Minnesota Department of Natural Resources
Division of Lands and Minerals
William C. Brice, Director

SURFICIAL GEOLOGY
MINNEOPA STATE PARK

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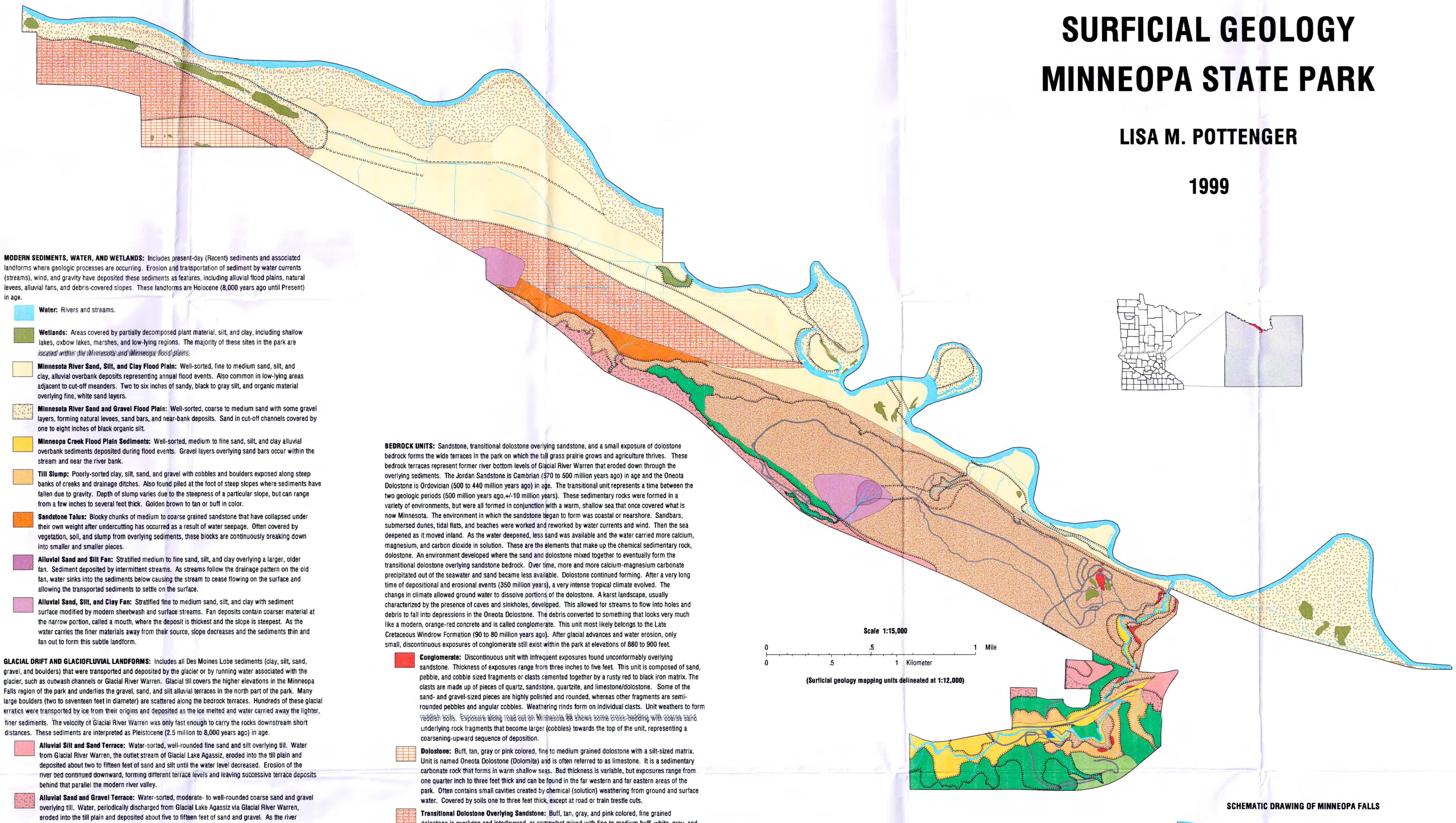
1999



MODERN SEDIMENTS, WATER, AND WETLANDS: Includes present-day (Recent) sediments and associated landforms where geologic processes are occurring. Erosion and transportation of sediment by water currents (streams), wind, and gravity have deposited these sediments as features, including alluvial flood plains, natural levees, alluvial fans, and debris-covered slopes. These landforms are Holocene (8,000 years ago until Present) in age.

- **Water:** Rivers and streams.
- **Wetlands:** Areas covered by partially decomposed plant material, silt, and clay, including shallow lakes, oxbow lakes, marshes, and low-lying regions. The majority of these sites in the park are located within the Minnesota and Minneopa flood plains.
- **Minnesota River Sand, Silt, and Clay Flood Plain:** Well-sorted, fine to medium sand, silt, and clay, alluvial overbank deposits representing annual flood events. Also common in low-lying areas adjacent to cut-off meanders. Two to six inches of sandy, black to gray silt, and organic material overlying fine, white sand layers.
- **Minnesota River Sand and Gravel Flood Plain:** Well-sorted, coarse to medium sand with some gravel layers, forming natural levees, sand bars, and near-bank deposits. Sand in cut-off channels covered by one to eight inches of black organic silt.
- **Minneopa Creek Flood Plain Sediments:** Well-sorted, medium to fine sand, silt, and clay alluvial overbank sediments deposited during flood events. Gravel layers overlying sand bars occur within the stream and near the river bank.
- **Till Slump:** Poorly-sorted clay, silt, sand, and gravel with cobbles and boulders exposed along steep banks of creeks and drainage ditches. Also found piled at the foot of steep slopes where sediments have fallen due to gravity. Depth of slump varies due to the steepness of a particular slope, but can range from a few inches to several feet thick. Golden brown to tan or buff in color.
- **Sandstone Talus:** Blocky chunks of medium to coarse grained sandstone that have collapsed under their own weight after undercutting has occurred as a result of water seepage. Often covered by vegetation, soil, and slump from overlying sediments, these blocks are continuously breaking down into smaller and smaller pieces.
- **Alluvial Sand and Silt Fan:** Stratified medium to fine sand, silt, and clay overlying a larger, older fan. Sediment deposited by intermittent streams. As streams follow the drainage pattern on the old fan, water sinks into the sediments below causing the stream to cease flowing on the surface and allowing the transported sediments to settle on the surface.
- **Alluvial Sand, Silt, and Clay Fan:** Stratified fine to medium sand, silt, and clay with sediment surface modified by modern sheetwash and surface streams. Fan deposits contain coarser material at the narrow portion, called a mouth, where the deposit is thickest and the slope is steepest. As the water carries the finer materials away from their source, slope decreases and the sediments thin and fan out to form this subtle landform.

GLACIAL DRIFT AND GLACIOFLUVIAL LANDFORMS: Includes all Des Moines Lobe sediments (clay, silt, sand, gravel, and boulders) that were transported and deposited by the glacier or by running water associated with the glacier, such as outwash channels or Glacial River Warren. Glacial till covers the higher elevations in the Minneopa Falls region of the park and underlies the gravel, sand, and silt alluvial terraces in the north part of the park. Many large boulders (two to seventeen feet in diameter) are scattered along the bedrock terraces. Hundreds of these glacial erratics were transported by ice from their origins and deposited as the ice melted and water carried away the lighter, finer sediments. The velocity of Glacial River Warren was only fast enough to carry the rocks downstream short distances. These sediments are interpreted as Pleistocene (2.5 million to 8,000 years ago) in age.

- **Alluvial Silt and Sand Terrace:** Water-sorted, well-rounded fine sand and silt overlying till. Water from Glacial River Warren, the outlet stream of Glacial Lake Agassiz, eroded into the till plain and deposited about two to fifteen feet of sand and silt until the water level decreased. Erosion of the river bed continued downward, forming different terrace levels and leaving successive terrace deposits behind that parallel the modern river valley.
- **Alluvial Sand and Gravel Terrace:** Water-sorted, moderate- to well-rounded coarse sand and gravel overlying till. Water, periodically discharged from Glacial Lake Agassiz via Glacial River Warren, eroded into the till plain and deposited about five to fifteen feet of sand and gravel. As the river eroded downward, the former channel bed became a terrace.
- **Till Collapse Channel:** Poorly-sorted clay, silt, sand, cobbles, and boulders deposited as till, collapsed to fill in former outwash channel. Eight to ten inches of black loamy soil overlie this golden tan unit. May have lenses of well-sorted sands and patchy gravel throughout. Landscape may have more of a rolling appearance due to partial or complete, random collapse events.
- **Till Plain:** Unsorted to poorly sorted sand, pebbles, cobbles, and boulders within a clay to silt sized matrix. Very compact and forms steep walls where water has cut through to form channels, such as Minneopa Creek. Eight inches to one and one half feet of black loamy soil overlie this light brown, tan to buff colored unit. Interpreted as sediments deposited when the most recent ice lobe of the Ice Age, called the Des Moines Lobe, advanced southward and retreated (or melted) northward.

GEOLOGIC CONTACTS AND LANDFORMS

- Geologic contact - Well defined boundary between mapping units.
- Geologic contact - Inferred, gradational, or approximate boundary between mapping units.
- Levee sediments - Natural/man-made levee overbank deposits of well-rounded, medium to coarse sand.
- Scarp - Well defined channel wall or boundary of former river level.
- Scarp - Inferred or approximate location of channel wall or boundary of former river level.
- Intermittent stream - stream that contains water for only part of the year.

BEDROCK UNITS: Sandstone, transitional dolostone overlying sandstone, and a small exposure of dolostone bedrock forms the wide terraces in the park on which the tall grass prairie grows and agriculture thrives. These bedrock terraces represent former river bottom levels of Glacial River Warren that eroded down through the overlying sediments. The Jordan Sandstone is Cambrian (570 to 500 million years ago) in age and the Oneota Dolostone is Ordovician (500 to 440 million years ago) in age. The transitional unit represents a time between the two geologic periods (500 million years ago,+/-10 million years). These sedimentary rocks were formed in a variety of environments, but were all formed in conjunction with a warm, shallow sea that once covered what is now Minnesota. The environment in which the sandstone began to form was coastal or nearshore. Sandbars, submersed dunes, tidal flats, and beaches were worked and reworked by water currents and wind. Then the sea deepened as it moved inland. As the water deepened, less sand was available and the water carried more calcium, magnesium, and carbon dioxide in solution. These are the elements that make up the chemical sedimentary rock, dolostone. An environment developed where the sand and dolostone mixed together to eventually form the transitional dolostone overlying sandstone bedrock. Over time, more and more calcium-magnesium carbonate precipitated out of the seawater and sand became less available. Dolostone continued forming. After a very long time of depositional and erosional events (350 million years), a very intense tropical climate evolved. The change in climate allowed ground water to dissolve portions of the dolostone. A karst landscape, usually characterized by the presence of caves and sinkholes, developed. This allowed for streams to flow into holes and debris to fall into depressions in the Oneota Dolostone. The debris converted to something that looks very much like a modern, orange-red concrete and is called conglomerate. This unit most likely belongs to the Late Cretaceous Windrow Formation (90 to 80 million years ago). After glacial advances and water erosion, only small, discontinuous exposures of conglomerate still exist within the park at elevations of 880 to 900 feet.

- **Conglomerate:** Discontinuous unit with infrequent exposures found unconformably overlying sandstone. Thickness of exposures range from three inches to five feet. This unit is composed of sand, pebble, and cobble sized fragments or clasts cemented together by a rusty red to black iron matrix. The clasts are made up of pieces of quartz, sandstone, quartzite, and limestone/dolostone. Some of the sand- and gravel-sized pieces are highly polished and rounded, whereas other fragments are semi-rounded pebbles and angular cobbles. Weathering rinds form on individual clasts. Unit weathers to form reddish soils. Exposure along road cut on Minnesota 68 shows some cross-bedding with coarse sand underlying rock fragments that become larger (cobbles) towards the top of the unit, representing a coarsening-upward sequence of deposition.
- **Dolostone:** Buff, tan, gray or pink colored, fine to medium grained dolostone with a silt-sized matrix. Unit is named Oneota Dolostone (Dolomite) and is often referred to as limestone. It is a sedimentary carbonate rock that forms in warm shallow seas. Bed thickness is variable, but exposures range from one quarter inch to three feet thick and can be found in the far western and far eastern areas of the park. Often contains small cavities created by chemical (solution) weathering from ground and surface water. Covered by soils one to three feet thick, except at road or train trestle cuts.
- **Transitional Dolostone Overlying Sandstone:** Buff, tan, gray, and pink colored, fine grained dolostone is overlying and interlayered, or somewhat mixed with fine to medium buff, white, gray, and pink sandstone. Small cavities lined with calcite crystals and calcite veins are common. This layer is interpreted as a transition zone representing a change in the environment from one that produced sediment for sandstone to one where water deepened and precipitated the calcium-magnesium carbonate for the dolostone. Outcrop is near the surface and forms terraces. This unit is overlain primarily by modern flood plain deposits and glacial outwash sediments that range from one to ten feet thick.
- **Sandstone:** White, buff, tan, pink, or yellow, medium to coarse grained quartzose sandstone. Unit is named the Jordan Sandstone Formation. Minneopa Falls offers the best view and representative exposure of this Formation. Lower portions of outcrops in the park often exhibit trough cross-bedding, but are sometimes massive. Iron stained erosion surfaces between cross beds occur as thin, rusty lines tracing the tops of dunes. The lower portion is less consolidated with little silica cement, and contains iron stained burrows and thin (less than one-half inch), discontinuous layers of light green shale. Exposures in the park range from 10 to 40 feet thick. The upper portion of the exposure is a medium to fine grained, moderately well cemented layer that is often mistaken for dolomite because it exhibits small holes in the cliff faces and often appears more buff in color. Exposures in the park are usually 10 to 20 feet thick. Within this unit is a very resistant layer that forms a shelf between the upper and lower falls on Minneopa Creek and a large sandstone terrace in the northern part of the park. This unit is covered by six inches to two feet of organic soils on the sandstone terrace and several feet of till in the Minneopa Falls area of the park.

PARK BOUNDARY, ROADS, TRAILS

- Park boundary - Defined as the statutory park boundary. Private ownership lies within this boundary.
- Road - Road lying within the park boundary.
- Trail - Hiking trail lying within the park boundary.

Scale 1:15,000

0 .5 1 Mile
0 .5 1 Kilometer

(Surficial geology mapping units delineated at 1:12,000)

RELATIONSHIP BETWEEN GEOLOGIC AGES AND MAPPING UNITS

QUATERNARY PERIOD: Representing 2.5 million years ago until present.
HOLOCENE EPOCH: Representing 8,000 years ago until Present.
- Water
- Wetlands
- Minnesota River Sand, Silt, and Clay Flood Plain
- Minnesota River Sand and Gravel Flood Plain
- Minneopa Creek Flood Plain Sediments
- Till Slump
- Sandstone Talus
- Alluvial Sand and Silt Fan
- Alluvial Sand, Silt, and Clay Fan

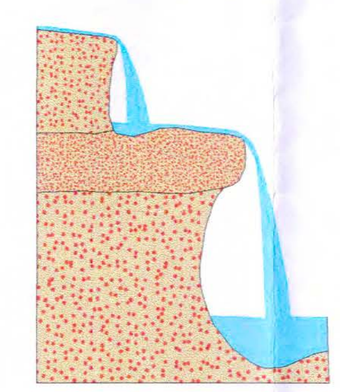
PLEISTOCENE EPOCH: Representing 2.5 million to 8,000 years ago.
- Alluvial Silt and Sand Terrace
- Alluvial Sand and Gravel Terrace
- Till Collapse Channel
- Till Plain

CRETACEOUS PERIOD: Representing 130 to 70 million years ago.
- Conglomerate

ORDOVICIAN PERIOD: Representing 500 to 440 million years ago.
- Dolostone
- Transitional Dolostone Overlying Sandstone

CAMBRIAN PERIOD: Representing 570 to 500 million years ago.
- Sandstone

SCHEMATIC DRAWING OF MINNEOPA FALLS



Sandstone type
- Moderately resistant - contains moderate amount of silica cement
- Highly resistant - contains high amount of silica cement
- Least resistant - contains low amount of silica cement

Minneopa Falls: *Minneopa* is a Dakota word meaning *water falling twice*. This is an appropriate way to describe the double water fall on Minneopa Creek, which is one of the major geologic attractions in the park. The characteristic staircase profile of the falls is related to the formation of the sandstone over which it flows. There are layers within the Jordan sandstone that have different degrees of resistance to water erosion and form the "steps" of the falls. Each of these steps has a different amount of silica cement holding the grains of sand together. The best place to see an example of the layers is the 40 foot exposure of sandstone at the falls. The base of the sandstone forms a 20 foot, concave cliff of loosely consolidated, quartzose sandstone that erodes more easily than the overlying shelf. The portion directly above the less consolidated sandstone is a fine-grained, very resistant layer that forms a shelf between the upper and lower falls. It does not erode as quickly as the sandstone above or below. Parts of this 3 to 10 feet thick layer appear to have converted to quartzite. The fifteen feet of sandstone above this layer is medium- to fine-grained sandstone with a moderate amount of silica cement. This layer forms the top "step" in the falls. The falls continue to retreat upstream and the creek gorge continues to deepen, as water cuts down through the glacial sediments to the bedrock. To appreciate how much erosional retreat has occurred, the falls were once located in an area near the confluence of Minneopa Creek and the Minnesota River, about 1 mile from its current location.

Surficial geology:
Aerial photograph interpretation and delineation of mapping units by Lisa M. Pottenger and Jonathan B. Ellingson, 1999, Minnesota Department of Natural Resources, Division of Lands and Minerals. Field work and digitizing by Lisa M. Pottenger, 1999. Source information included aerial photographs from NAPP (National Aerial Photography Program), 1991, 9" x 9" color infrared photos at 1:40000; DOQs (Digital Orthophoto Quadrangles) at 1:12,000 from USGS (United States Geological Survey), 1991; DRGs (Digital Raster Graphics) at 1:24,000 from USGS; 7.5-minute USGS topographic quadrangles; and Soil Survey of Blue Earth County from USDA-SCS (United States Department of Agriculture, Soil Conservation Service), 1978.

Base map:
Statutory park boundary, roads, and trails from Minnesota Department of Natural Resources, Division of Parks, 1999.

GIS database design and cartography by Renee Johnson.