SUMMARY REPORT OF THE SURFICIAL GEOLOGIC MAP OF FLOYD COUNTY, IOWA

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INTRODUCTION

The 'Surficial Geologic Map of Floyd County, Iowa' represents the final of three phases of surficial mapping in Floyd County. A bedrock geologic map was also produced as part of this mapping project (Liu et al., 2018). The Floyd County map covers an area from 42° 54' to 43° 14' N latitude and 93° 02' to 92° 33' W longitude. Floyd County is located in north-central Iowa on the Wisconsin-age Iowan Surface (IS) landform region (Prior, 1976; Prior and Kohrt, 2006). The map area is dominated by unnamed loamy sediments (IS materials) of variable thickness overlying Wisconsin-age Sheldon Creek Formation glacial sediments, Pre-Illinoian age glacial sediments, or shallow rock. Significant areas of bedrock outcrop or areas with less than 5 m (16 ft) of loamy material over bedrock are present, especially along Flood Creek, the Cedar and Shell Rock rivers and their tributaries, and portions of Burr Oak Creek and the Little Cedar River. Alluvial sediments including outwash sand and gravel and finer grained alluvium are present in the valleys. The thickness of Quaternary deposits in Floyd County is highly variable as they are typically less than 15 m (50 ft) in the western part of the county and reach a maximum thickness of 90 m (295 ft) in a bedrock valley on the eastern side of Floyd County.

Issues arising from interactions between surficial materials and bedrock aquifers have been repeatedly investigated in Floyd County (Buchmiller et al., 1985; Libra et al., 1984; Libra et al., 1985). These studies highlighted the significance of understanding the complicated relationship between shallow rock areas that are prone to karstification and unconsolidated materials. Statewide bedrock geologic maps by Hershey (1969), and most recently by Witzke and others (2010), illustrate the improved understanding of the complex distribution of geologic units at the bedrock surface across north-central Iowa, including Floyd County. Previous surficial geologic mapping completed as part of the STATEMAP program in Floyd County includes the Surficial Geologic Map of the Orchard Quadrangle (Kerr et al., 2016), the Surficial Geologic Map of the Charles City Quadrangle (Streeter et al., 2016), the Surficial Geologic Map of the Greene Quadrangle (Kerr et al., 2017a), and the Surficial Geologic Map of the Colwell Quadrangle (Kerr et al., 2017b). Mapping adjacent to the project area includes the Surficial Geology of Worth County, Iowa (Quade et al., 2012), the Surficial Geology of Cerro Gordo County, Iowa (Tassier-Surine et al., 2015), and the Surficial Geologic Map of Mitchell County (Tassier-Surine et al., 2016).

PURPOSE

Detailed geologic mapping of Floyd County was completed as part of the Iowa Geological Survey's (IGS) ongoing participation in the United States Geological Survey (USGS) STATEMAP Program. Mapping in Floyd County was produced as part of the IGS Impaired Watershed mapping initiative and provides comprehensive surficial and bedrock geologic information. These maps are the basis for further development of derivative datasets and map products for use by local, county and state decision-makers. In recent years, Iowa's State Mapping Advisory Committee (SMAC) has recommended mapping in areas with environmental concerns related to groundwater quality and land-use planning issues, and/or in rapidly developing areas. The IGS and SMAC recognize the need for maps of varying scales to address the complex environmental issues facing urban and rural Iowans. Mapping in Floyd County provides much needed geologic maps in the Upper Cedar River watershed. The basin has been the subject of water quality projects in the past, but there was a renewed focus on the Cedar River following catastrophic flooding in 2008. Many new partners are concentrating efforts on water supply, water quantity and quality, land-use planning, and flood protection studies. Geologic mapping is crucial and foundational for many of these studies, and

the project enjoys broad support from the Upper Cedar Watershed Management Improvement Authority (UCWMIA) and the Cedar River Watershed Coalition (CRWC).

Bedrock mapping efforts were successful in subdividing the Devonian mapping units used by Witzke and others (2010) into formations and in better identifying Cretaceous outliers. From a Quaternary perspective, characterizing and identifying the extent of the middle Wisconsin Sheldon Creek Formation is a fundamental question, as this unit extends much farther east than was previously mapped. The mapping location also includes the Cedar and Shell Rock rivers, which carried outwash from the Des Moines Lobe glacial advance, and has helped to further identify and characterize sand and gravel resources associated with glacial outwash plains and channels. A more refined knowledge of both bedrock topography and bedrock geology provides an important bedrock perspective within this region that has significant shallow bedrock and karst terrain. The Quaternary IS materials are highly variable and poorly consolidated, and therefore do not provide good groundwater quality protection in shallow rock areas. It is necessary to identify areas of either better consolidated Quaternary materials or bedrock aquitards. Combining the bedrock and surficial map information is allowing stakeholders to address key questions related to shallow rock areas, karst issues, aggregate resource potential and protection, and groundwater vulnerability, while achieving the evolving goals of the watershed management plans.

QUATERNARY HISTORY AND REGIONAL SETTING

The map area has a rich and complex Quaternary geologic history punctuated by at least seven periods of glaciation between 2.6 million to 500,000 years ago. Early researchers believed there were only two episodes of Pre-Illinoian glaciation in Iowa. Later regional studies determined that at least seven episodes of Pre-Illinoian glaciation had occurred and led to the abandonment of the classic glacial and interglacial terminology: Kansan, Aftonian and Nebraskan (Boellstorff, 1978a,b; Hallberg, 1980, 1986). Hallberg (1980, 1986) undertook a regional scale project in east-central Iowa that involved detailed outcrop and subsurface investigations, including extensive laboratory work and synthesis of previous studies. Hallberg's study marked a shift from the use of time-stratigraphic terms and resulted in the development of a lithostratigraphic framework for Pre-Illinoian till. In east-central Iowa, Hallberg (1980) formally classified the units into two formations primarily on the basis of differences in clay mineralogy: the Alburnett Formation (several undifferentiated members) and the younger Wolf Creek Formation (including the Winthrop, Aurora and Hickory Hills members). Both formations are composed predominantly of till deposits, but other materials are present. Paleosols are formed in the upper part of these till units. Following the Pre-Illinoian glaciations, several episodes of landscape development resulted in the formation of an integrated drainage network, slope evolution and soil development on stable land surfaces (Bettis, 1989).

In north-central Iowa, the highly eroded and dissected Pre-Illinoian upland is overlain by much younger Wisconsin-age glacial sediments. During the Middle Wisconsin, ice advances dating from approximately 46,000 and 29,000 years before present were deposited throughout the map area. In Iowa, this glacial deposit is formally recognized as the Sheldon Creek Formation (Bettis et al., 1996; Bettis, 1997), and in earlier literature is referred to as the "Tazewell till" (Ruhe, 1950). These sediments are typically buried by loamy erosional sediments associated with the IS. The most recent glacial advance of the Des Moines Lobe did not extend into Floyd County, but its influence is evident in the development of river valleys and periglacial alteration of the landforms.

Results from this mapping project and others in Cerro Gordo, Mitchell, and Worth counties indicate that the Sheldon Creek glacial materials extend much farther east than were previously mapped. The ice marginal position in Floyd County is based on numerous factors due to the lack of moraines. The Little

Cedar River, in the northern part of the county, is thought to represent an ice marginal position due to the geometry of the river not following the regional pattern of NW to SE drainage. Near the town of Colwell, the Little Cedar resumes the general parallel pattern of the rivers beyond the margin. The first order stream density, a rough estimate for relative ages of surfaces, shows a significantly different pattern to the east and west of the boundary. The density of these drainages, measured by the ratio of first order streams to area, is nearly twice that on the eastern surface when compared to the western portion indicating a longer time of drainage development and therefore an older surface. Another factor in delineating the boundary is the presence of extensive sand bodies. These deposits, especially around Flood Creek, could represent outwash deposits associated with the margin of the Sheldon Creek or colluvial deposits relating to the downcutting of the IS. Erosional remnants and outliers associated with the formation of the IS, as well as the presence of sand bodies overlain by weathered till, make it difficult to absolutely differentiate stratigraphic units and complicate establishing an exact ice-marginal (moraine) position. When compared with Pre-Illinoian tills exposed elsewhere on the IS landform region, the Sheldon Creek till is generally less dense and contains less clay in the matrix. The surface of the Pre-Illinoian in Floyd County has a significant pedogenic carbonate accumulation in certain locations. These horizons are generally 1 to 2 m (3-6 ft) thick and contain large nodules and can have a complete cementation of the matrix. This feature was not seen in the Sheldon Creek Fm weathering profile. Twenty-nine new core holes helped to characterize and delineate the boundary of the Sheldon Creek Formation.

Following the deposition of Sheldon Creek materials, a period of intense cold occurred during the Wisconsin full glacial episode from 21,000 to 16,500 years ago (Bettis, 1989). This cold episode and ensuing upland erosion led to the development of the distinctive landform recognized as the IS (Prior, 1976). The depositional history of the IS was under great debate for an extended period of time. Early researchers believed the IS was a separate glaciation occurring sometime between the Illinois and Wisconsin episodes. Later work disproved this idea and determined that erosional processes controlled the landscape development (Ruhe et al., 1968). Hallberg and others (1978) revisited the “Iowan Erosion Surface” to further research the mechanisms behind the formation of the erosion surfaceand to illustrate the need for continued study of this landform region. The IS boundary was further refined by Prior and Kohrt (2006) utilizing higher resolution topographic information and slope classification.

A periglacial environment prevailed during this period with intensive freeze-thaw action, solifluction, strong winds, and a host of other periglacial processes (Walters, 1996). As a result, surface soils were removed from the IS and the Sheldon Creek and Pre-Illinois till surfaces were significantly eroded. A regional colluvial lag deposit referred to as a “stone line” developed. Thick packages of stratified loamy and sandy sediments located low in the upland landscape and adjacent to streams are remnants of solifluction lobes associated with the formation of the IS. These materials can be found along the Little Cedar River and its tributaries, along tributaries of the Shell Rock and Cedar rivers, and portions of Flood Creek. Wisconsin age sand and gravel associated with outwash from the Des Moines Lobe glacial advance was also deposited in both the Shell Rock and Cedar River valleys.

Younger sediments may include Peoria Formation eolian deposits and Hudson Episode alluvial sediments. Two loess units were deposited in Iowa between 30,000 and 12,000 years ago (Bettis, 1989), the older Pisgah Formation and the younger Peoria Formation. The Pisgah is thin and includes loess and related slope sediments that have been altered by colluvial hillslope processes, pedogenic and periglacial processes. The unit is characterized by the presence of a weakly developed soil recognized as the Farmdale Geosol. It is not uncommon to see the Farmdale developed throughout the Pisgah and incorporated into the underlying older Sangamon Geosol. Most likely, the Pisgah loess was deposited on the eastern Iowa

landscape from 30,000 to 24,000 years ago (Bettis, 1989). The Pisgah Formation is typically buried by Peoria Formation loess. The Peoria Formation loess accumulated on stable landsurfaces in eastern Iowa from 25,000 to 21,000 years ago. Eolian materials are generally thin (less than 3 m, 10 ft) and are present on either the eastern (downwind) side of the Cedar and Shell Rock rivers or as sand stringers on the uplands between the Cedar and Little Cedar rivers.

Sediment continued to accumulate in stream valleys throughout the Hudson Episode between 14,000 to 11,000 radiocarbon years before present (Bettis et al., 1996). These deposits are part of the Deforest Formation which is subdivided into the Camp Creek, Roberts Creek, Gunder, Corrington, and Woden members. These materials consist of fine grained alluvium, colluvium and pond sediments in steam valleys, on hillslopes, and in closed and semi-closed depressions.

METHODS

Numerous existing sources of geologic information were utilized in the production of the Floyd County surficial and bedrock geologic maps including subsurface information, USDA NRCS soil survey data, aerial photography, DEM's, satellite imagery, landform characteristics, and LiDAR. Where available, engineering borings from public utilities, the Iowa Department of Transportation, and monitoring well records of the USGS were used. Subsurface lithologic and stratigraphic information was mostly derived from analysis of water well cutting samples reposited at the IGS and stored in the IGS online GeoSam database. Over 1,000 public and private wells in GeoSam, including 306 strip logs, were reviewed for lithology, stratigraphy and locational accuracy, and updated where needed. Quaternary mappers used NRCS digitized soils data of Floyd County (Voy, 1995) to assist with delineating areas with loess cover, thin or no loess cover, shallow bedrock, extent of alluvium, and to attempt to differentiate till units and identifiy paleosols. Bedrock mappers also used the digital soil surveys to help delineate areas of shallow rock outcrop prior to field reconnaissance.

New geologic information was obtained from field investigations of 129 outcrops (including 29 quarries) and logging of well cutting samples for 143 unstudied wells totaling 25,852 feet. Quaternary geologists utilized the IGS Giddings truck mounted probe to drill a mix of solid stem and continuous core holes. Twenty-nine drill holes totaling 475 feet were completed during this project year in addition to drill holes from previous years in Floyd County. Samples have been submitted to the Quaternary Materials Lab at the University of Iowa's Earth and Environmental Sciences Department for grain-size analysis. All results are expected by July, 2018. Four organic samples collected near the base of the Sheldon Creek Formation were sent for radiocarbon dating, but returned greater than values. It is thought that the organic material was found in peat bodies that were greater than eight halflives of 14C, and were incorporated in the base of the Sheldon Creek Formation. Other dates from previous projects in the area place the Sheldon Creek Formation in the Middle Wisconsin.

Project geologists combined information from the sources listed above to delineate surficial geologic mapping units at 1:100,000 scale for Floyd County. IGS mappers used ArcGIS and on-screen digitizing techniques developed during previous STATEMAP projects. The final map entitled 'Surficial Geologic Map of Floyd County, Iowa' will be available as a shapefile in the Iowa Department of Natural Resources NRGIS library, as a pdf file on the IGS Publications website, and will be submitted to the USGS National Geologic Map Database. This Summary Report is also available as a PDF file.

STRATIGRAPHIC FRAMEWORK FOR NORTH-CENTRAL IOWA

An important aspect of surficial geologic mapping on the IS is the development of map units that utilize previously established lithostratigraphic frameworks for the Hudson, Wisconsin and Pre-Illinoian deposits in Iowa (Johnson et al., 1997). A stratigraphic framework allows us to better understand the surficial materials of north-central Iowa. Surficial deposits in the map area are composed of seven formations: DeForest, Noah Creek, Peoria, Sheldon Creek, Wolf Creek, and Alburnett formations, as well as unnamed erosion surface sediments. Hudson age deposits associated with fine-grained alluvial, organic, and colluvial sediments include the DeForest Formation which is subdivided into the Camp Creek, Roberts Creek, Gunder, Corrington, and Woden members. The Noah Creek Formation includes coarse sand and gravel associated with outwash from the Des Moines Lobe, as well as coarse to finer grained fluvial deposits associated with local stream and river valleys. Unnamed erosion surface sediments consist of reworked till and slopewash deposits associated with periglacial activity during the Wisconsin ice advance. Areas of Peoria Formation eolian materials are present east of the town of Floyd and intermittently mantle most other mapping units. Sheldon Creek Formation glacial deposits are undifferentiated and occur in northwest and north-central Iowa. In the northwestern portion of the county, the Sheldon Creek Formation is generally the first till sheet encountered, while the Pre-Illinoian is the first in the southeastern half. Pre-Illinoian glacial deposits in Iowa consist of two formations: the younger Wolf Creek Formation and the Alburnett Formation. The Wolf Creek Formation is divided into the Winthrop, Aurora, and Hickory Hills members (oldest to youngest). The Alburnett Formation consists of several “undifferentiated” members.

Five bedrock mapping units (Cretaceous Dakota/Windrow Formation; Devonian Lime Creek, Shell Rock, Lithograph City, and Coralville formations) are exposed at the surface in Floyd County, with the Shell Rock and Lithograph City formations comprising most of the outcrop in the map area. Bedrock outcrops occur along most rivers and creeks in the western half of the county and occasionally along the Little Cedar River. The Devonian rocks are dominated by carbonates varying between limestone and dolomite, accompanied with minor shale. The Cretaceous Dakota/Windrow Formation is characterized as a reddish shaly sandstone with siderite pellets.

DESCRIPTION OF LANDFORM SEDIMENT ASSEMBLAGE MAP UNITS

Recent studies and mapping indicate that the map area encompasses a complex suite of depositional landforms and sediment sequences related to glaciations, alluviation, subaerial erosion, and wind-blown transport. To map diverse landscapes at 1:100,000 scale, we have selected the most comprehensive mapping strategy- a landform sediment assemblage (LSA) approach. Various landforms are the result of specific processes at work in the geologic system. Landforms typically have similar relief, stratigraphic and sedimentologic characteristics. Recognition of the genetic relationship among landforms and their underlying sediment sequences allows one to generalize and map complex glacial terrains over areas of large extent (Sugden and John, 1976; Eyles and Menzies, 1983). Bettis and others (1999) found that LSA mapping concepts were extremely useful in overcoming the difficulties of mapping in large valleys and noted that LSA's provided a unique opportunity to associate landforms with their underlying sediment packages. Sixteen landform sediment assemblage units were identified in the map area utilizing aerial imagery, topographic expression, digitized soils, and existing and new subsurface geologic boring information. The following is a description of each landform sediment assemblage listed in order of episode:

HUDSON EPISODE

Qal - 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 hillslopes and in closed depressions. May overlie the Noah Creek, Sheldon Creek, Wolf Creek/Alburnett formations, or fractured Devonian and Cretaceous 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.

Qalb - Alluvium Shallow to Bedrock (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 hillslopes and in closed depressions. May overlie the Noah Creek, Sheldon Creek, Wolf Creek/Alburnett formations, or fractured Devonian and Cretaceous bedrock. Bedrock surface is within 5 m (16 ft) of the land surface. 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.

Qallt - Low Terrace (DeForest Formation - Camp Creek and Roberts Creek members) - 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. Overlies the Noah Creek Fm. or Devonian bedrock. Occupies the lowest position on the floodplain, i.e. modern channel belts in the Shell Rock, Cedar, and Little Cedar river valleys. Seasonal high water table and frequent flooding potential.

Qali-ht –Intermediate to High Terrace (DeForest Formation - Camp Creek, Roberts Creek, and Gunder members) - Variable thickness of less than 1 m to 5 m (3-16 ft) of very dark gray to brown, noncalcareous, stratified silty clay loam to loam that overlies the Noah Creek Formation or Devonain bedrock. Occupies the intermediate to high terrace position in the Shell Rock, Cedar, and Little Cedar river valleys. Seasonal high water table and low to moderate flooding potential.

HUDSON and WISCONSIN EPISODE

Qe - Sand Dunes and Sand Sheets (Peoria Formation - sand facies) - Generally less than 3 m (10 ft) of yellowish brown, massive, calcareous loamy sand to fine sand. It occurs as sand stringers or dunes overlying Wisconsin aged outwash, unnamed erosion surface loamy sediments, or bedrock.

Qnw2 - Sand and Gravel (Noah Creek Formation) - 2 to 12 m (7-40 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. Along many valleys, 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. This unit encompasses deposits that accumulated in low-relief stream valleys during the Wisconsin and Hudson episodes.

WISCONSIN EPISODE

Qps1 - Loess and Intercalated Eolian Sand (Peoria Formation- silt facies) - Generally 2 to 5 m (7-16 ft) of yellowish brown to gray, massive, fractured, noncalcareous grading downward to calcareous, silt loam and intercalated fine to medium, well sorted, sand. Overlies massive, fractured, loamy glacial till of the Sheldon Creek, Wolf Creek or Alburnett formations with or without the intervening clayey Farmdale/Sangamon Geosol. This unit is found mainly to the east of the Cedar River.

Qnw - Sand and Gravel (Noah Creek Formation) - Up to 20 m (66 ft) of yellowish brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel. In the map area this unit usually overlies Devonian carbonate, but may overlie diamicton of the Sheldon Creek, Wolf Creek or Alburnett formations in isolated areas. This unit encompasses outwash deposits that accumulated in valleys during the Wisconsin Episode in the Cedar River.

Qnw T2 - Sand and Gravel (Noah Creek Formation) - Up to 10 m (33 ft) of yellowish brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel. In the map area this unit usually overlies Devonian carbonate bedrock, but may overlie Pre-Illinois Episode diamicton of the Sheldon Creek, Wolf Creek or Alburnett formations in isolated areas. This unit encompasses outwash deposits that accumulated in valleys during the Wisconsin Episode in the Shell Rock River Valley. This unit represents the younger, lower terrace and generally sits 7 m (23 ft) above the modern channel.

Qnw T1 - Sand and Gravel (Noah Creek Formation) - Up to 17 m (56 ft) of yellowish brown to gray, poorly to well sorted, massive to well stratified, coarse to fine feldspathic quartz sand, pebbly sand and gravel. In the map area this unit usually overlies Devonian carbonate bedrock, but may overlie diamicton of the Sheldon Creek, Wolf Creek or Alburnett formations in isolated areas. This unit encompasses outwash deposits that accumulated in valleys during the Wisconsin Episode in the Shell Rock River Valley. This unit represents the older, higher terrace and generally sits 3 m (10 ft) above the lower terrace and 10 m (33 ft) above the modern channel.

Qnw3 - 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 2 m (7 ft) of silty alluvial sediments. In places mantled with fine to medium well-sorted feldspathic quartz sand derived from wind reworking of the alluvium. Bedrock is less than 5 m (16 ft) below the land surface.

Qsc2 - Loamy Sediments Shallow to Glacial Till (Unnamed erosion surface sediment) - 1 to 6 m (3-20 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 1 m (3 ft) of Peoria Formation (silt or sand facies). Formed in and often overlies massive, fractured, slightly firm glacial till of the Sheldon Creek Formation. This unit is absent in southeastern portion of Floyd County.

Qsc - Glacial Till (Sheldon Creek Formation - Undifferentiated) - Generally 3 to 15 m (10-49 ft) of yellowish brown to gray, calcareous, fractured to massive clay loam; at depth this unit can be variably textured and contain significant sand and gravel bodies with a thickness generally ranging from 2 to 8 m (7-26 ft). The upper 3 to 6 m (10-20 ft) may be periglacially altered. This unit overlies Pre-Illinois diamicton, Devonian carbonate bedrock or Cretaceous sandstone and mudstone and is only shown on the cross-section. This unit is absent in southeastern portion of Floyd County.

Qwa2 - Loamy Sediments Shallow to Glacial Till (Unnamed erosion surface sediment) - 1 to 6 m (3-20 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 1 m (3 ft) of Peoria Formation (silt or sand facies). Overlies massive, fractured, slightly firm glacial till of the Wolf Creek or Alburnett formations in the eastern and southeastern portions of Floyd County.

PRE-ILLINOIS EPISODE

Qwa3 - Glacial Till (Wolf Creek or Alburnett formations) - Generally 3 to 15 m (10-50 ft) but can be more than 90 m thick (295 ft) within the bedrock valley in the eastern part of the mapping area. This

mapping unit consists of very dense, massive, fractured, clay loam glacial till of the Wolf Creek or Alburnett formations. This mapping unit can be overlain by unnamed erosion surface sediments, outwash, alluvium or younger glacial sediments (Sheldon Creek Fm) in the western portion of the mapping area. This unit is shown only on the cross-section.

Qbr - Loamy Sediments Shallow to Dolomite, Limestone, Shale and Sandstone (DeForest, Noah Creek, Peoria, Sheldon Creek, Wolf Creek and Alburnett formations) - 1 to 2 m (3-7 ft) of yellowish brown to gray, massive to weakly stratified, well to poorly sorted loamy, sandy and silty sediments that overlie the Devonian or Cretaceous bedrock surface. All areas of bedrock outcrop or shallow to bedrock soils are shown in red on the map, regardless of the bedrock mapping unit. Bedrock units are only shown on the cross-section and may be identified on the bedrock map of the Floyd County with the following descriptions:

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