

# **TECHNICAL REPORT**

Surficial Geology of the Cass County Portions of the  
Sumnerville & Sister Lakes 7.5 Minute Quadrangles, Cass County, Michigan

Agreement Number G17AC00278



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Cartography/GIS: John M. Esch

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## **Abstract**

Surficial geologic mapping of the Surficial Geology of the Cass County Portions of the Sumnerville & Sister Lakes 7.5 Minute Quadrangles located in Cass County, Michigan was completed by the Michigan Geological Survey. The map area is located within the Lake Michigan Lobe deposits of the Laurentide Ice Sheet. Two large morainic uplands in the area have been traditionally described and the Kalamazoo Morainic complex to the east and the Valparaiso Moraine to the west. Glacial Lake Dowagiac which was a major glacial meltwater sluiceway between these two uplands runs diagonally through the map area. Significant sand and gravel mining operations occur within the mapped area. Gravel is at or near the surface over large portions of the mapped area. Significant additional sand and gravel deposits may potentially occur in these deposits. A number of unmapped sand dunes and ice-walled lakes plains were mapped during this investigation. A very deep bedrock valley with over 800 feet of glacial drift has been discovered by this investigation. This is the thickest drift in the southern half of the lower peninsula of Michigan.

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## **Acknowledgements**

Michigan Geological Survey appreciates the help of Joseph Sherer, Phillip Crawford, Eldon Paustian, and John Gleason for granting permission to their properties and Ed Everett, Todd Fenster, and Katz Drilling for supplying data from other deep borings in the area.

Funding for the field work and preparation of this map was provided by United States Geological Survey, National Cooperative Geologic Mapping Program, Great Lakes Geologic Mapping Coalition Grant Cooperative Agreement award number G17AC00278.

# **Technical Report**

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## **Introduction**

In Oct. 2011, the Michigan State Legislature transferred responsibility for applied geological research and geological mapping within the state to the Michigan Geological Survey (MGS), which was created by this act within the Geosciences Dept. at Western Michigan University. The Geological Survey Division of the Michigan Dept. of Environmental Quality (MDEQ), which previously conducted geologic mapping, was renamed the Office of Oil, Gas, and Minerals.

This quadrangle was part of a larger project initiated by MGS in Cass County under the USGS STATEMAP program and Great Lakes Geologic Mapping Coalition, composed of eight state geological surveys and USGS and this product was produced through the National Cooperative Geologic Mapping Program, STATEMAP.

## **Location and Geologic Setting**

The surficial geology of the western portions of the Sumnerville and Sister Lakes Quadrangles were recently mapped by the USGS as part of their Berrien County project (Stone, et al, 2017) and the northern part of Sister Lakes quad was mapped as part of an earlier Van Buren County mapping project (Kehew, et al, 2002). The Cass County portions of the Sumnerville and Sister Lakes Quadrangles, which were mapped as part of the larger Cass County project area, are underlain by unconsolidated deposits of glacial and post-glacial origin from the Saginaw and Lake Michigan Lobes (Leverett and Taylor 1915) of the Laurentide Ice Sheet. Kehew et al. (2012) describe the regional sediment-landform associations of the Saginaw Lobe and Kehew et al. (2005) discuss the dynamics of the Lake Michigan Lobe. The sediments include diamicton (till), sand and gravel and interbedded silt and clay. Till is a characteristic type of glacial deposit that is unsorted and has a range of grain sizes from clay to boulders. The glacial deposits are late Wisconsinan (~30,000 to ~15,000 yrs. before present) in age, although some deeply buried deposits may be Illinoian or older (Winters and Rieck 1982).

The Lake Michigan Lobe deposited two large morainic uplands in the area that have been traditionally described and the Kalamazoo Morainic complex to the east and the Valparaiso Moraine to the west. The higher elevation portions in the NW corner of the map area have been previously been mapped as the Valparaiso Moraine from earlier statewide mapping effort (Leverett and Taylor, 1915; Martin, 1955; Farrand and Bell, 1982). Recent mapping by Stone and others have extended the Kalamazoo Moraine significantly further west with several ice marginal position immediately west of the mapped area in Berrien County (Stone, et al, 2017) The NE trending, slightly elevated topography in the SE part of the Sumnerville quad has traditionally mapped as the inner Kalamazoo Moraine.

## **Purpose and Justification**

The mission of the National Cooperative Geologic Mapping Program (NCGMP) includes mapping the surficial geology in the high priority areas of Michigan and the adjoining glacial states. This project is within one of the Michigan high priority areas. This task fulfills the mapping priorities of

the NCGMP by providing these previously unavailable detailed surficial geologic map products to the public within these priority areas and it will deliver scientific information in formats readily usable by public policymakers. It also supports sustainable development of resources and understanding of environmental issues. Cass County includes portions of the Kalamazoo Moraine of the Lake Michigan Lobe in the western part of the county transitioning to the east into Saginaw Lobe terrain. Detailed mapping began in 2015 in this area and will incorporate subsurface information from drilling and review of subsurface data in developing a projected 3D mapping network. This project will also contribute to the effort to develop a Quaternary stratigraphic framework for the Lake Michigan and Saginaw Lobes.

Cass County lies just south and east of I-94, the major interstate connecting Chicago and Detroit. This project fits well with Michigan's long-range plan of mapping around development corridors and to consolidate areas where mapping has already been done. Berrien County to the west has been mapped by the U.S.G.S. and St. Joseph and Van Buren Counties to the east and north, respectively, have been mapped by the Michigan Geological Survey.

One of the most pressing and significant scientific problems in Michigan is management of groundwater resources using the Michigan Water Withdrawal Assessment Tool (MI-WWAT). Every new high capacity well (>70 gal per min) must be permitted using this tool, which is based on modeling of stream flow response from water withdrawals from aquifers connected to streams and aquatic ecosystems. Wells that are predicted to produce an adverse response by the tool then must proceed to and pass the site-specific review (SSR) process, in which owners must submit site specific drilling and hydrogeologic data. For areas utilizing aquifers in glacial deposits, the SSR currently uses the statewide Quaternary geology map (Ferrand, 1982), which is highly generalized and outdated. Detailed surficial geologic maps and more accurate subsurface data (relative to water well logs which are currently used) are urgently needed. These maps make a huge contribution to the accuracy of the MI-WWAT process where they are available. Cass County is in the southwest part of the state, in which the demand for new irrigation wells is the highest in the state.

There are several objectives to this project in sequential order, namely:

- To produce surficial geological maps in a high priority area having complex geology with little available public domain surficial and subsurface geological data and incorporate this data into a 3D format for a more comprehensive understanding of the geologic setting.
- Make these maps available to the geological community, groundwater management staff of MDEQ, engineering firms, aggregate industry, water supply industry, researchers, teachers, and to the public.
- To complete the detailed mapping in Cass County.
- To map the interlobate area between the Lake Michigan and Saginaw Lobes. New subsurface data will be used for correlation with deep boreholes in Saginaw Lobe deposits

in Barry County to the north and in Kalamazoo and St. Joseph Counties to the northeast and east, respectively. The Lake Michigan Lobe portion of the county will be correlated with borings in Van Buren County to the north. The goal is to develop a regional stratigraphic framework for the Wisconsin deposits of both lobes, which can be tested against future borings.

- To delineate the occurrence and stratigraphy of aquifers and sand and gravel deposits, the abundance of which are not known in this and adjoining quads. This project will provide support for the proposed aquifer study and modeling project being implemented by a coalition composed of MDEQ and private Cass County entities.

## **Methods and Personnel**

Surficial geologic maps are produced by field investigation of surficial materials observed in natural exposures, road and stream cuts, building and construction excavations, shallow hand-augered borings, and small pits dug by the investigators. Depth of investigation is generally around 6 feet except in areas of greater exposure like deep cuts and gravel pits. In addition, aerial photographs, topographic maps, digital elevation models (DEMs), county soil surveys, existing geologic maps, reports, and the geologic literature for the area are reviewed. Farmers often provided valuable insight into the soils in the area. LiDAR data, which include high-resolution elevations of the land surface, were available for Cass County and were used to create DEMs. The LiDAR data was a critical tool to allow interpretation of the subtle features like the ice-walled lakes, eskers, and terraces. Without the LiDAR data many of these features would not have been recognized. Subsurface information concerning the thickness, extent, and stratigraphic position of surficial geologic units was obtained to the extent possible by reviewing digital well log data from the MDEQ Wellog and historical scanned water-well log databases.

Gamma-ray logs are made of the borehole at the time of drilling. This method involves measurement of the natural gamma ray content of surficial materials detected as a probe is lowered down and up the borehole within the drill pipe. Clays and other fine-grained materials emit more gamma radiation than sands and gravels and the gamma ray log is compared to the cores for interpretation of the contacts between different types of strata. Geologic cross-sections are created from the digital water well data and a representative cross-section is shown on each map. For mapping projects in areas of thick glacial drift, logs from oil and gas test wells are reviewed.

Due to the limited number of bedrock control points in the quad, a Tromino passive seismic instrument was used at 87 locations and with the addition of 27 oil and gas test wells and other wells to determine the depth to bedrock and the bedrock topography. This technique uses the horizontal -to-vertical spectral ratio (HVSr) method to record ambient seismic noise with 3-component geophones (Lane, et al., 2008). This data is processed and along with a local HVSr calibration curve, a bedrock depth can be estimated at each station. This information can assist in developing a better understanding of groundwater models and the use of 3D maps can present a greater understanding of the subsurface geology. This indirect mapping does not replace drill

holes and logging water well cuttings but can greatly assist the selection of drill holes to capture the greatest thickness of the glacial sequence. This mapping product also is used to map for possible bedrock valleys below the glacial sediments, potential sources of untapped groundwater resources. These derivative maps are then available for others to assist their mapping of subsurface resources.

Primary field mapping of the area was done by John Esch (contract mapper with support from Alan Kehew and John Yellich with the drilling, data compilation and review. GIS input was directed by John Esch.

## **Results for the Cass County Portions of the Sumnerville & Sister Lakes 7.5 Minute Quads**

The Lake Michigan Lobe deposited two large morainic uplands in the area that have been traditionally described and the Kalamazoo Morainic complex to the east and the Valparaiso Moraine to the west. The higher elevation portions in the NW corner of the map area have been previously been mapped as the Valparaiso Moraine from earlier statewide mapping effort (Leverett and Taylor, 1915; Martin, 1955; Farrand and Bell, 1982). Recent mapping by Stone and others have extended the Kalamazoo Moraine significantly further west with several ice marginal position immediately west of the mapped area in Berrien County (Stone, et al, 2017) The NE trending, slightly elevated topography in the SE part of the Sumnerville quad has traditionally mapped as the inner Kalamazoo Moraine.

Land surface elevation ranges from 690 feet to 870 feet above mean sea level across the mapped area with an average elevation of 760 feet. The most prominent glacial landform in the area is the broad valley of the Dowagiac River which was occupied at times by glacial Lake Dowagiac and served as a major southwesterly flowing sluiceway for glacial meltwater in the area. A few streamlined features along the sluiceway are evidence of the large volumes of water that flowed through the valley. An erosional scarp at an elevation of approximately 790 feet amsl occurs only on the east side of the valley. The broad relatively flat uplands to the NW of the Dowagiac Valley are mostly Qsg1, and appear to be extensions of ice-marginal deltaic deposits (Fairland ice-marginal deltaic deposits, Keeler ice-marginal deltaic deposits, and Cushing ice-marginal deltaic deposits) mapped by the USGS immediately to west in Berrien County (Stone, et al, 2017).

The areas of outwash mapped as Qsg2 are irregular sand and gravel deposits that lack a distinct fan shape. They are also very hummocky, which suggests that they were deposited on discontinuous masses of stagnant ice which melted out and collapsed to form the high relief hummocks and depressions. There are many places mapped as Qsg2, and especially Qsg1, with a significantly pitted surface. In addition, there are also many kettles in areas mapped as Qsg1. Several prairies with mollisol soil types occur across Cass County; a prominent one called the Pokagon Prairie occurs in section 32 of T6S, R16W and another in section 29. A few ice-walled lake plains (Qiw) are mapped mostly using LiDAR in uplands in the NE and SW part of the map area. Generally flat topped, these landforms represent the formation of a short-lived lake that existed while stagnant and partially buried glacial ice was still in the area. Stagnant ice masses formed the

boundary of the lake and left the flat-topped lake deposits of sand to clay size material in a relatively high position on the landscape. Numerous sand dunes (Qsd) were mapped across the project area and, in addition, loess deposits have been reported in the map area (Luehmann, et al., 2016), but no obvious loess exposures were noted in this investigation. An inferred NW-SE oriented tunnel valley occurs in the Sister Lakes area and extends to the SE toward the Dowagiac River lowland. This tunnel valley may be an extension of a major tunnel valley that continues SE on the other side of the Dowagiac River valley. The exact ages of the glacial deposits have not been determined in the study area but are correlated to dated features elsewhere. Some recent optically stimulated luminescence (OSL) dates suggest that the Kalamazoo Moraine of the Saginaw Lobe in Calhoun County, which lies northeast of the Vandalia Quadrangle, was probably formed about 19,000 years ago (Kehew and Esch, unpublished). Six samples were collected for OSL dating as part of this map project. Three of them are plotted on the map as CASS-OSL-18-01, CASS-OSL-18-02, and CASS-OSL-18-03 and one designated as VB-OSL-18-01 is just 1/2 mile north of the NW corner of the map. Results were not available at the time of map publication.

A boring using the mud-rotary drilling methods was drilled as part of this mapping project (CAS-18-03) to a depth of 257 feet. Gamma-ray and single point resistance logs were runs in the mud filed hole at total depth. This boring encountered 37 feet of coarse gravel and sand from 0-37 feet resulting in significant lost-circulation problems and hole stabilization problems. This was followed by a diamicton from 37-64 feet, a sand and gravel from 64-88, another diamicton from 88-107, and a thick sand and gravel from 107-195 feet. A very hard diamicton with a series of thin 4-5 feet thick sand units was encountered from 195 to 257 feet.

Bedrock of Mississippian Coldwater Shale underlies the northeastern two-thirds of Cass County. A distinctive reddish colored informal marker bed, the Coldwater Redrock, occurs at or near the base of the Coldwater Shale. The underlying Ellsworth Shale forms the bedrock surface in the southwestern one-third of the county. Its, often tabular to rectangular clasts and cobbles with a distinctive light green color are common in the drift in the SW part of Cass County. These formations dip to the northeast toward the center of the Michigan Basin. Within the current mapped area, the Coldwater Shale is the bedrock subcrop in underlying NE part and the Ellsworth Shale subcrop in the SW. The Upper Devonian Antrim Shale likely subcrops at the bottom of a deep bedrock valley (see below). The bedrock surface ranges from approximately 10 feet below sea level at the bottom of a deep bedrock valley in the NW part of the mapped area feet to 630 feet above mean sea level. A pronounced buried bedrock valley runs NNW along the west side of the mapped area. Another bedrock valley trending NW intersects the NNW trending bedrock valley. This bedrock valley system is likely an extension of a deep bedrock valley that runs SE-NW across Van Buren County to the north. The NE trending bedrock valley partially underlies an inferred tunnel valley extension to the main tunnel valley to further to the SE. The glacial deposits in the mapped area average 300 feet thick with a range from 106 feet NW of Dowagiac to 830 feet thick over the deep bedrock valley. The 830 feet of glacial drift is the thickest known in the southern half of the Lower Peninsula of Michigan! Significant sand and gravel mining operations occur within the mapped area. Most of the gravel pits are associated with outwash Qsg1 deposits. Significant additional sand and gravel deposits may potentially occur in these deposits. Gravel is at



or near the surface over large portions of the mapped area; this is evidenced by a number of the major soil units with a “gravelly” textural description. The majority of the mapped area is within the Dowagiac River watershed. The northwest corner of the quad is within the St. Joseph River watershed. All the water wells in the quad are screened in glacial drift aquifers. The average depth of water wells in the quad is 83 feet and average water table depth is 20 feet. Most of the land use within the quad is for agriculture. Agricultural irrigation is prevalent across the quad with a significant number of high capacity irrigations wells.

## **Conclusions**

The surficial geological of the Cass County portions of the Sumnerville and Sister Lakes Quadrangles has provided additional new, detailed information on surficial landforms and deposits within the Lake Michigan Lobe in southern Michigan.

Surficial geologic mapping of the Surficial Geology of the Cass County Portions of the Sumnerville & Sister Lakes 7.5 Minute Quadrangles located in Cass County, Michigan was completed by the Michigan Geological Survey. The map area is located within the Lake Michigan Lobe deposits of the Laurentide Ice Sheet. Two large morainic uplands in the area have been traditionally described and the Kalamazoo Morainic complex to the east and the Valparaiso Moraine to the west. Glacial Lake Dowagiac which was a major glacial meltwater sluiceway between these two uplands runs diagonally through the map area. Significant sand and gravel mining operations occur within the mapped area. Gravel is at or near the surface over large portions of the mapped area. Significant additional sand and gravel deposits may potentially occur in these deposits. A number of unmapped sand dunes and ice-walled lakes plains were mapped during this investigation. A very deep bedrock valley with over 800 feet of glacial drift has been discovered by this investigation. This is the thickest drift in the southern half of the lower peninsula of Michigan.

The map produced in this project will be of use for aggregates producers exploring for new deposits, planners, and hydrogeologists in MDEQ who must evaluate permits for high-capacity water wells that now require a permit and must be shown to not deplete streams in the area beyond an amount that will not affect fish populations.

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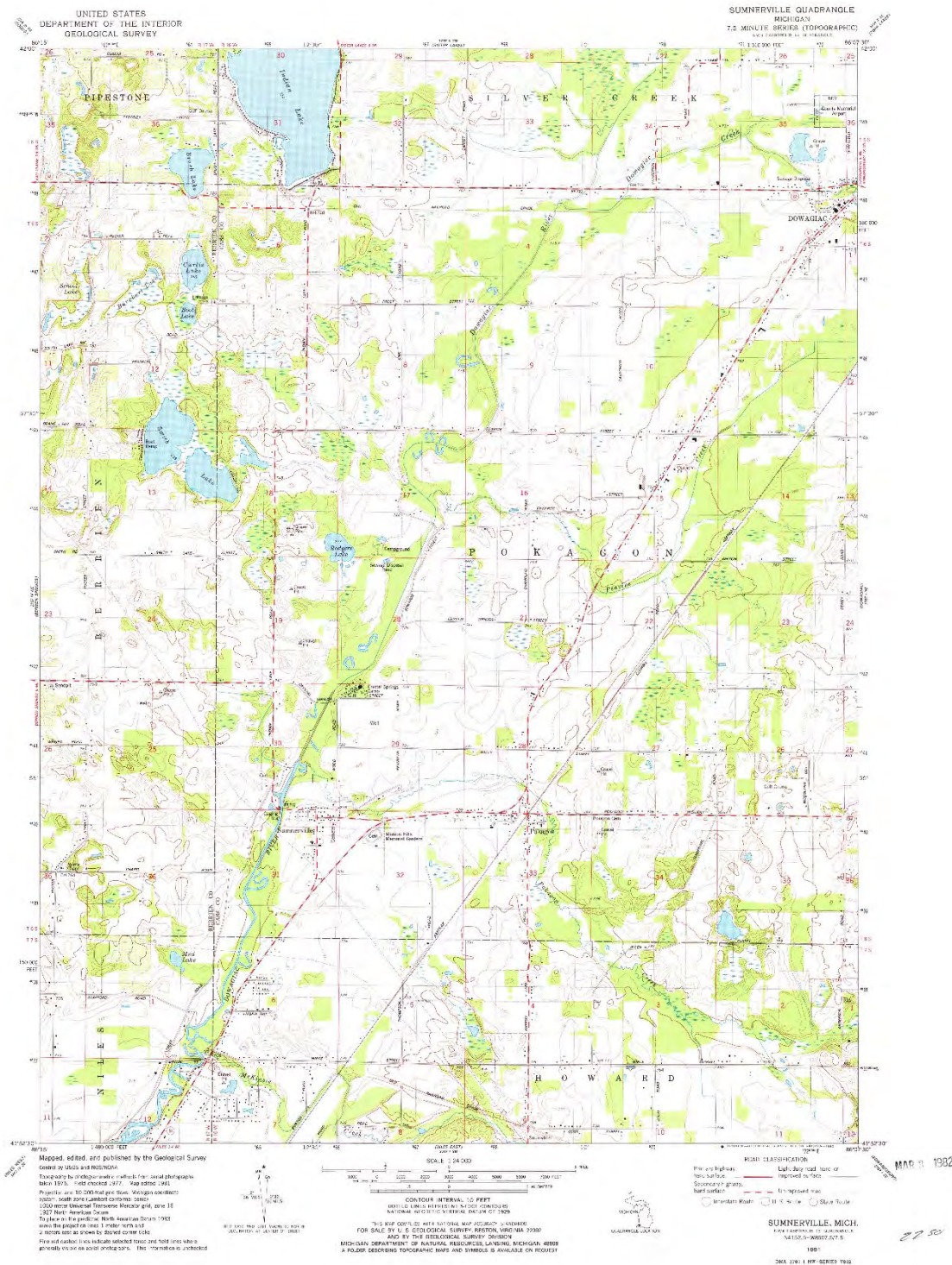
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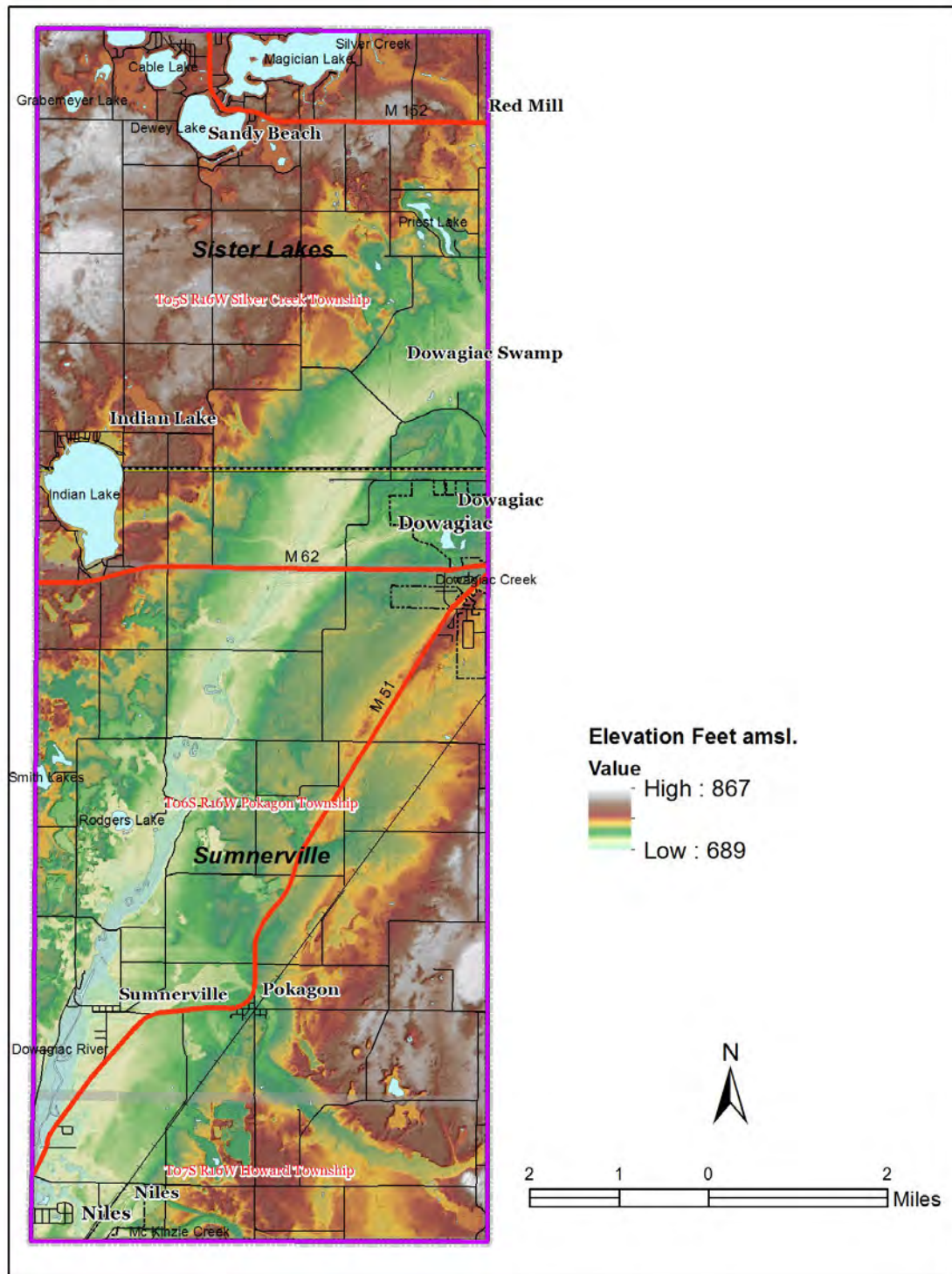
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Figure 2: Sumnerville Topographic Quadrangle



**Figure 3 Sumnerville & Sister Lakes Quads LiDAR Shaded Relief**





**Figure 4: Sumnerville & Sister Lakes Quads LiDAR Hillshade**

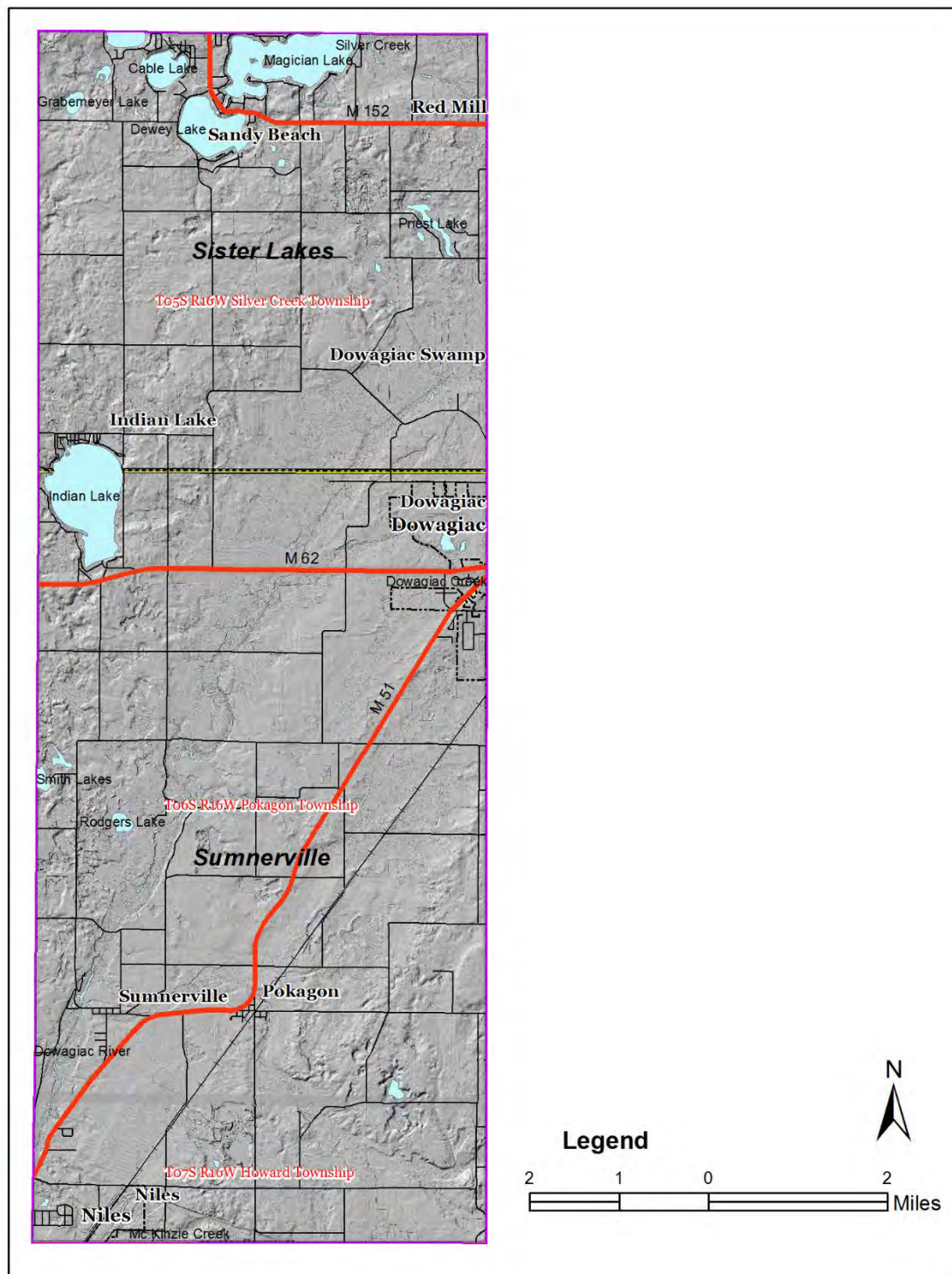
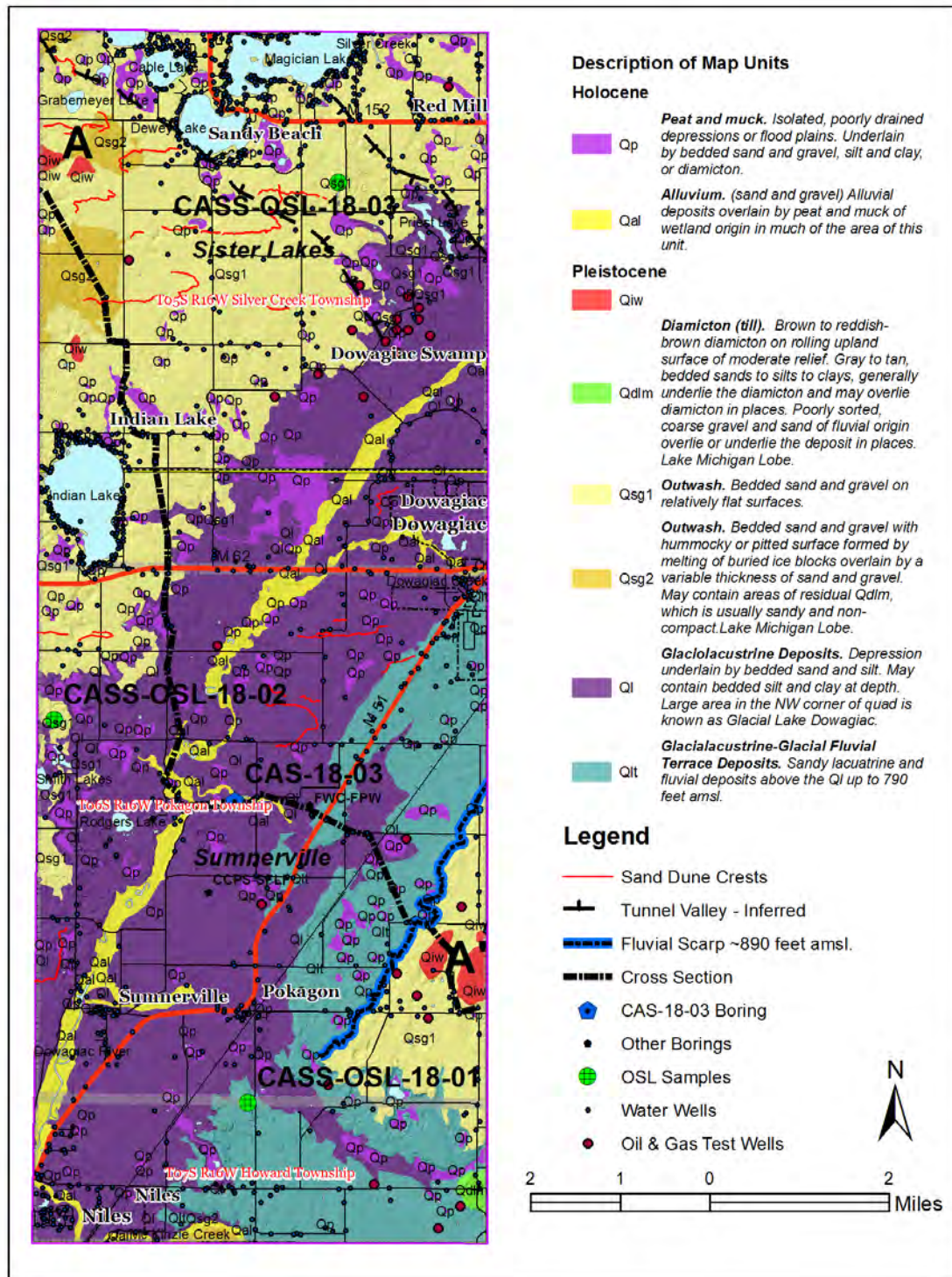
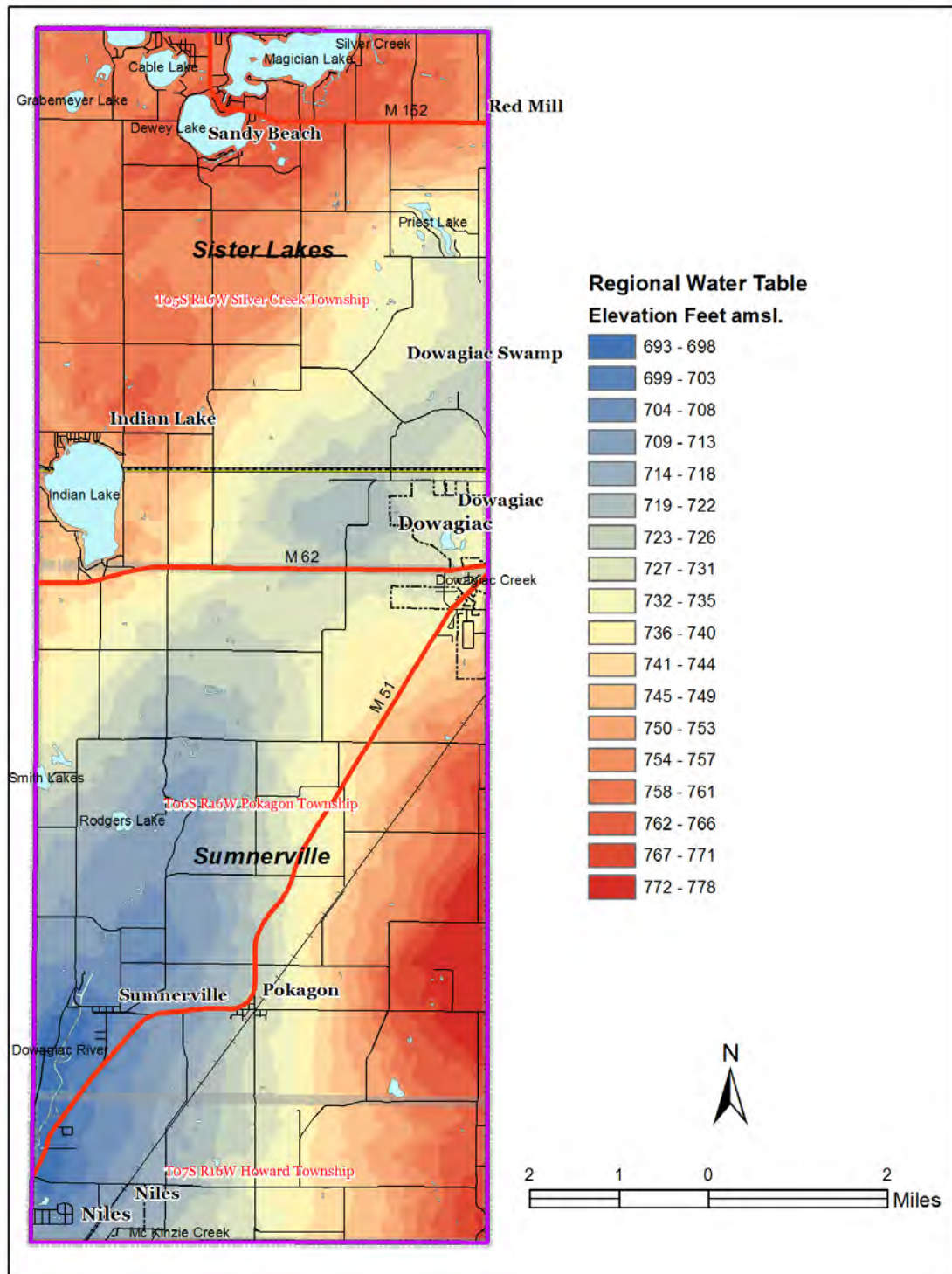


Figure 5 Sumnerville & Sister Lakes Quads Geologic Map





**Figure 6: Sumnerville & Sister Lakes Quads Regional Water Table**



**Figure 7: Boring Log CAS 18-03**

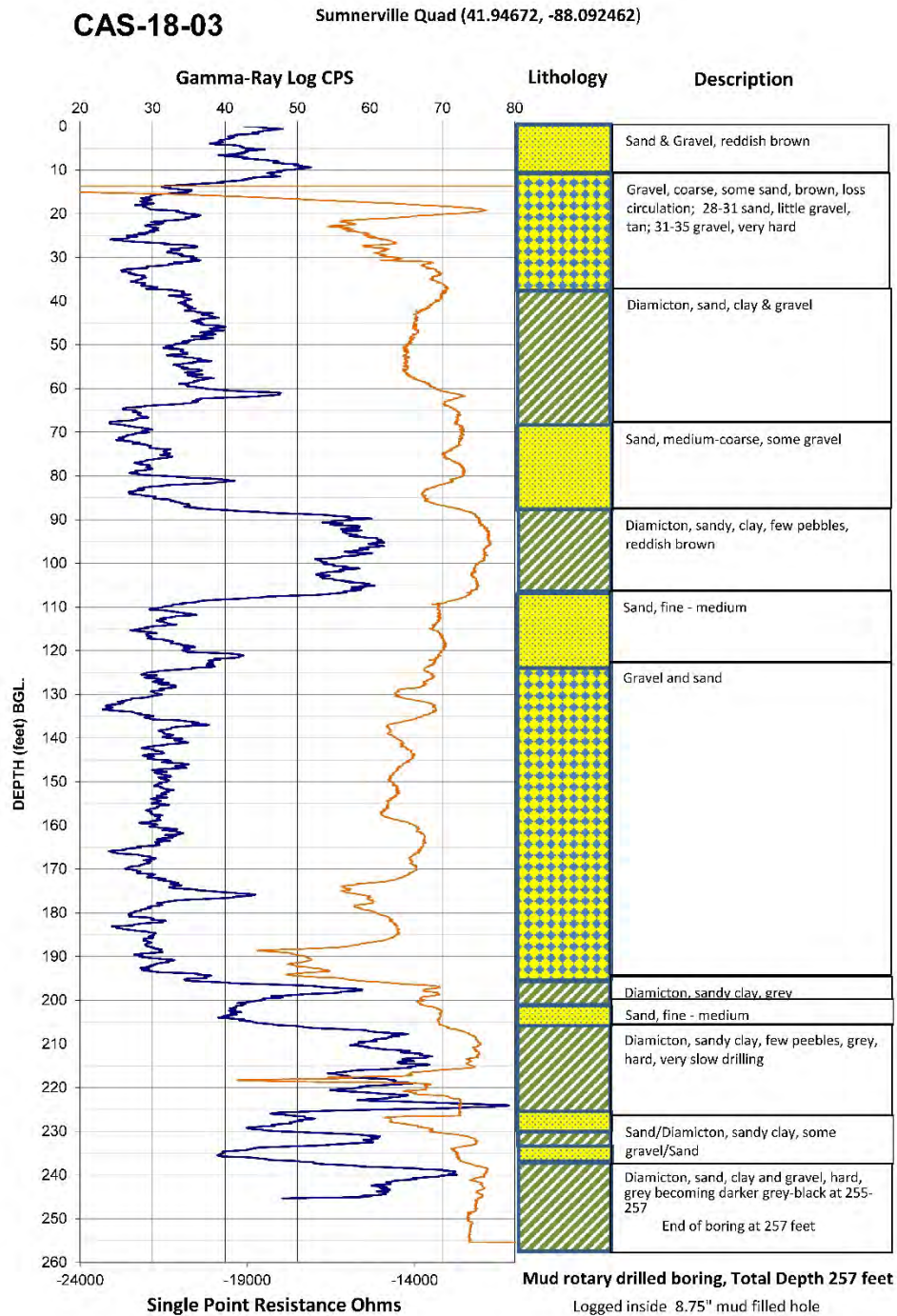


Figure 8 Geologic Cross-Section

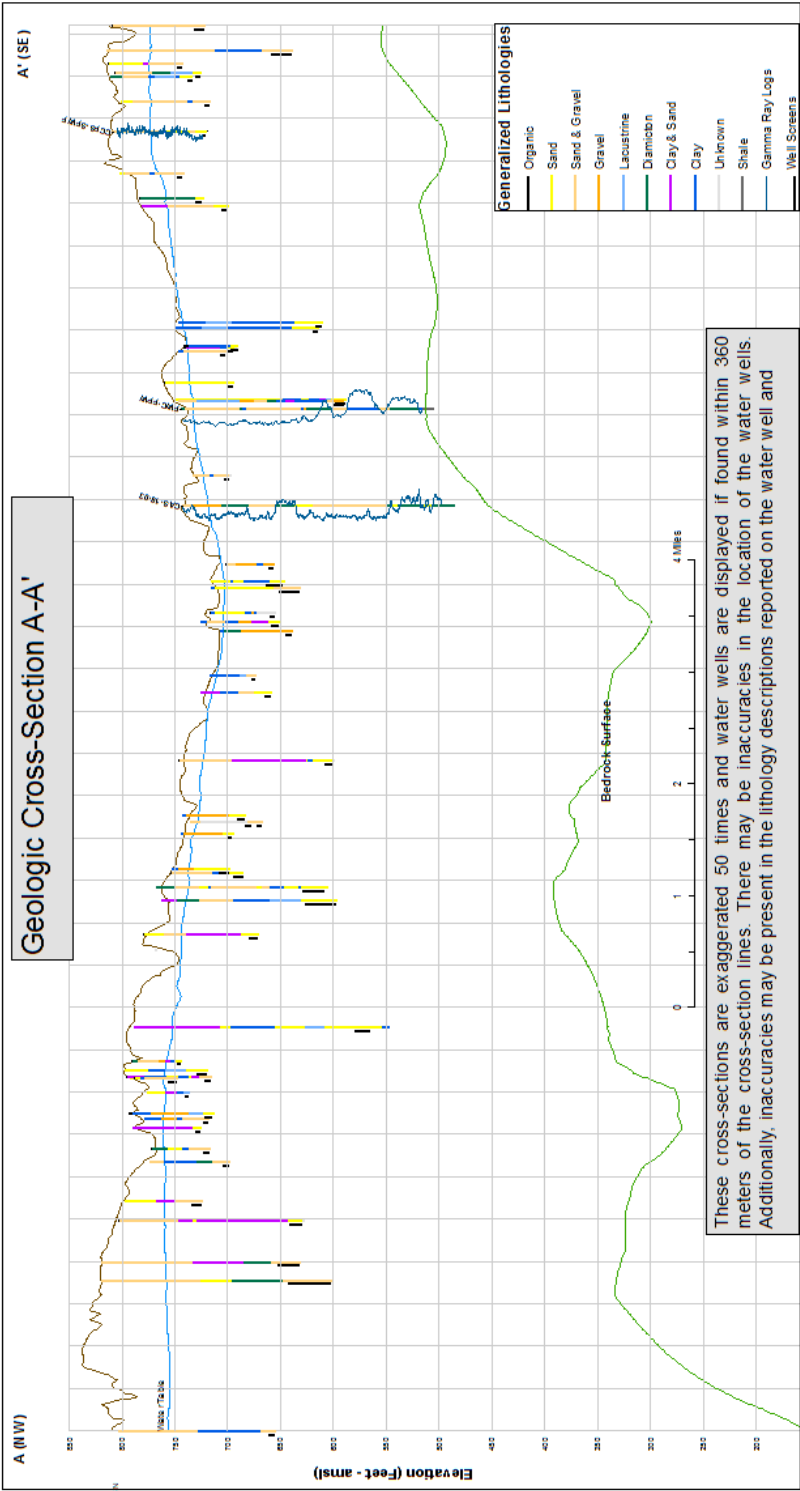


Figure 9: Drift Thickness

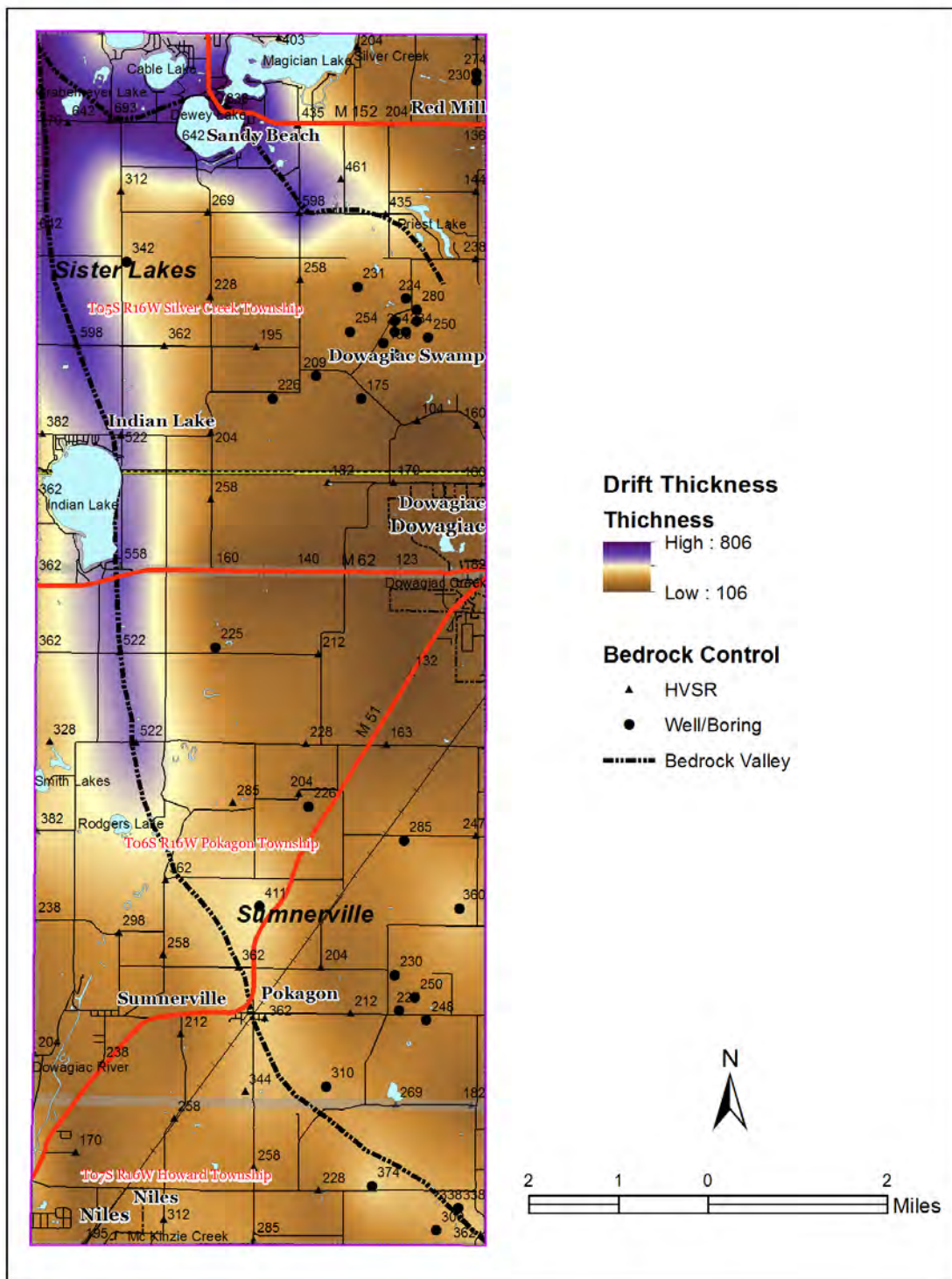




Figure 10: Bedrock Topography

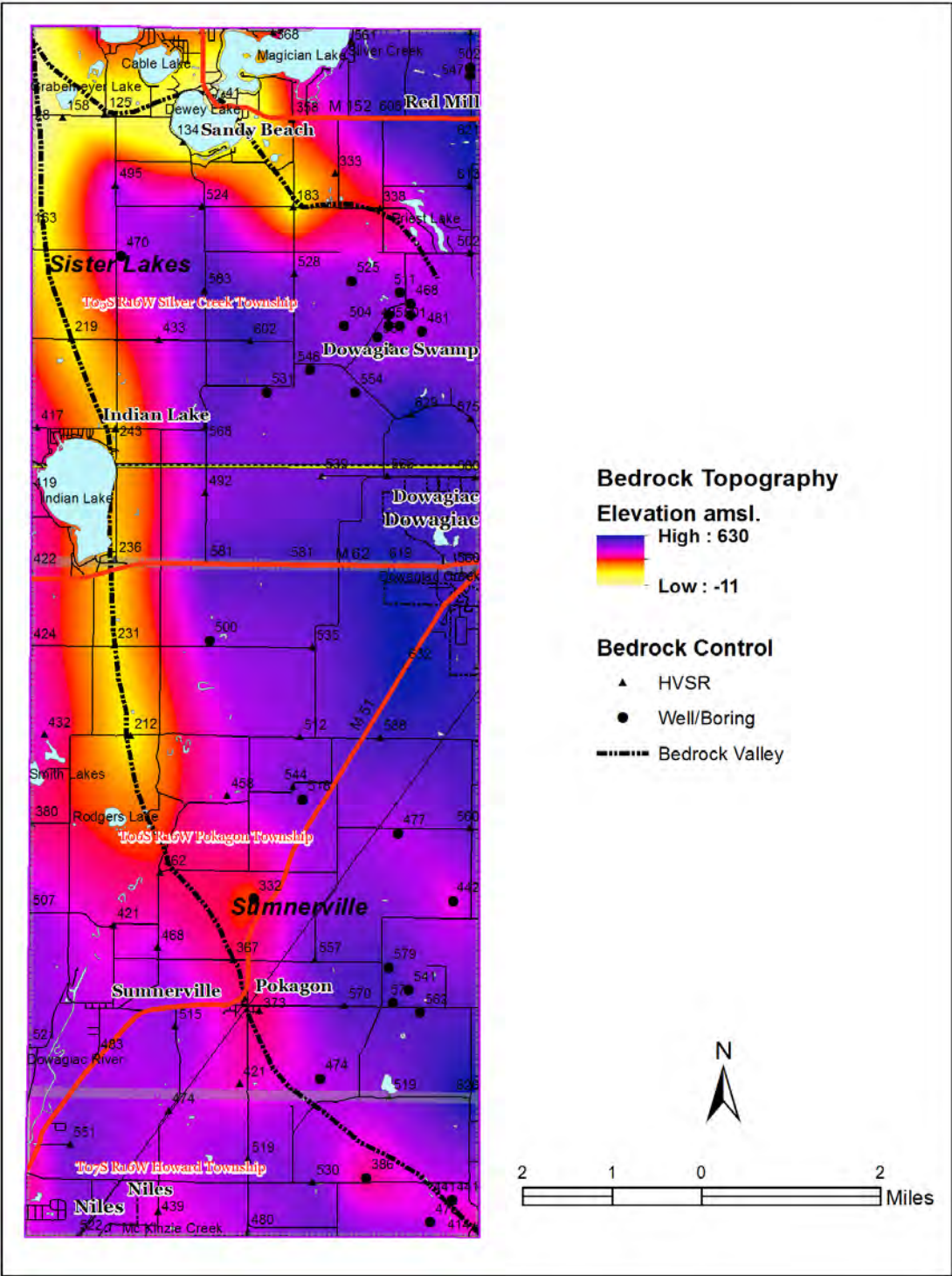


Figure 11: Bedrock Geology

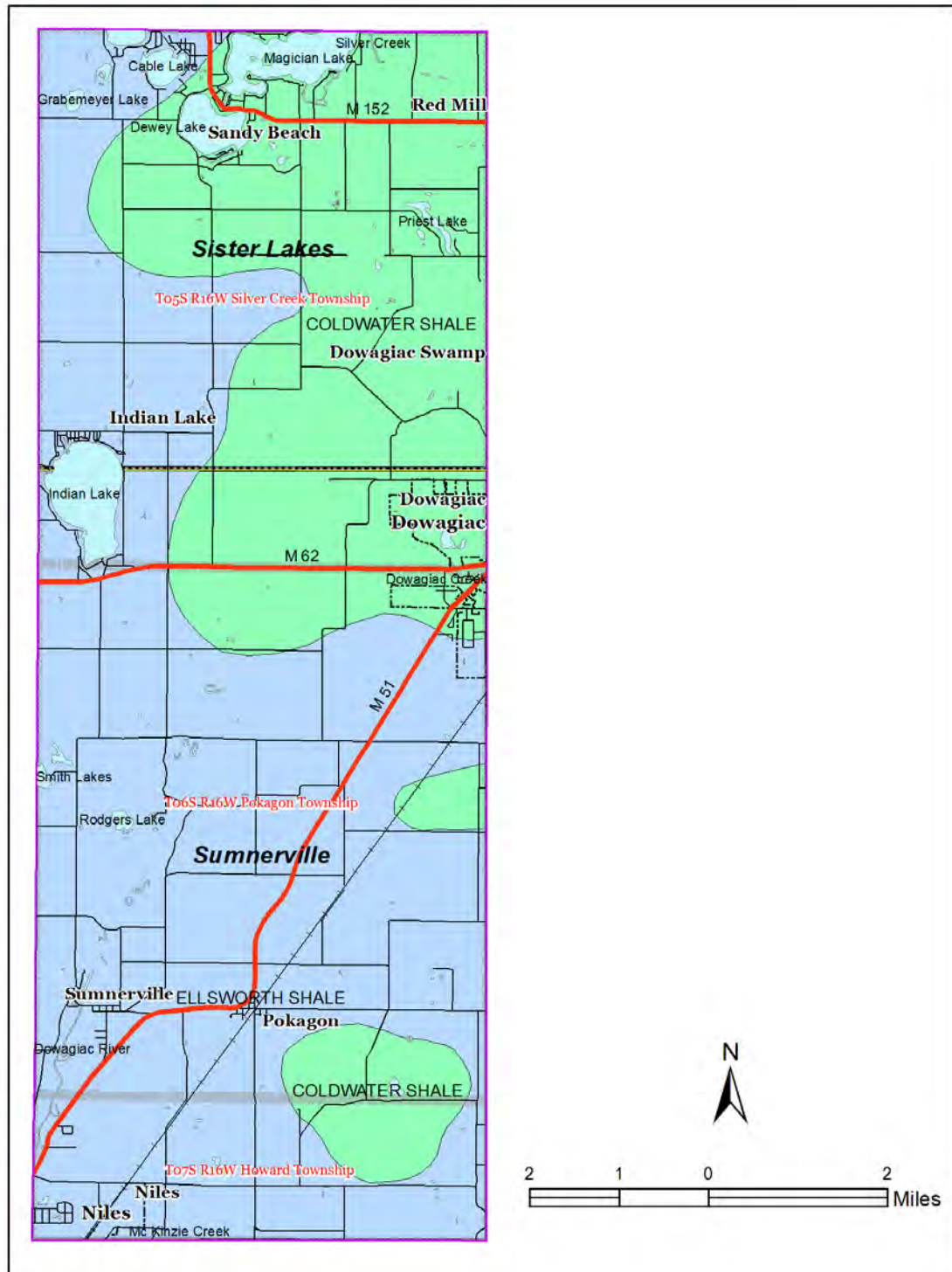


Figure 12: SSURGO Soils “Gravelly” textured

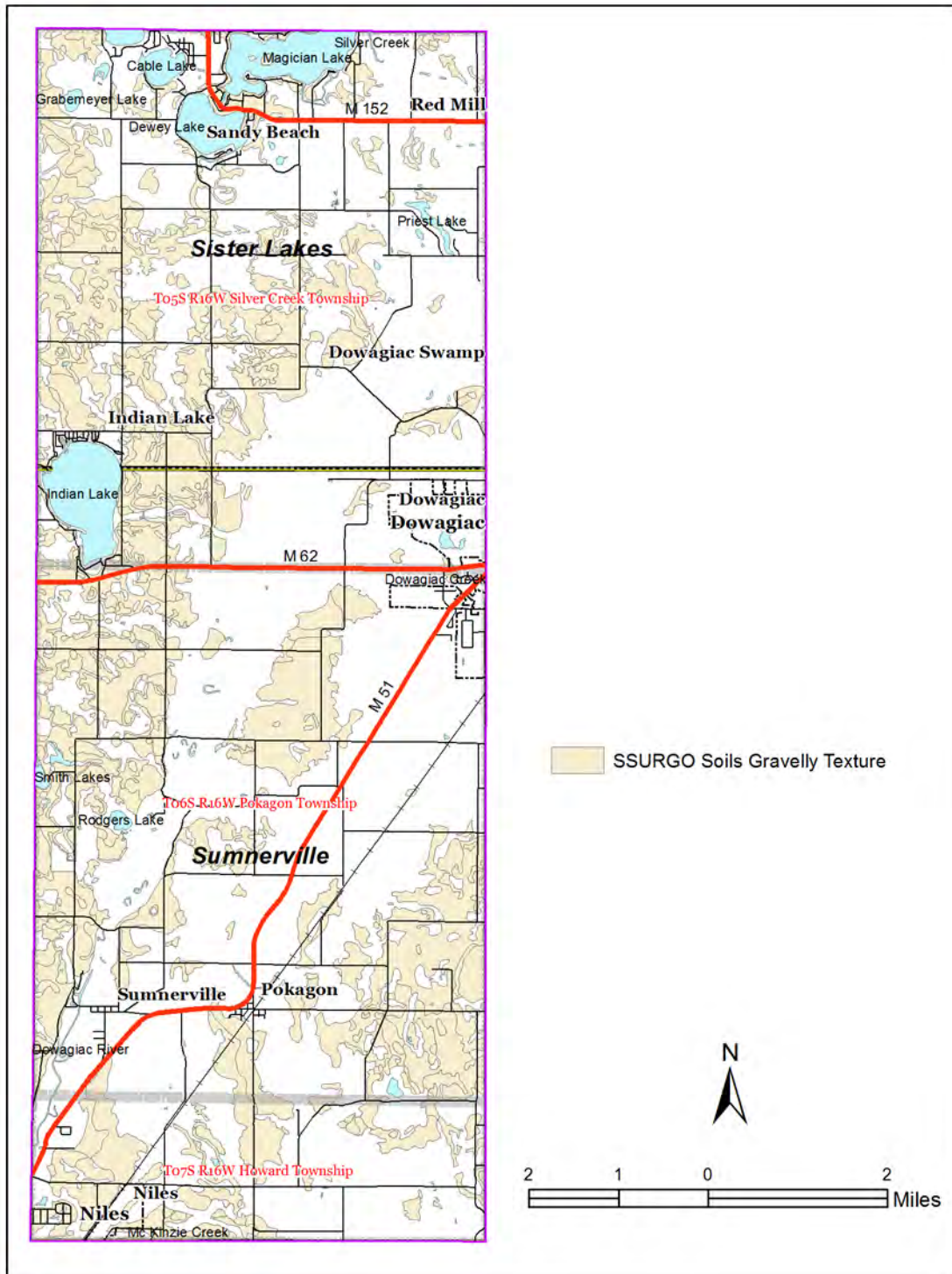


Figure 13 3D Views LiDAR Shaded Relief DEM

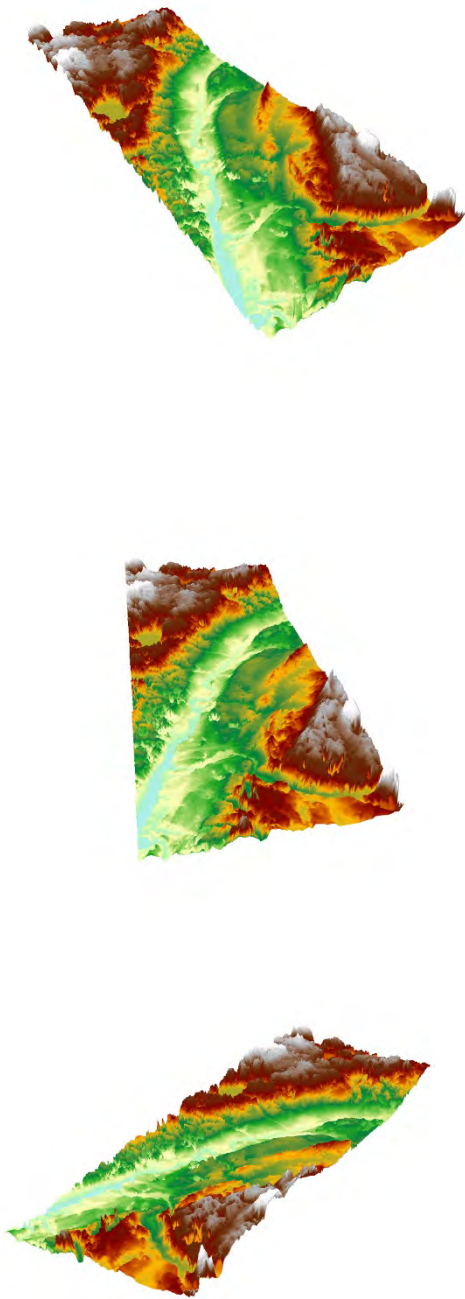




Figure 14 3D Views, DEM flooded to 750' ~ amsl of glacial lake Dowagaic

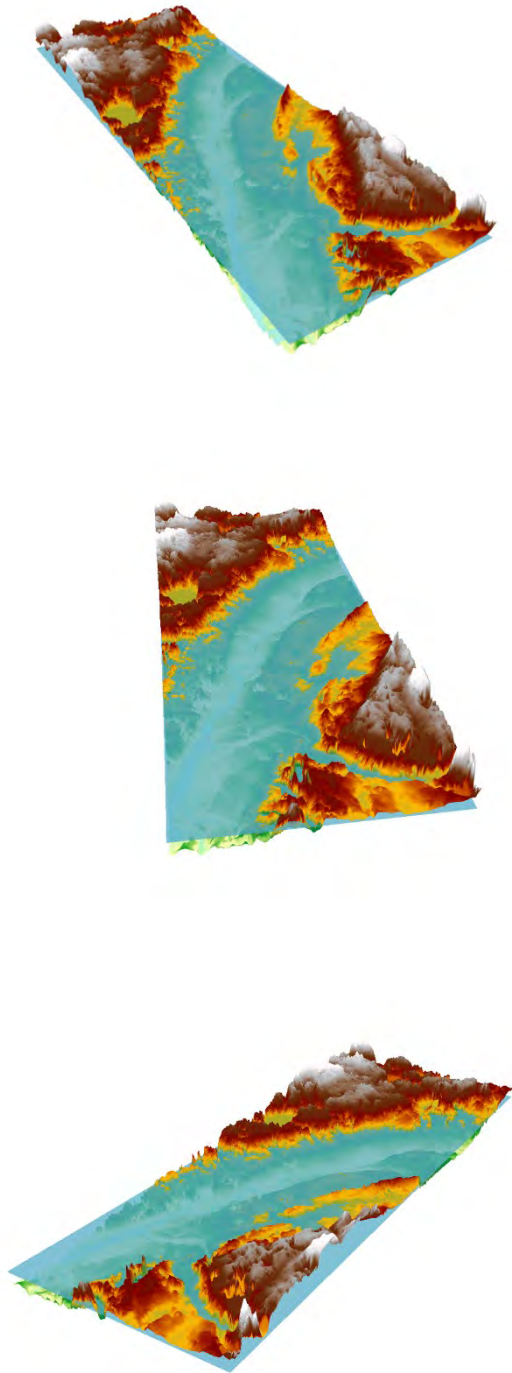


Figure 15 3D View LiDAR Shaded Relief DEM Looking NW

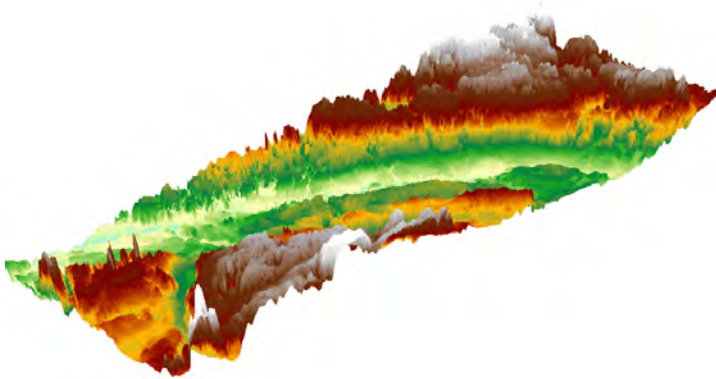


Figure 16 3D Views 3D Water Well Log Borings Looking NW

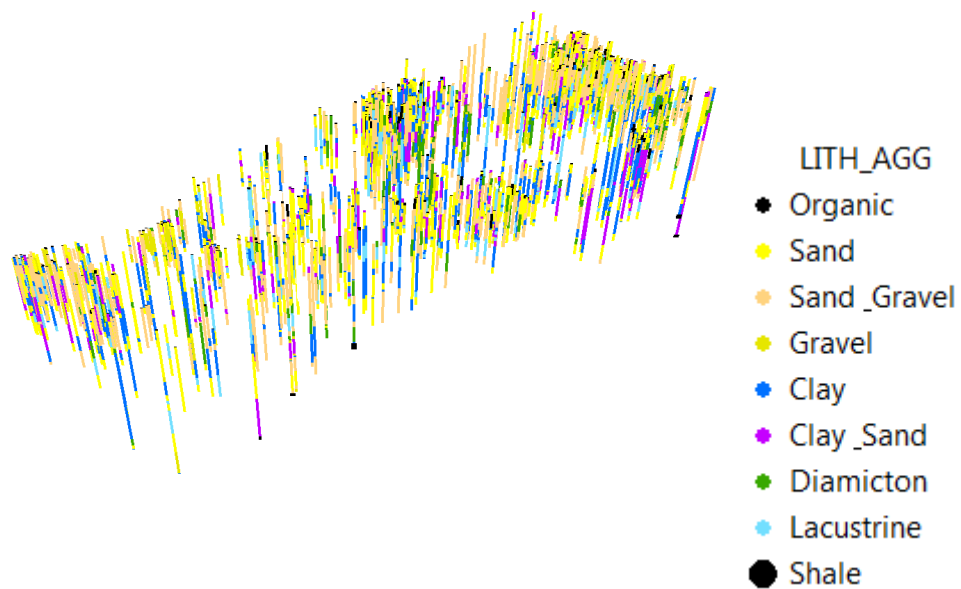


Figure 17 3D View 3D water wells & screened intervals Looking NW

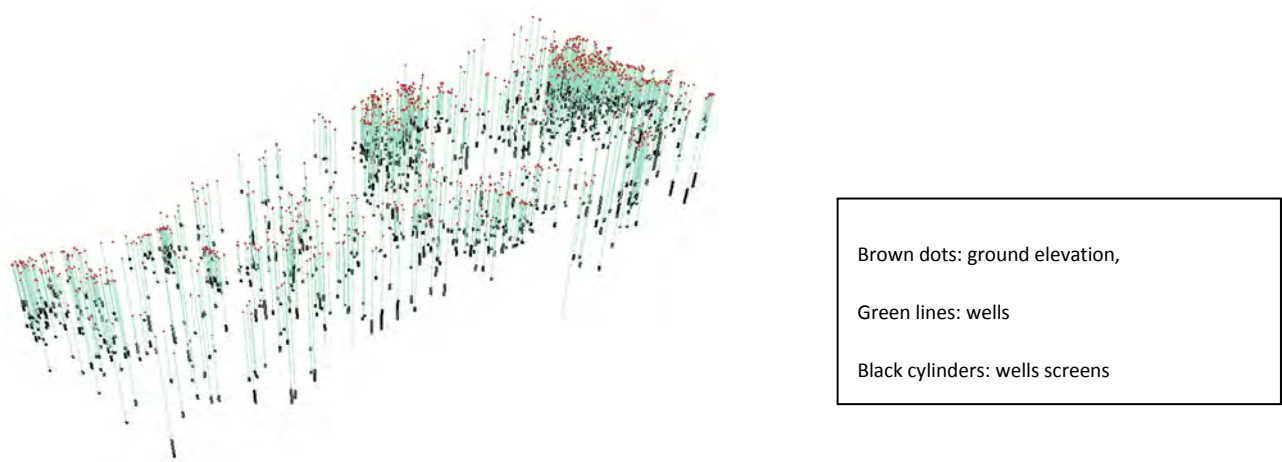
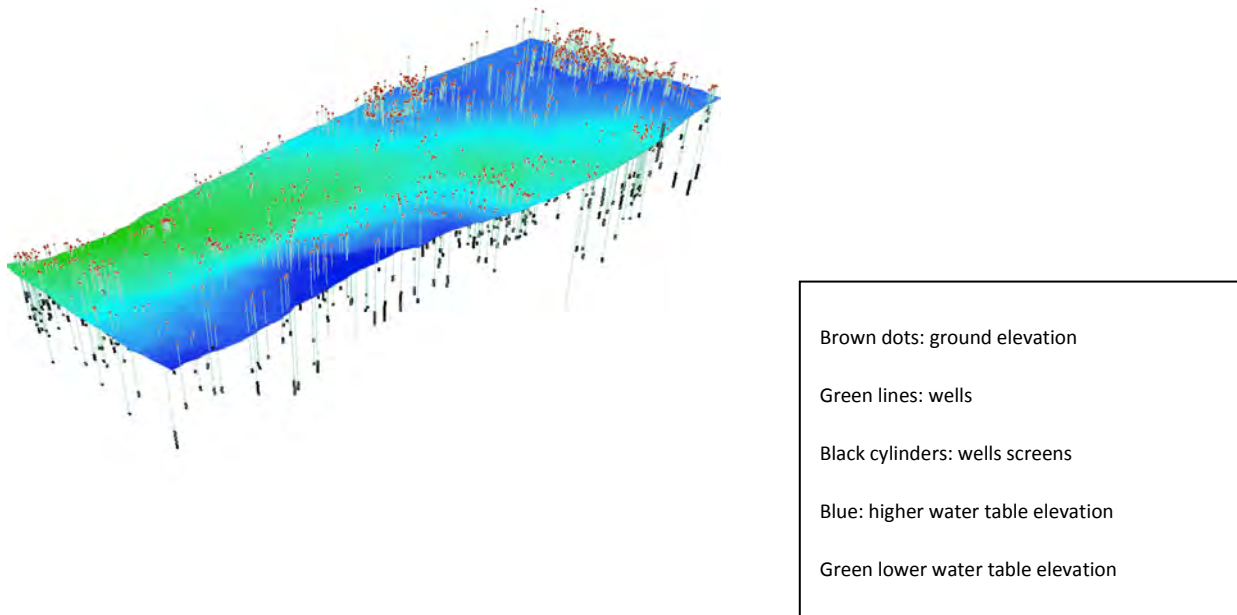
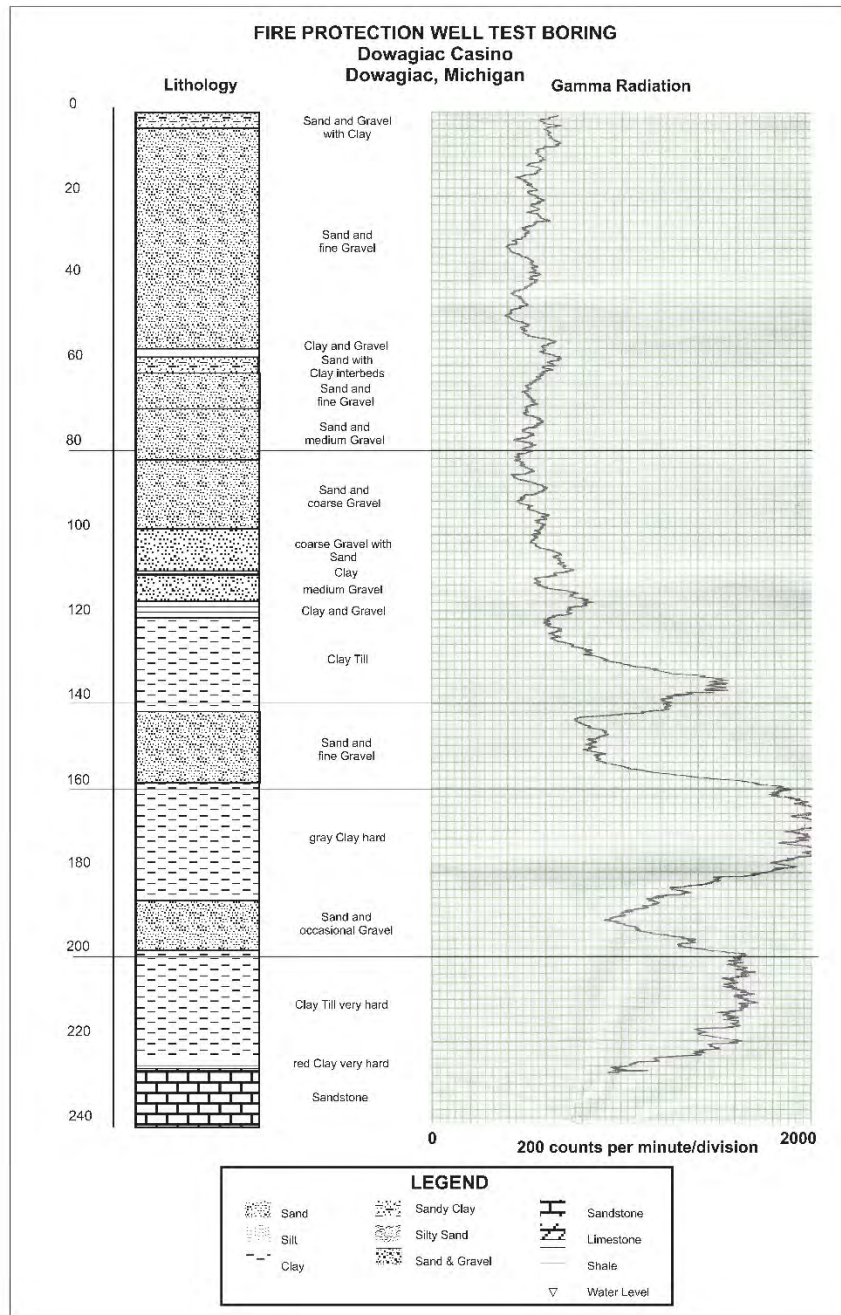


Figure 18 3D View 3D water wells & screened intervals and regional water table Looking NW



**Figure 19: Boring Log FWC-FPW**



Courtesy Ed Everett of Strata Environmental & Katz Drilling



Figure 20 Cass County Drift Thickness

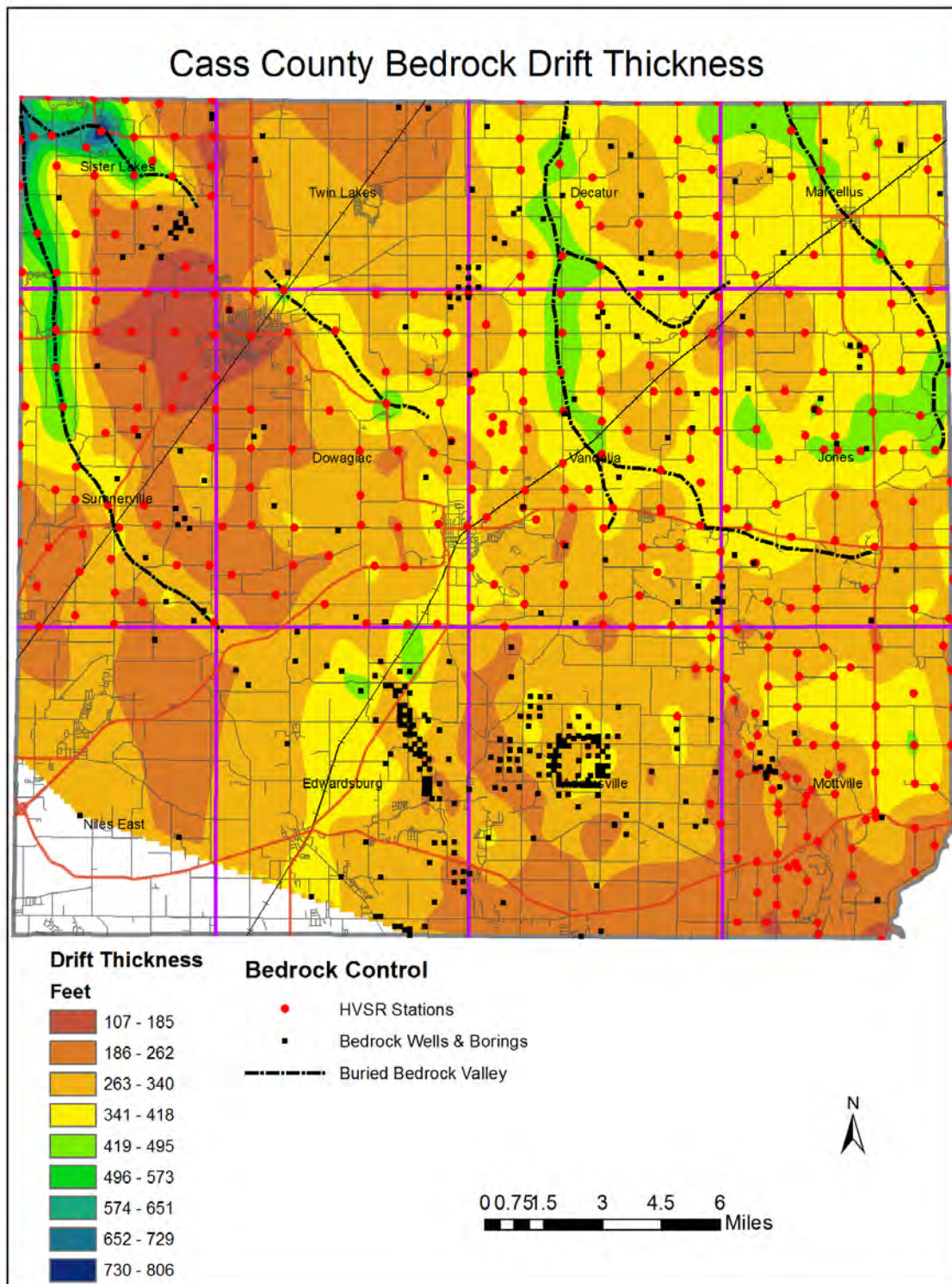


Figure 21 Cass County Bedrock Topography

