster-trending highland between two, distinct, subglacial till sheets. Interpreted as a shear zone demarcating differential flow of neighboring ice streams where the drag and frictional melting between adjacent ice steams created an ice-surface low that focused supraglacial debris and meltwater. *Ice stream shear zone deposits.*

Qs Sand and gravel forming horizontal layers in channels oriented down-gradient from and around former ice margins. *Glacial stream sediment.*

Qsb Prominent streamlined forms in unit **Qs** with decimenter-scale foresets. *Bar in a meltwater stream.*

Qcss Poorly sorted gravel and sand intercalated with loamy, poorly sorted glacial sediment (diamicton); in places fines up to silt; confined to narrow, low ridges. Interpreted to have been deposited in crevasses or low areas on the ice surface by running water and gravity. Also includes small areas interpreted as subglacial tunnel deposits (eskers). *Collapsed stream sediment.*

Qcssb As above but shallowly buried, commonly by lacustrine deposits. Close enough to the surface to lighten color of overlying unit on black and white aerial photo indicating dryer conditions**.** *Buried, collapsed stream sediment.*

Qsd Fan-shaped mound of sand and gravel located at the mouth of collapsed channel interpreted as a subglacial stream, unit **Qtc** (tunnel valley) or where a glacial meltwater stream entered a lake basin**.** *Fan or fan delta* (deposited in a lake).

Qfb As above but shallowly buried, most commonly by clayey lacustrine sediment. Close enough to the surface to lighten color of overlying unit on black and white aerial photo indicating dryer conditions**.** *Buried fan or fan delta.*

Ql Low-lying area of silt and clay, commonly finely laminated. *Glacial lake sediment.*

Qlc As above with irregular topography lying within a broad, linear, low indicating that the ice surface collapsed over an ice cavern ; interpreted as a subglacial drainage (tunnel valley) that collapsed after inundation of the stagnant ice surface by water. *Collapsed lake sediment.*

Qb Discontinuous, low, linear bench or ridge of sand with gravel, aligned along or near the margins of unit **Ql** and associated with unit **Qsd**. *Glacial lake beach.*

Qlw Located within unit **Ql** but with streamlined shapes trending southeast. Interpreted as scoured lake sediment or a drape of lake sediment over a scoured surface created during a lake outburst. *Washed lake sediment.*

Prk Precambrian and Paleozoic bedrock, undifferentiated, at or near the surface.