Minnesota Department of Natural Resources
Division of Minerals
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DATA SOURCES
AND
MAPPING METHODOLOGY
BLUE EARTH COUNTY, MINNESOTA

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1999

INTRODUCTION

The purpose of this study is to identify and classify potentially valuable aggregate resources in Blue Earth County, Minnesota. This information is intended to assist local planners in making land-use decisions regarding aggregate resources, introduce aggregate resource protection, spread the burden of development, and promote orderly and environmentally sound development of the resource. To accomplish this goal four plates were constructed for this study: 1) A summary of the significant aggregate resource deposits (those most likely to be evaluated and explored for future commercial use), 2) a more detailed breakdown of all identified and potential aggregate resource deposits, including geological characteristics about the deposits, 3) a description of the surficial geology, and 4) a discussion of the methodology and data sources used.

Aggregate material consists of sand, gravel, and crushed stone. Aggregate is a high-bulk, low-value commodity, therefore transportation costs account for a considerable amount of the delivered price. Land-use conflicts involving aggregate mining and urban development are becoming increasingly more common. Cities expand into adjacent rural areas, thus covering the deposits; residential development occurs adjacent to aggregate sources causing opposition of nearby homeowners; and depletion of the aggregate resources occurs due to high use in urban areas (such as Mankato). Due to these land-use conflicts, it is necessary to transport aggregate from areas increasingly farther away, thus increasing the cost of the delivered aggregate and all products constructed with that aggregate.

Due to urban sprawl and several other land-use conflicts, aggregate resource development is becoming increasingly more difficult. With this in mind, the 1984 Minnesota legislature passed a law (M.S. 84.94, Aggregate Planning and Protection) that mandates the Department of Natural Resources (with cooperation of the Minnesota Geological Survey and Department of Transportation) to conduct a program to identify and classify potential aggregate resources where urbanization or other factors are or may result in a loss of aggregate resources. This information is then provided to local governments to assist them in making land-use decisions. This study does not eliminate the need for a detailed site evaluation prior to a development proposal, especially in regard to aggregate quality.

METHODOLOGY AND DATA SOURCES

The first step in determining the distribution of aggregate resources is to understand the surficial geology and the recent geological history of the area. The geological history basically tells us the story, or sequence of events, of when the aggregate and other sediments were deposited. By understanding this story we can determine where the aggregate was deposited, as well as some of the general characteristics about the material. This was accomplished for this study by completing an aerial photograph interpretation of the entire county and confirming these interpretations with over 1,500 water well logs and by observing approximately 450 field sites. Several other data sets and techniques were also used and are described below. These interpretations and observations were then compiled to form a sequence of events to tell the geologic story. Finally, the aggregate bearing landforms were delineated and categorized based on their geological characteristics.

A literature and data search was completed to get a basic understanding of the geology in the area and to compile a list of existing data. Much of this information was already available in a digital format or it was incorporated into digital datasets. Some of the datasets used included aerial photographs, topographic maps, digital elevation models, shaded relief, subsurface data, gravel pit locations, quarry locations, geology, wetlands, streams, lakes, vegetation, soils, land-use, as well as several datasets of background information, including roads, railroads, township-range-section boundaries, and others. Once all this information was digital, a computer program by ESRI called Arcview, was used to help interpret, compile, and summarize the data. This information was then incorporated into the development of a working geologic model for Blue Earth County.

The subsurface data used for this study included the County Well Index (CWI) database and the Minnesota Department of Transportation's (MN/DOT) files (Figure 1). The CWI is an online database maintained by the Minnesota Geological Survey (MGS,1998) that contains basic information for over 200,000 wells drilled throughout Minnesota. Approximately 2,500 of these wells are located in Blue Earth County; the well data were downloaded in early 1998. About 1,550 of the wells contained geological descriptions that were found to be useful for this study. The MN/DOT gravel pit sheets consist of shallow test hole logs, textural (sieve) data, quality data, and a diagram of test hole locations; these test hole locations were digitized and the associated data were summarized in a database. The subsurface information was used to look for buried sand and gravel deposits, interpret buried glacial deposits, determine the depth to bedrock, and identify the type of bedrock encountered.

Color infrared and black-and-white aerial photographs were used to delineate geological landforms and aggregate resources. Stereoscopic pairs of color infrared aerial photographs (NAPP, 9"x9" at 1:40,000 scale, April 1991 and 1992) were used along with reconnaissance-level, high-altitude, black-and-white photographs (1:80,000 scale). Aerial photographs (DOQs) were also available digitally and used within ARCVIEW (1:12,000 scale; Figure 2). Aerial photographic interpretation was completed with a glacial mapping technique known as the landsystems approach (Eyles, 1983). This technique relies on the principle that depositional glacial landforms are composed of a predictable range of sediments, some consisting of sorted sand and gravel and others consisting of silts, clays, or unsorted materials. In addition to the landsystems approach, several other general characteristics helped determine the nature of the material, such as tonal contrasts, texture, context, shape, size, trend, association, and patterns. These characteristics can help determine the properties of the surface material (e.g., certain vegetation grows on well drained soils such as sand and gravel, which on an aerial photograph has a distinctive texture, tone, pattern, etc.).

The landform recognition approach (part of the landsystems approach) was also used when interpreting the topography within Blue Earth County; glacial landforms have distinct and unique shapes and patterns that can be observed in their topographic expression. Topographic maps (USGS 1:24,000), digital elevation models, and shaded relief maps (Figure 3) were all used to help delineate these sand and gravel bearing features. The topographic expression of a feature can also be observed by looking at the distribution of lakes and wetlands. For example, a string of lakes and/or wetlands may be the signature of a glacial outwash channel or collapsed channel, which may host sand or gravel deposits. Several aggregate bearing features were located using this technique (outwash channels, collapsed channels, deltas, kames, eskers, and terraces).

The aerial photographs, subsurface data, topographic expressions, and soils were all compiled and the inferred geologic and aggregate resource contacts were plotted on 7.5 minute topographic maps (1:24,000); these maps were then ready to be field checked. Field work consisted of confirming landform recognition, looking for natural exposures of the surficial material, and drilling test holes where aggregate had been mapped. Landform recognition was accomplished by driving every accessible road in the county, checking interpretations made with aerial photographs and topographic models. Streams and road cuts offered several places where the surficial materials, glacial stratigraphy, and bedrock formations were exposed. Excavations, such as basements, trenches (wires, pipes, foundations), judicial ditches, construction projects, and even badger holes, supplied additional exposures to the geological materials. Gravel mines and quarries exposed some of the already mined aggregate resources in the county. These locations supplied additional quality data and good stratigraphic cross-sections to help interpret the modes of deposition. Additional test holes were drilled, with the permission of the owner, where data was needed to confirm the presence of sand and gravel (Figure 4).

After completing the field work, a very detailed interpretation of the aerial photographs was done to finalize the geologic map units, incorporate the field data, and separate out the areas with potential aggregate resources. The aggregate resources were divided into six categories (see Plate 2): 1) highly desirable sand and gravel resources, 2) moderately desirable sand and gravel resources, 3) less desirable sand and gravel resources, 4) moderately desirable crushed stone resources, 5) less desirable crushed stone resources, and 6) limited potential for aggregate resources. The sand and gravel resources were divided into these categories based on the host geological feature, probability, sand and gravel thickness, overburden thickness, deposit size (areal extent), textural characteristics (sieve analysis), quality (soundness and durability), and the sediment description as observed in the field (Table 1). For example, a terrace deposit typically hosts sand and gravel, thus the feature may have potential. If the deposit has a gravel pit located on or adjacent to it and sand and gravel were encountered during drilling while doing field work, it has a very high probability. If that deposit is 30 feet thick with 2 feet of overburden and covers 40 acres in areal extent, the aggregate thickness, overburden thickness, and deposit size are all in the high to very high category. If the gravel percent is high and the quality meets MN/DOT specification, then this terrace deposit is categorized as a highly desirable sand and gravel deposit (Table 1).

Characteristic	Desirability Ranking			
	High	Moderate	Less	Slight
Surficial Geology Features	Glaciofluvial outwash channel, terrace, delta	Outwash channel, delta, kame, esker, terrace, alluvium	Terrace, alluvium, delta, beach, kame, outwash channel	Glacial lake bed, moraines - till, small flood plains
Probability[1]	High to very high	Moderate to very high	Moderate to moderately high	Very low to moderate
Sand and Gravel Thickness (in feet)	10-50	0-40	0-20	0-20
Overburden Thickness (in feet)	0-15	0-20	0-20	0-80
Sand and Gravel Deposit size (as areal extent)	Moderate to very large	Moderate to very large	Small to large	Very small to moderate
Sand and Gravel Textural Characteristics	Moderately good to very good	Moderate to very good	Moderate to moderately good	Very poor to moderate
Sand and Gravel Quality[2]	Moderate to very good	Moderate to very good	Moderate to moderately good	Very poor to moderate
Sediment Description	Sand and gravel	Sand and gravel	Sand with occasional sand and gravel	Clay/silt/sand with occasional sand and gravel

Table 1. SAND AND GRAVEL POTENTIAL

[1] Probability is the degree of certainty that aggregate exists within a unit.

[2] Quality is defined in terms of soundness, durability, and mineral make-up.

Note: Colors associated with rankings (High, Moderate, Less, Slight) correspond to colors shown on Plate II for aggregate potential.

The crushed stone resources were divided into either moderately desirable or less desirable; none of the crushed stone resources meet the quality specifications to be categorized as highly desirable. These crushed stone resources were divided into their categories based on the following characteristics: deposit thickness, overburden thickness, probability, quality, deposit size, environment of deposition, and bedrock description. The deposit thickness, environment of deposition, and bedrock description took into account the thicknesses of consolidated beds, the presence of shale and unconsolidated beds, and other field observations. If the overburden thickness was less than 50 feet, the unit was considered accessible, and if it was less than 10 feet, it was consider more accessible. The probability, deposit size, and quality were determined similarly to that of the sand and gravel category.

The areas identified as limited aggregate potential did not meet the above mentioned criteria. The deposits may have been too small, not thick enough, had too much overburden, may not have met the quality specifications, or contained material too fine in size. Along with aggregate potential, all known identified sources of aggregate were mapped. This included gravel pits and quarries ranging in size from less than an acre to more than 50 acres. These gravel pits and quarries may be active, inactive, depleted, or reclaimed, but represent an area where aggregate is or has been mined.

REFERENCES

Eyles, N., 1983, Glacial Geology: A Landsystems Approach, Glacial Geology: An Introduction for Engineers and Earth Scientists, Pergamon Press, Oxford, p. 1-18.

Minnesota Geological Survey, 1998, County Well Index for Blue Earth County, Minnesota, 2552 records.

SUBSURFACE INFORMATION

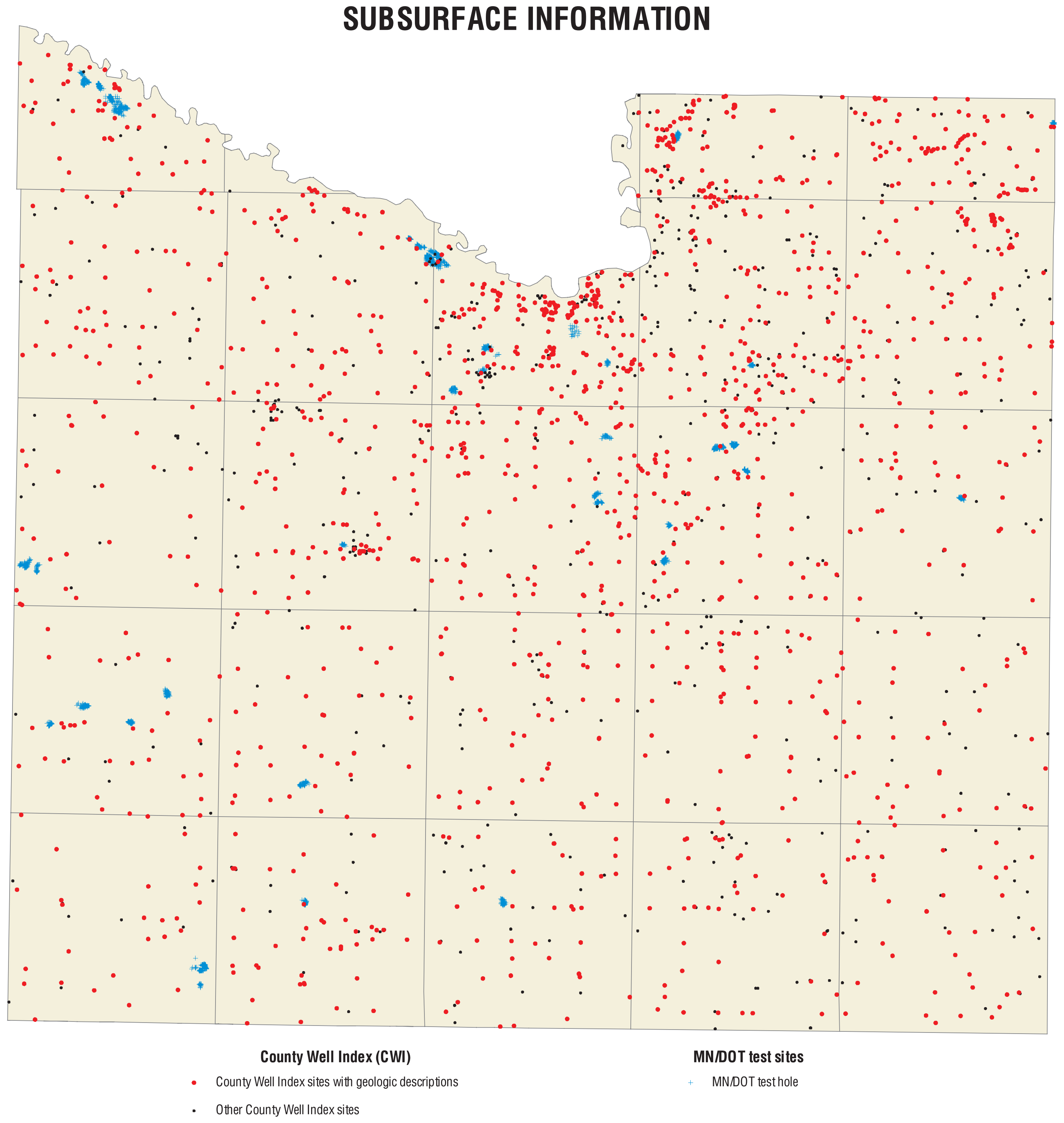

Figure 1. The County Well Index (CWI) is an online database of the Minnesota Geological Survey. CWI stores basic information for over 200,000 wells that have been drilled in Minnesota. For Blue Earth County, approximately 2500 wells were included in this database when the data were downloaded in 1998. Of these 2500 wells, about 1550 wells were found to contain geological descriptions that were used for this project. The Department of Transportation (MN/DOT) test pit data consists of a series of auger drill holes with both textural (sieve analysis) and quality (soundness and durability) data. The test pits data sheets are from 1935 to 1987.

AERIAL PHOTOGRAPHY

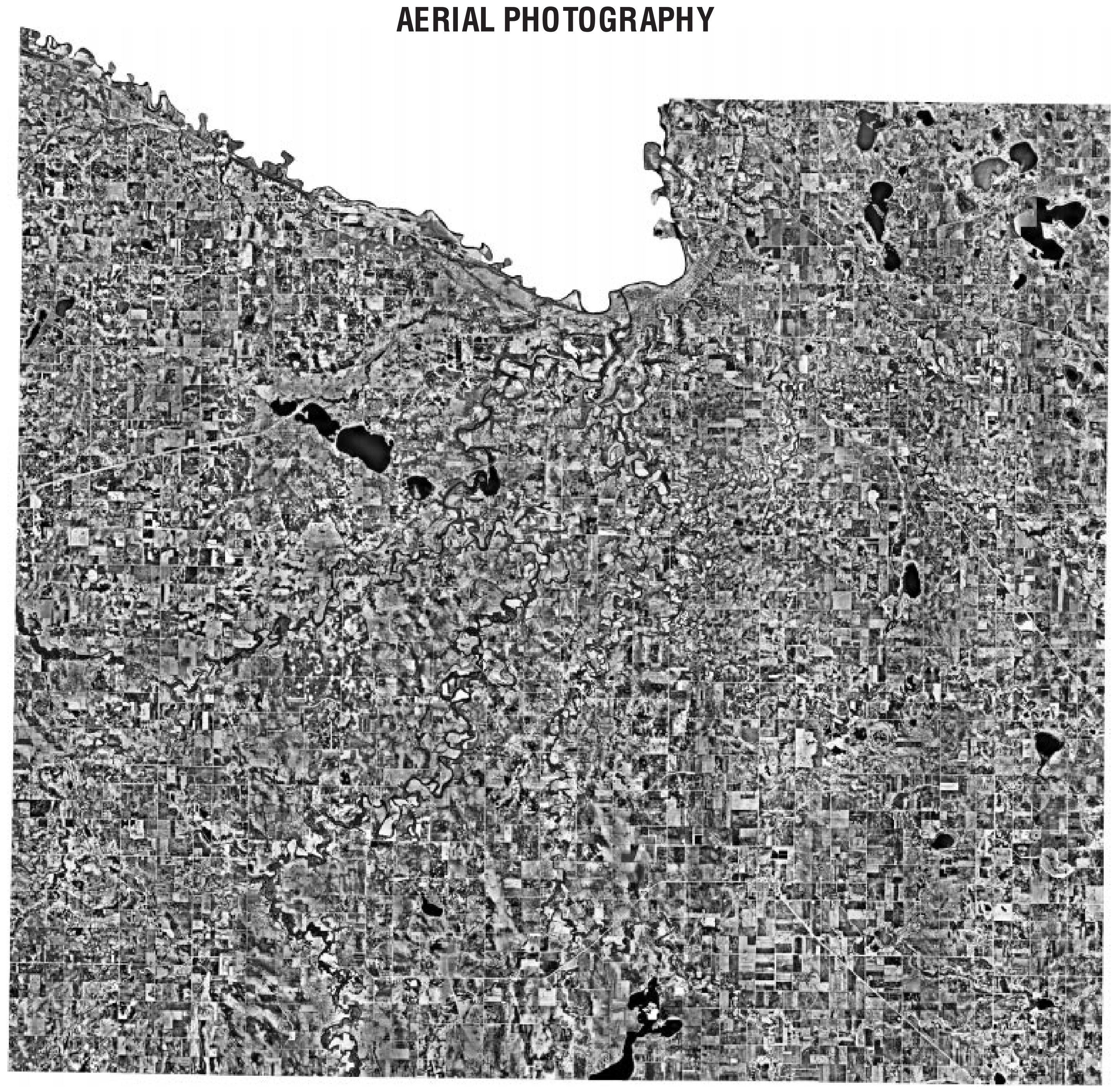

Figure 2. This aerial photography mosaic is composed of Digital Orthophotoquads (DOQs), that is, computer-readable images of aerial photography, that are available from the U.S. Geological Survey (USGS). The aerial photographs were taken in April 1991 and April 1992, from an airplane that was at 20,000' above the land surface on film that was 10" wide. The photographs were then scanned at a 1-meter resolution to create the 1:12,000 quarter-quad DOQ products. For this mosaic, the scanned photographs were resampled at a 10-meter resolution and combined into a countywide image.

SHADED RELIEF

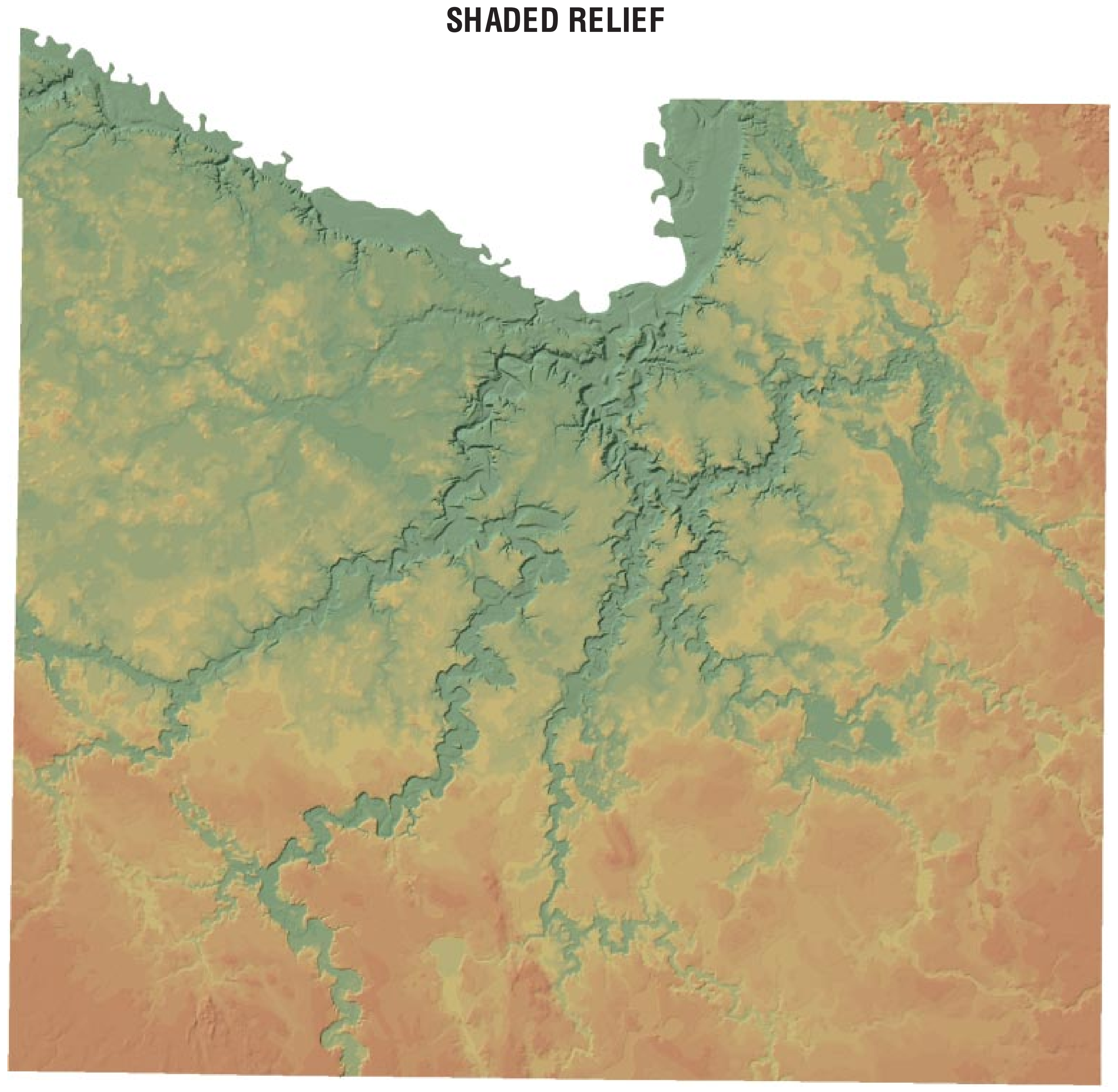

Figure 3. The shaded relief plot of Blue Earth county was derived from Digital Elevation Model data and the use of a hillshading command to make the elevations appear 3-dimensional, by adding bright spots and shadows as they might be cast by the sun. Digital Elevation Models (DEMs) are digital files storing terrain elevations at regularly spaced, horizontal intervals derived from U.S. Geological Survey (USGS) 7.5-minute quadrangles. The DEM data used in this case are available at 30-meter spacing from the USGS. In general, the green colors are lower elevations and the brown tones are higher elevations. Darker shades of the colors are those areas in shadow, due to the hillshading.

FIELD OBSERVATION SITES

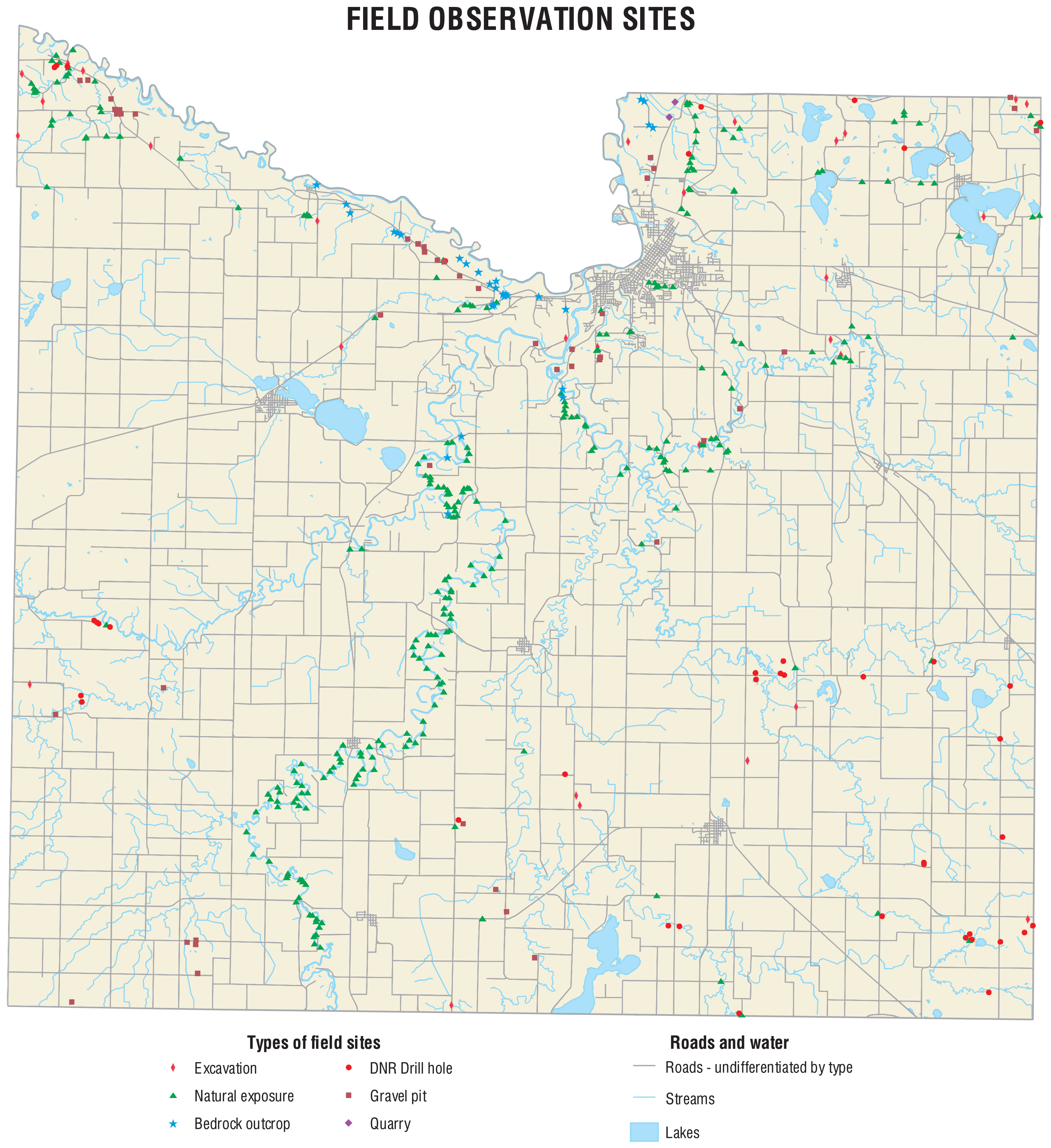

Figure 4. Field work was completed during the summer and fall (June to October) of 1998. Field observation sites consisted of bedrock outcrops, natural exposures, excavations, 4" diameter auger drill holes by the author, gravel pits, and quarries. Every accessible road in the county was traveled looking for these sites and to help determine the landform expressions. Field observations by the author were made at approximately 450 sites throughout the county.

Base map data sources:
Lakes and major rivers from National Wetland Inventory, U.S. Fish and Wildlife Service, compiled at 1:24,000 from aerial photography (1979-1988) and spot field checked. Minor rivers from State of Minnesota Basemap, 1996, Department of Transportation Surveying and Mapping BaseMap Development Group.
Public Land Survey - PLS Project, 1999, Minnesota Department of Natural Resources, Division of Minerals.
Roads from State of Minnesota Basemap, 1996, Department of Transportation Surveying and Mapping BaseMap Development Group.

GIS database design and cartography by Renee Johnson (1999).

Prepared with support from the Mineral Diversification Program of the Minnesota State Legislature.
Projects are determined by a committee composed of Governor-appointed members from the public and private sectors.