SURFICIAL GEOLOGY OF THE DUNKERTON 7.5' QUADRANGLE BLACK HAWK COUNTY, IOWA

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A glacial erratic in the mapping area just off Big Rock Road (an official name)

ABSTRACT

Our objective for developing the surficial geologic map of the Dunkerton Quadrangle was to obtain data that may be used for land use planning tools for the city of Dunkerton, IA, the Natural Resources Conservation Service (NRCS), and the local landowners. The city of Dunkerton and the surrounding Cedar Falls/Waterloo metro area need these data to improve their water resources management plans, wetland protection programs, aggregate resource management programs, and the pollution potential from Iowa's growing confined animal farming operations (CAFOs). UNI's EDMAP program collaborated with Federal (NRCS, EPA), State (Iowa Geological and Water Survey), and local to address the need for sufficient geologic mapping data. Five geologic formations were identified within the Dunkerton Quadrangle (Qal, Qal_lt, Qnw2, Qnw3, and Qwa2).

Introduction

The purpose for developing the surficial geologic map of the Dunkerton Quadrangle is to obtain geologic data that can be used for county-specific land use planning tools for the town of Dunkerton, IA, the Natural Resources Conservation Service (NRCS), and the local farmers. The study area was located in northeastern Iowa, in Black Hawk County (Fig. 1). The Dunkerton 7.5' Quadrangle covers an area from 42^{o} 30' to 42^{o}37'30'' N latitude and 92^{o}07 30" to 92^{o} 15" W longitude. The Dunkerton Quadrangle lies in a terrain of dissected Pre-Illinoian glacial deposits that blanket a bedrock surface with significant relief. The study area also represents a portion of the Iowan Erosion Surface and exhibits Wisconsinan and Holocene alluvial surfaces, eolian landforms, and discontinuous outcrops of Paleozoic bedrock. Geologic units within the project area include Devonian carbonate bedrock, Pre-Illinoian glacial sediment and alluvium, Wisconsin outwash, loess, Holocene alluvium, and eolian sand.

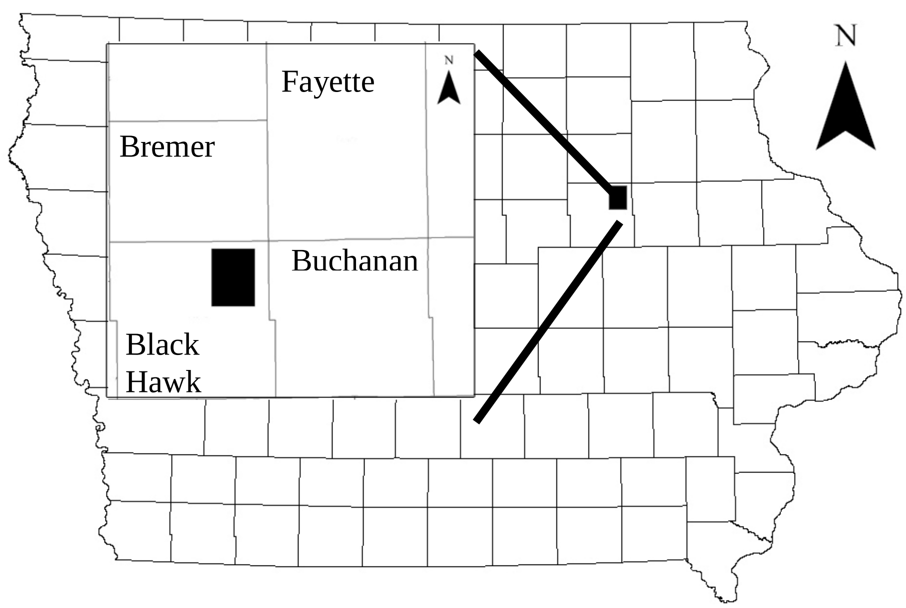

Figure 1. Locality map of Dunkerton Quadrangle (highlighted in black) with an inset depicting the adjacent counties.

Regional setting

During the Pleistocene continental glaciers advanced over Iowa, depositing sediments during and after ice contact. The main glacial stages from oldest to youngest were the Pre-Illinoian, Illinoian, and Wisconsinan (Fig. 2). The Dunkerton Quadrangle lies on the Iowan Surface (Fig. 3). The Iowan Surface displays sweeping, relaxed, open topography. The surface usually appears slightly inclined to gently rolling with long slopes, low relief, and open views to the horizon (Prior, 1991). This region of Iowa has no constructional features associated with glaciations. There are no moraines, eskers, kames, or outwash plains. The Iowan Erosion Surface was previously known as the Iowan Drift Region. A considerable amount of this region is covered by loess, but the major part of the region is characterized by a thin loam sediment that overlying a stone line on the till (Ruhe, 1969). The Iowan Drift does not exist in northeastern Iowa. The Iowan Drift Region is actually an erosion surface (Ruhe, 1969).

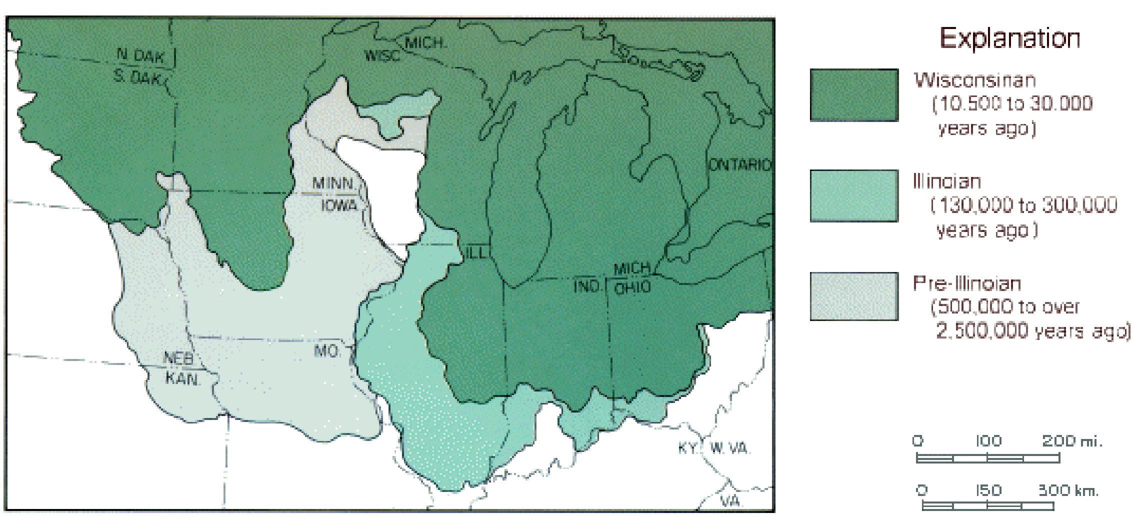

Figure 2. Limits of major Pleistocene glacial advances into the Midwest (Prior, 1991)

The edge of the erosion surface extends under the thick loess. Thus, the erosion surface itself cannot be the primary source for the loess (Hallberg, 1979). It is postulated that much of the Iowan Erosion Surface must have been created before the loess began to be deposited. Radiocarbon ages indicate that loess deposition began on the erosion surface approximately 18,000-23,000 radiocarbon years ago and between 21,000-29,000 radiocarbon years ago on the areas with paleosols. This aging indicates that erosion and loess deposition were occurring simultaneously (Zanner, 1999). The Iowan Surface was last inhabited by glaciers in Pre-Illinoian time and has since lain exposed to various episodes of weathering and soil development, erosion, and loess deposition (Prior, 1991).

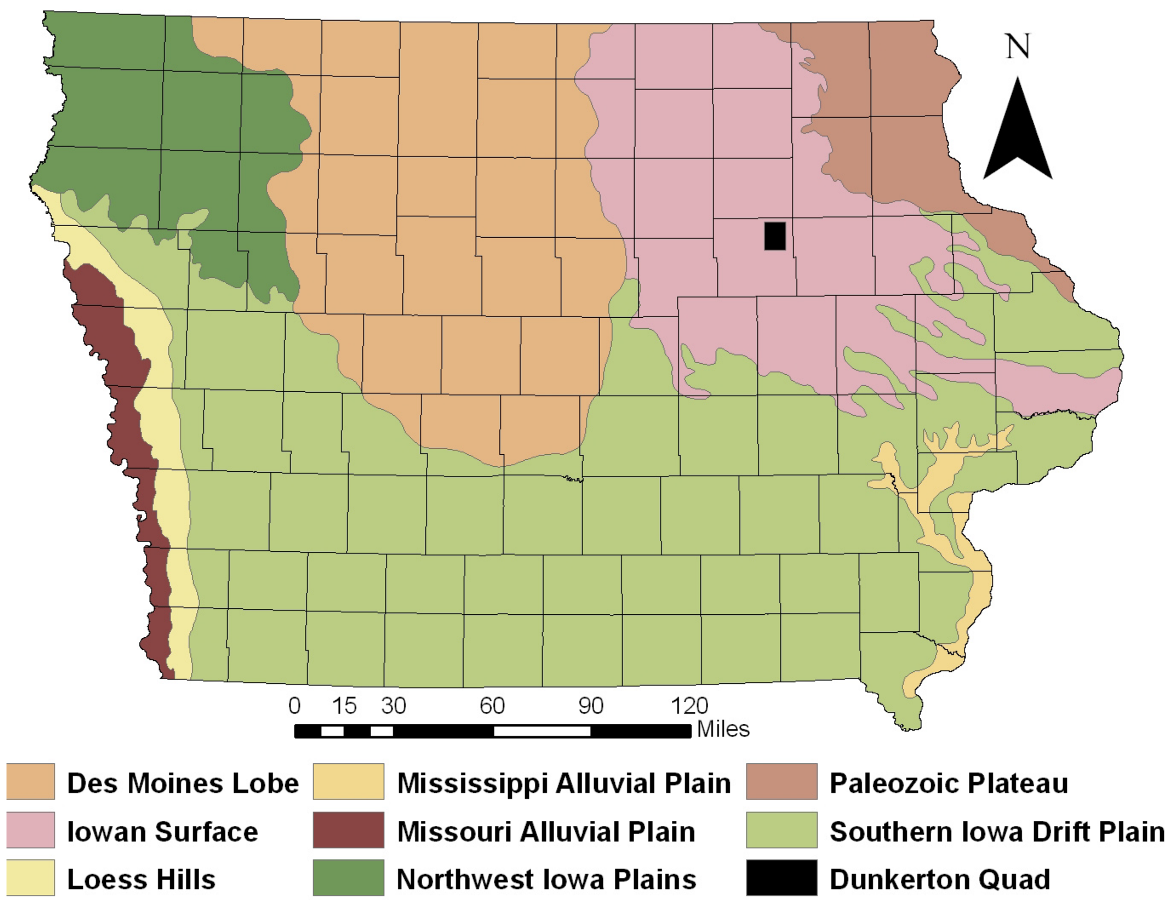

Figure. 3 Landform Regions of Iowa with the Dunkerton Quadrangle (highlighted in black)

METHODS

Spatial data collection

Geographically referenced data were necessary for this mapping project. This project required obtaining geospatial data (digital raster – topography, aerial photography, depth to bedrock, and other shape files) from the Iowa Natural Resources Geographic Information Systems Library (http://www.igsb.uiowa.edu/nrgislibx/gishome.htm). Spatial data were also collected in the field using a Trimble GeoXH unit. This mobile mapping enables the collection of field data to lessen the possibility of error in identifying geologic sampling points and mapping units.

Field work

Samples were taken from the field using a hand-auger (2" diameter) and shovel excavations of surficial outcrops (Fig. 4 and 5). Samples were described in a field notebook on the basis of sediment identification methods. In most cases the maximum range reached for mapable surface geologic units (soil parent material) was 3 to 12 feet. The hand auger was capable of reaching depths of 20 feet, but the UNI EDMAP team often encountered the seasonally high water tables and/or gravel to cobble sized glacial sediment. Each of these naturally occurring conditions made drilling by hand at depths greater than 4 feet difficult. The UNI EDMAP team hand drilled 42 cores and had access to 59 well descriptions from Iowa Geosam database (http://www.igsb.uiowa.edu/webapps/geosam/default.asp?state=1). Working in collaboration with the Iowa Geologic and Water Survey on the surficial mapping of the Gilbertville Quadrangle the team participated in drilling five (35 to 45 feet) cores with a drilling rig. We also extensively used soil profiles, vegetation features, and landscape positions to assist our mapping efforts (Figure 6). The soil samples were collected for lab analysis.

Figure 4. Nick Bosshart (right) and Jordan Vastine on the banks of the Wapsipinicon River sampling a unit that was later interpreted Qal.

Figure 5. Investigating a recently cut section of Qwa2 on a miserable spring day.

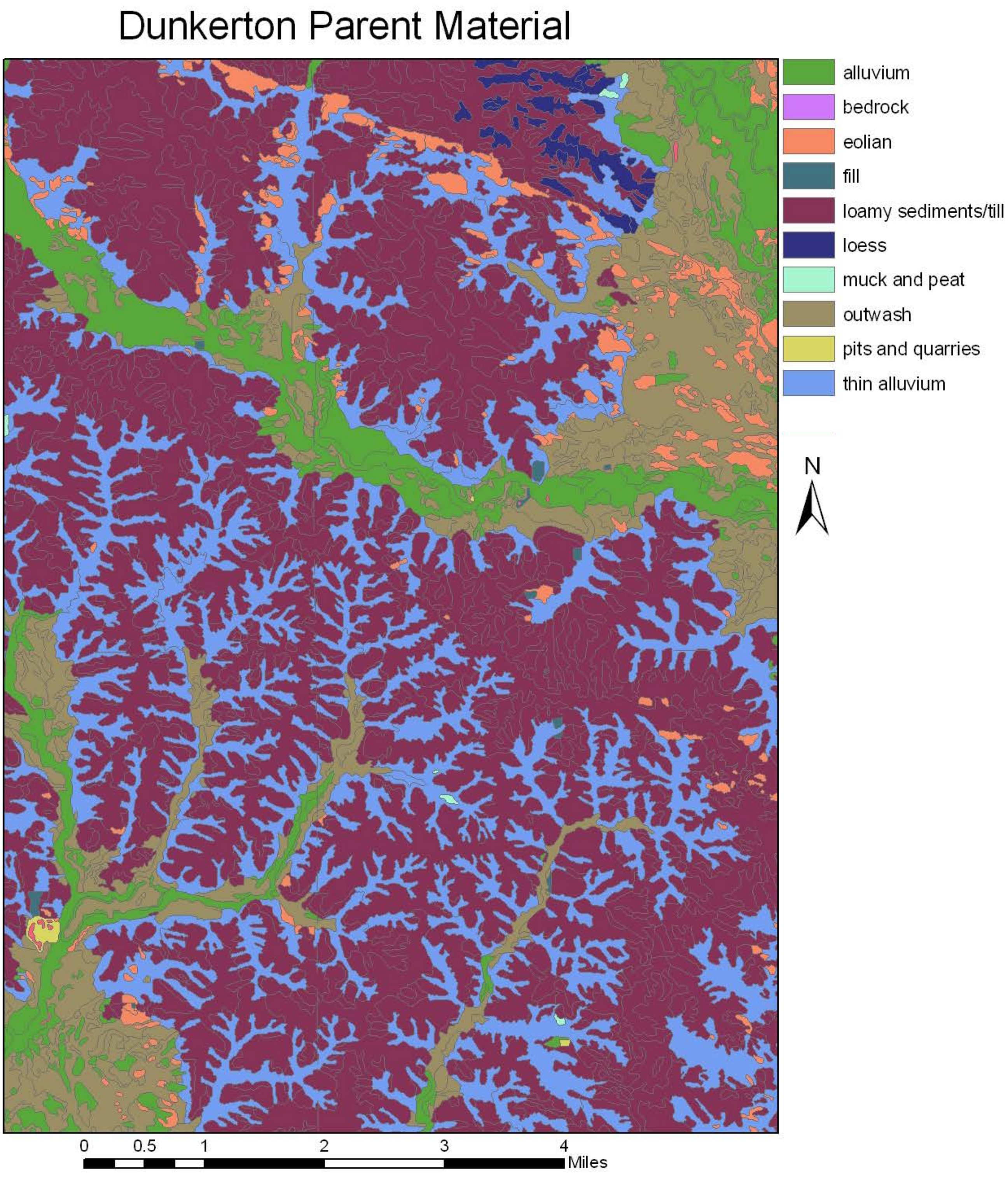

Figure 6. Mapping exhibiting the Dunkerton Quad's primary soil to parent materials relationships.

GIS data processing

Geospatial data were obtained for Black Hawk County and the Dunkerton Quadrangle from the Iowa Natural Resources Geographic Information Systems Library. While drawing the map features (shape files) and contacts a combination of field, supporting geospatial data (aerial photos, NRCS –soil survey data, topography, LIDAR etc.), and ArcGIS 9.3 editing tools were used.

Laboratory methods

Particle size analysis is being used to quantify the textural content and variability for unconsolidated sediment (fine-earth fraction) and soil samples from the Dunkerton Quadrangle. Identifying textural variability between a series of depositional units or soil horizons is important because they are indicative of changing energy in depositional systems or changes in weathering environments for soils.

The initial coarse (>2mm) fraction including pebbles, cobbles, and boulders was visually estimated from each stratigraphic unit during field descriptions. Clay-rich units and samples were disaggregated to access homogenous samples. Forced air was used to clean the sieve and crusher between each use to avoid sample contamination of organics and sedimentary particles. The fine particle size (x<2mm) distribution for each sample was determined using the pipette method of Gee and Bauder (1986). The procedure categorizes sediment from each depositional unit into the Wentworth Geometric Progression Scale (Table 1). In addition, the USDA textural classes were also determined from the Wentworth classes.

Table 1

Particle Size Analysis Distribution (Wentworth Scale) Categories

		(mm)			(μm)
Sand	VCS	2-1	Silt	VCSi	63-53
	CS	1-0.5		CSi	32-16
	MS	0.5-0.25		Msi	16-8
	FS	0.25-0.125		Fsi	8-4
	VFS	0.125-0.063		VFSi	4-2

*Abbreviations: V (very), C (coarse), M (medium), F (fine), S (sand), Si (silt).

Four pipetting sessions measured specific particle size fractions from each sample (16 μm, 8 μm, 4 μm, and 2 μm). The temperature was recorded from the salt factor (dispersion) bottle before each sampling period to achieve the proper sampling time. The sediment solutions were contained in crucibles and placed in an oven to evaporate the distilled water. The product (sediment and salt) was weighed to the 0.0000 decimal place after each crucible cooled in a desiccator for no longer than fifteen minutes, again to lessen the possibility of gaining water.

The sand to coarse silt fraction (2 mm to 32 μm) of each settling bottle was obtained by quantitatively washing the sediment through a 450 mesh (32 μm openings) sieve using tap water. The contents of the nineteen sedimentation bottles were rinsed in beakers and placed in an oven at 105 °C for 4 hours, completely evaporating the excess water. The sands and coarse silts were then carefully transferred into a sieve set (Table 2).

Table 2

Particle Size Analysis Sieve Series

Sieve #	Opening
18	1.0
35	0.5
60	0.25
120	0.125
230	0.063
270	0.053
pan	0.032

Each sediment fraction was placed into a Gilson three-inch sieve shaker for one and one-half minutes to complete particle separation. Each sieve and its contents were weighed individually on a top loading balance and measured to the nearest 0.01 g.

Data/Results

From our field and laboratory work we have interpreted five mappable units (1:24,000). The five units include the (Qal, Qal_lt, Qnw2, Qnw3, Qwa2) -

CENOZOIC
QUATERNARY SYSTEM

HUDSON EPISODE

- Alluvium (DeForest Formation-Undifferentiated) Variable thickness of less than 1 to 5 m (3-16 ft) of very dark gray to brown, noncalcareous to calcareous, massive to stratified silty clay loam, clay loam, loam to sandy loam alluvium and colluvium in stream valleys, on hill slopes and in closed depressions. May overlie Noah Creek Formation, Wolf Creek or Alburnett formations or fractured Devonian carbonate bedrock. Associated with low-relief modern floodplain, closed depressions, modern drainageways or toeslope positions on the landscape. Seasonal high water table and potential for frequent flooding.

- Low Terrace (DeForest Formation-Camp Creek Mbr. and Roberts Creek Mbr.). Variable thickness of less than 1 to 5 m (3-16 ft) of very dark gray to brown, noncalcareous, stratified silty clay loam, loam, or clay loam, associated with the modern channel belt of the Shell Rock and West Fork Cedar river valleys. Overlies the Noah Creek Formation. Occupies lowest position on the floodplain, ie. modern channel belts. Seasonal high water table and frequent flooding potential.

HUDSON and WISCONSIN EPISODE

- Sand and Gravel (Noah Creek Formation) Generally 2 to 8 m (6-26 ft) of yellowish-brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel with few intervening layers of silty clay. A thin mantle of loess, reworked loess or fine-grained alluvium (Qal) may be present. This unit includes silty colluvial deposits derived from the adjacent map units. In places this unit is mantled with 1 to 3 m (3-10 ft) of fine to medium, well sorted medium to fine sand derived from wind reworking of the alluvium. This unit encompasses deposits that accumulated in low-relief stream valleys during the Wisconsin Episode and Hudson Episode. Seasonal high water table and some potential for flooding.

WISCONSIN EPISODE

- Sand and Gravel Shallow to Bedrock (Noah Creek Formation) – 1 to 3 m (3-10 ft) of yellowish-brown to gray, poorly to well-sorted, massive to well stratified, coarse to fine feldspathic quartz sand,pebbly sand and gravel. May be overlain by up to 3 m (10 ft) of silty alluvial material. In places this unit may be mantled with fine to medium well sorted feldspathic quartz sand derived from wind reworking of the alluvium. Fractured carbonate bedrock is less than 5 m (16 ft) below the land surface. The unit encompasses deposits that accumulated in river and stream valleys during the late Wisconsin as well as exhumed Pre-Illinois Episode deposits of the Wolf Creek and Alburnett formations. Deposits may be slightly thicker along the Cedar River.

- Loamy and Sandy Sediment Shallow to Glacial Till (Unnamed erosion surface sediment) Generally 1 to 7 m (3-23 ft) of yellowish-brown to gray, massive to weakly stratified, well to poorly sorted loamy, sandy and silty erosion surface sediment. Map unit includes some areas mantled with less than 2 m (7 ft) of Peoria Formation materials (loess and eolian sand). Overlies massive, fractured, firm glacial till of the Wolf Creek and Alburnett formations. Seasonally high water table may occur in this map unit.

General map discussion

The majority of the Dunkerton Quadrangle may be characterized as an eroded glacial plain (The Iowan Erosion Surface, Figure 7). Qwa2 or a loamy to sandy till sequence make up approximately seventy-five percent of the quadrangle. In comparison to other adjacent till areas of the Iowan Erosion Surface, the Dunkerton Quad has noticeably more relief and a higher concentration of boulder/erratic fields. A possible explanation for this topographic variance may be that this area represents a different Pre-Illinoian till sheet than the surrounding area. UNI Earth Science students are currently conducting particle size and XRF analysis of the till/sediment to be able to compare it to other tills in the area. In addition, to the landscapes markedly different appearance the flooding potential for the area has been significant. While conducting field work we spoke with multiple area residence and gathered that flooding often occurred quickly (i.e. rapid stream level rise and subsequently rapid stream level fall). Crane Creek flows from west to east through the northern half of the quadrangle and past the town of Dunkerton. Recent intense rainfalls (up to 14" in a 24 hr period) have severely impacted this town. The high clay content and hardened surfaces of the abundant Qwa2 deposits may be contributing to flash flood events. The soils developed within Qwa2 parent materials have a difficult time adsorbing water during intense precipitation events. The moderate impermeability of the landscape coupled with modern tiling forces rainwater to the drainage system quickly.

The Dunkerton Quad. contained an abundance of sand upon the uplands (Qwa2). In some instances these sands were organized into linear, northwest to southeast trending, depositional features. LIDAR imagery and Soil Survey data for the mapping area provides insight into these linear sand concentrations and many other surficial landscape features (e.g. meandering channels) (Figures 8 & 9). These linear sand features are commonly called sand stringers upon the Iowan Erosion Surface (Zanner, 1999). UNI Earth Science students are also investigating the particle size distribution and mineralogy of these unique landscape features.

Figure 7. Typical landscape of the Iowan Erosion Surface throughout most of the mapping area (Qwa2)

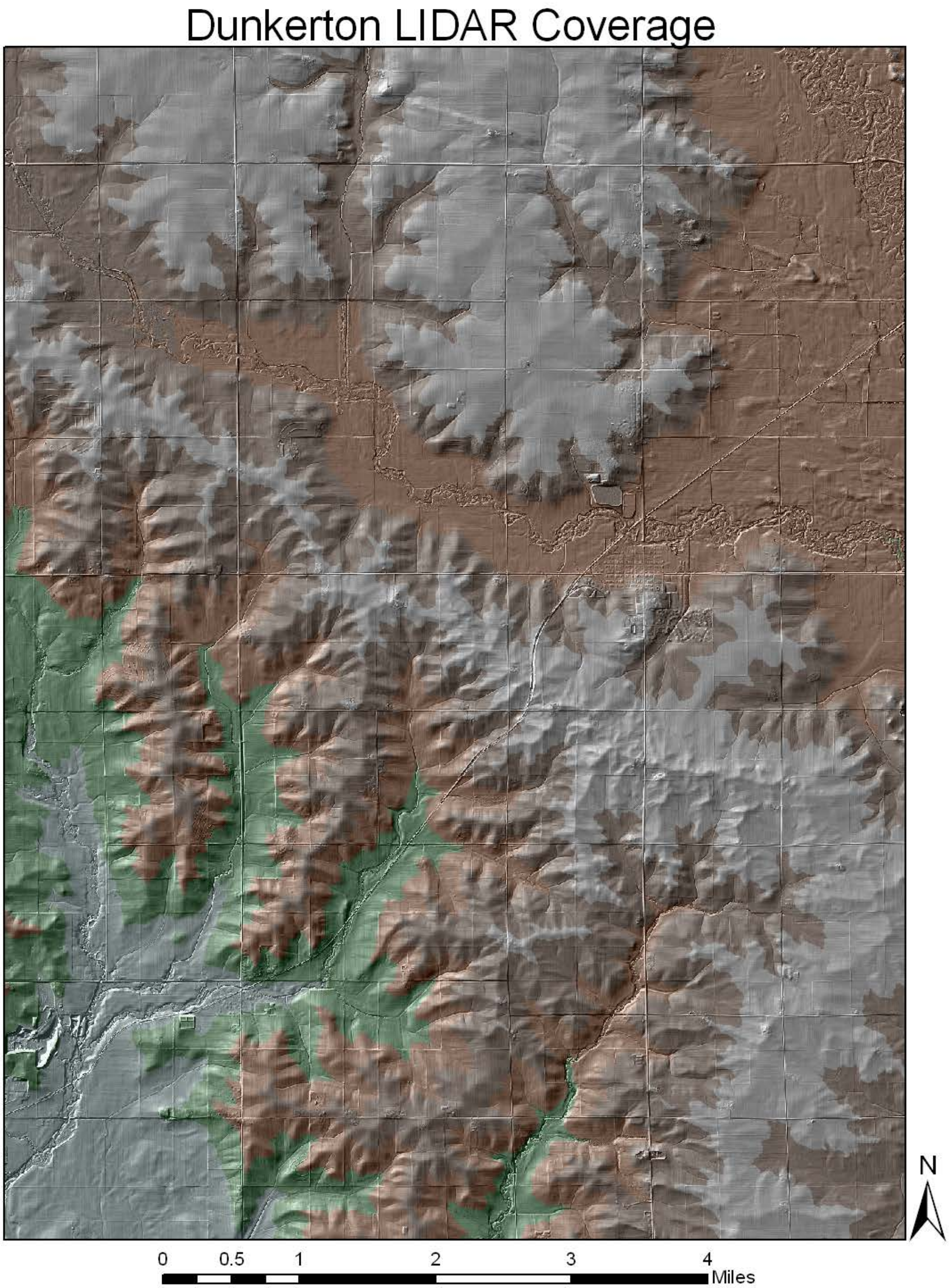

Figure 8. LIDAR coverage for the Dunkerton Quadrangle (based on DEM & Hill shade coverages).

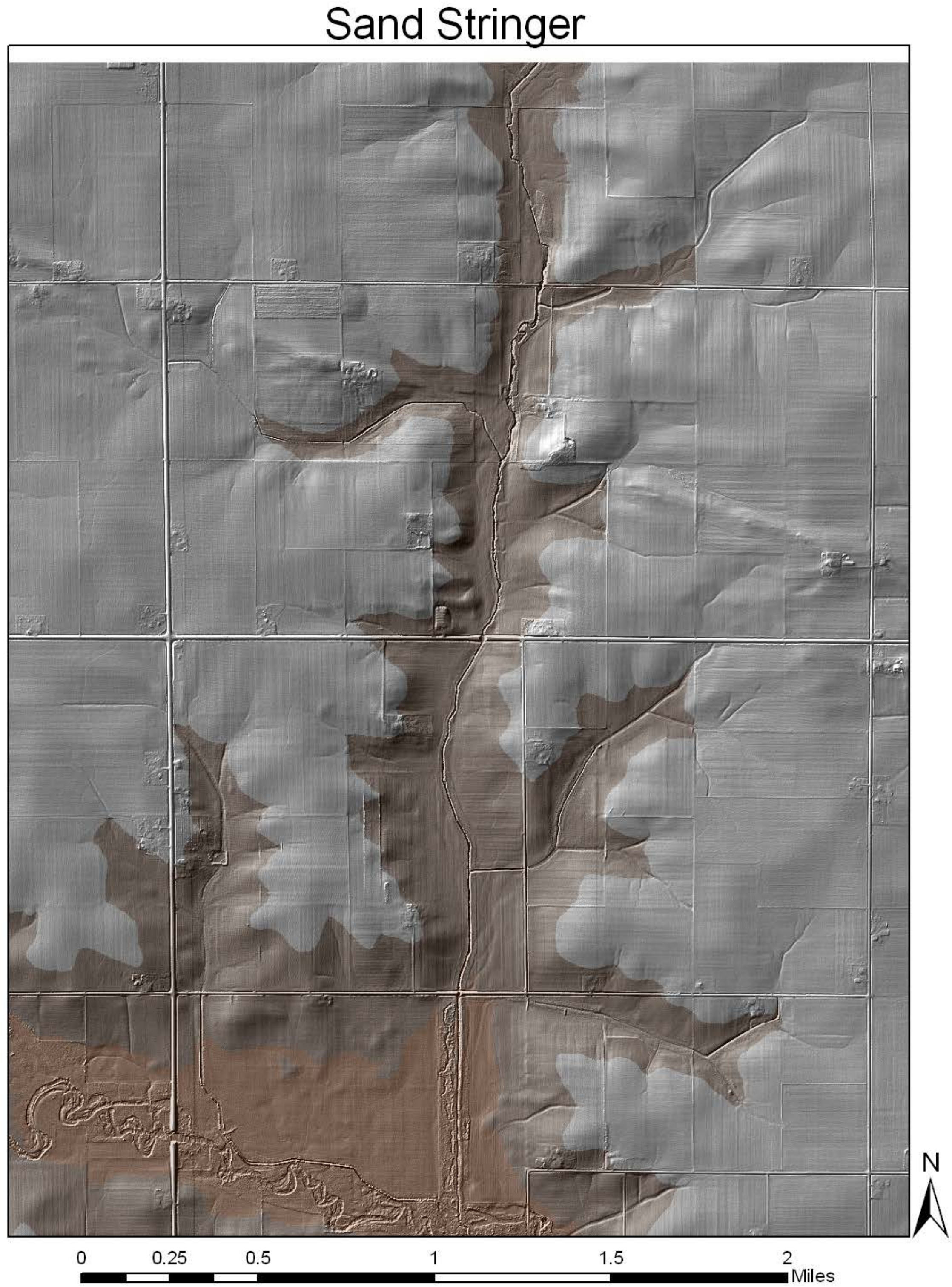

Figure 9. Sand stringer (linear/thin feature) trending northwest to southeast in the Dunkerton Quad.

Sources

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