Riverbank slumping along a cutbank meander of the Wild Rice River encroaches into the utility and transportation corridors adjacent to South University Drive, south of Fargo (NDGS, 2022).

GEOLOGISTS SEE CONTINUED GROWTH

in Civil and Energy Construction Activity in North Dakota

BY FRED J. ANDERSON

As a part of their daily duties, North Dakota Geological Survey geologists review the geological suitability of environmental and engineering projects across the state. Since 2015, over 1,000 projects have been reviewed to mitigate potential geologic hazards at these project locations (fig. 1). Survey geologists work closely with scientists, engineers, and planning staff in the private and public sectors such as the Department of Water Resources, Environmental Quality, Transportation, Emergency Services, and Public Service Commission. Project reviews come to our office by way of the requirements of the National Environmental Policy Act of 1969, which requires a collective review of planned civil infrastructure projects in order that all social, economic, and environmental effects are considered.

These project reviews are commonly initiated by environmental and engineering consulting firms seeking comments from various agencies on issues that may have an impact on proposed projects. Requests to review infrastructure projects also come from state and federal agencies. This is where Survey geologists act in an advisory capacity to other agencies on siting and suitability especially when new waste disposal sites are located or proposed for expansion. The Department of Environmental Quality has worked closely with Survey geologists during the pre-application phase to identify any geologic conditions that may be unsuitable for the location of a new or expanding solid waste facility.

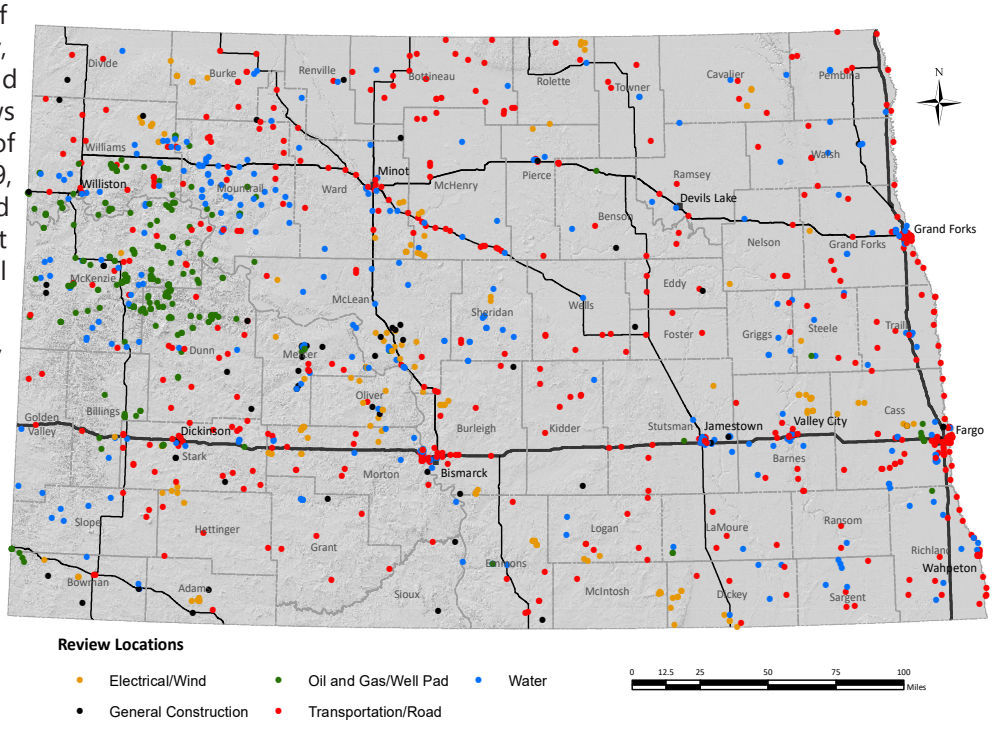

FIGURE 1.
Location and types of projects reviewed for geologic suitability 2016-2022.

Back in the '70s and '80s, before a formal review process was created, it was common for solid waste disposal to find its way into old sand and gravel pits. Survey geologists engaged other regulators to end this practice.

Over the last 20 years, the number of reviews completed annually by Survey geologists has increased over five-fold from around 50 in the mid-2000s to well over 250 in 2022 (fig. 2).

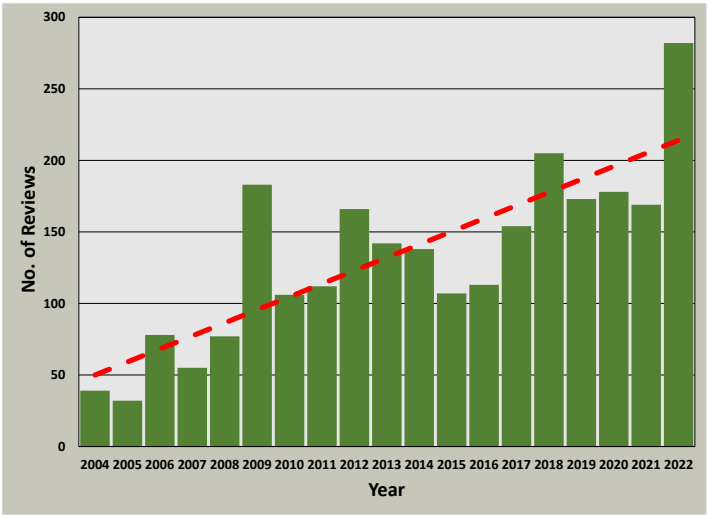

FIGURE 2.
The number of geologic reviews completed by Survey geologists continues to climb (green columns). Lately, these projects are transportation-related, consisting of bridge and structure replacements and roadway improvements.

TYPES OF PROJECTS

The types of projects that Survey geologists commonly review fall broadly into the energy and civil infrastructure sectors and consist dominantly of wind farms, oil and gas pipelines, roadway improvement projects (consisting dominantly of bridge replacements), and water and sewer line upgrades in urban and rural environments. General construction projects such as new facility or building expansions are also occasionally reviewed. Geologic reviews of coal mine permits and solid waste facility siting are also included in this geologic review program.

WIND

Wind projects continue to increase across the state as well (fig. 3). To date there are 2,157 wind turbines in service across the state (NDPSC, 2022) and there are nine new wind farms being proposed for construction in the coming years. Some locations are starting to approach their end of life where older outdated turbines are being decommissioned, such as two wind turbines south of Minot.

The two wind towers, south of Minot and one mile southeast of the old U.S. Air Force radar base along Highway 83, were some of the first wind towers constructed in North Dakota. These towers were operated by Basin Electric as part of the Minot Wind Facility. Known as "Willy and Wally," these two towers were removed this past spring (fig. 4), after 20 years of service. The towers were located on the southern end of the Max Moraine which marks one of the later glacial ice advances into North Dakota (Bluemle, 1989). These towers were positioned at topographically higher elevations than the surrounding area which enabled them to harness the winds rising across the Missouri Coteau.

In other parts of the state, such as south-central North Dakota near Wishek, a new $390 million dollar wind energy facility with as many as 74 new wind towers is being proposed (fig. 5) along the western margin of the Missouri Coteau at the edge of the Burnstadt end moraine. The northeastern part of the project will be located on hummocky end moraine sediments up to 300 feet thick. The southwestern part of the project will be located on the gently rolling topography created from subglacial clayey till sediments (Napoleon Drift) deposited around 38,000 years ago (Clayton, 1962).

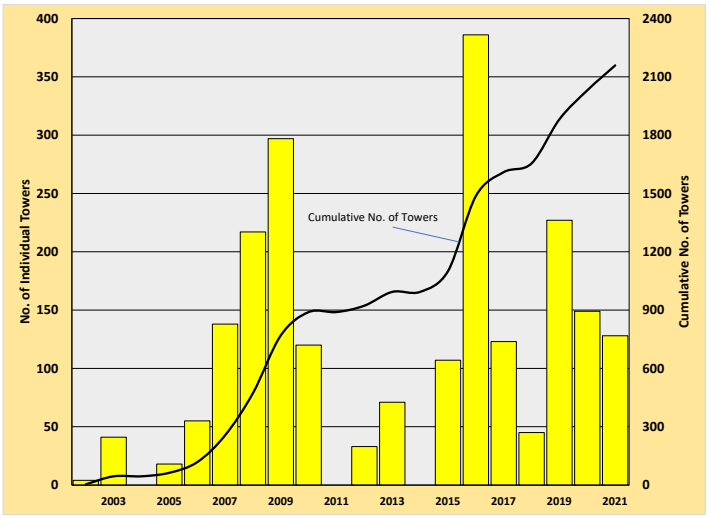

FIGURE 3.
The number of wind towers in operation in North Dakota continues to increase with new projects being proposed on nearly an annual basis (NDPSC, 2022).

FIGURE 4.
Decommissioning of the first wind towers in North Dakota south of Minot. This process is called chop and drop, similar to felling a large tree, where the base of the tower is cut and the tower is pulled over with cables and heavy equipment (Image by Jill Schramm, Minot Daily News).

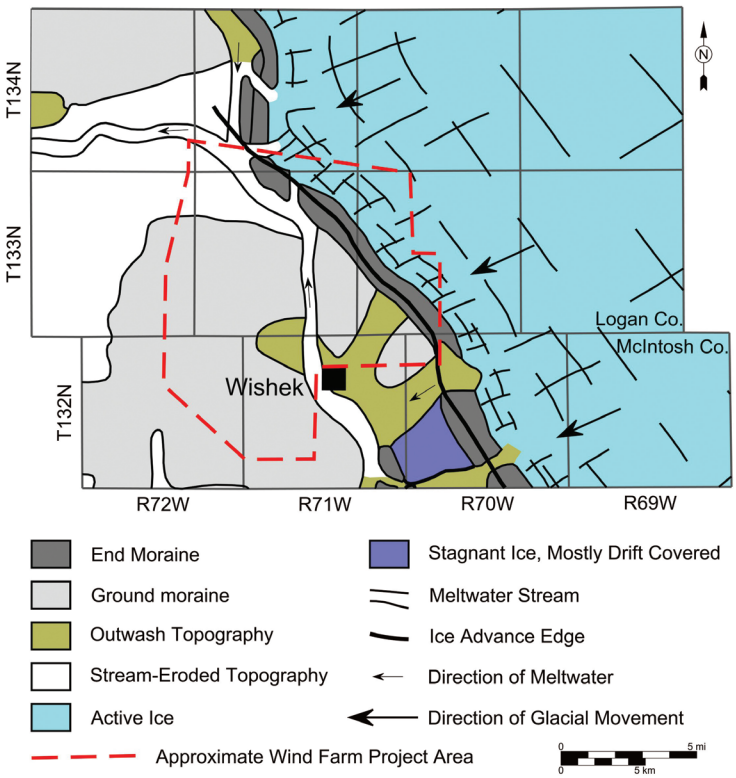

FIGURE 5.
The location of the proposed Badger Wind Energy Facility project area west and north of Wishek, North Dakota. This 251.6 MW facility, with as many as 74 proposed wind towers, is projected to be located on the western margin of the Missouri Coteau. This marks the edge of the Burnstadt end moraine, marking the edge of the last glacial ice advance in this area around 10,000 years ago (modified from Clayton, 1962).

These areas consist of gently rolling hills which are not associated with landslide development. The glacial sediments deposited in these areas consist of stony, sandy, silty types of clay-rich sediments that are generally well suited for construction activities.

In addition to the geologic review of the suitability of the entire wind farm project area, each turbine location is reviewed for its potential to be located near geologic hazards such as landslides or unstable soils (fig. 6). This is done both when the project siting application is first proposed and at the time of the filing of the Ten-Year Plan. When companies file their ten-year plans with the NDPSC, as required by law, notice is provided to the Survey. The Survey then takes the opportunity to review the location of the proposed or existing project and wind-tower locations against updated aerial imagery to determine if any recent changes to the landscape have occurred that could have an adverse effect on the structures. Landslide area maps, recently updated with high-resolution elevation data collected from LiDAR surveys, are available across the entire state. North Dakota is one of the first states in the nation to have completed a baseline landslide inventory for the entire state. This inventory now serves as a benchmark for future landslide and slope stability investigations.

FIGURE 6.
Aerial view of wind-tower foundation construction in the Souris River Valley in 2005 from an aerial photographic survey completed by the author. Towers are commonly bolted to reinforced concrete spread footings up to 70 feet wide and as much as 15 feet thick, depending on the geotechnical conditions encountered at each location. This provides for a stable base weighing in at around 1,400 tons (which is roughly the mass equivalent of eight Blue Whales).

TRANSPORTATION

Many of the state's aging bridges and structures on roads are being proposed for upgrades or full replacement by the NDDOT. Over the past eight years, the locations of just over 200 bridges or structures, such as culverts, have been reviewed during the replacement process (fig. 2). Most of these structures occur where county roads cross local rivers and streams. Knowing where potential landslides or unstable slopes may be at these crossings is important when considering structure replacement or repair of slopes affected by riverbank slumping (fig. 7).

WATER

Many municipalities across the state have been updating and improving their water and sewer lines and expanding water supplies to rural users. For example, the City of Galesburg is located on 50 to 120 feet of sandy silt of the Galesburg Delta in southwestern Traill County (fig. 8). The city is preparing to replace their aging water and sewer line system with nearly four miles of new line planned (fig. 9).

OIL AND GAS PRODUCTION INFRASTRUCTURE

Oil and gas pipelines and natural gas processing plants continue to expand across western North Dakota to meet

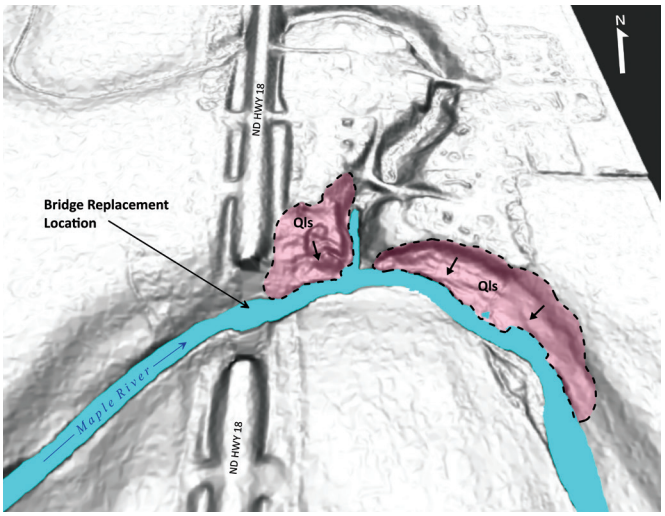

FIGURE 7.
This proposed structure replacement on ND HWY 18 crosses a reach of the Maple River where considerable slumping along the northern riverbank has been occurring as can be seen in this 3D surface model of the bridge location created from LiDAR elevation data. This bare earth LiDAR surface model artificially removes structures from the data (in this case the existing bridge). Areas of slumping (Qls) are occurring along the riverbank in close proximity to the bridge and are being closely monitored by the NDDOT.

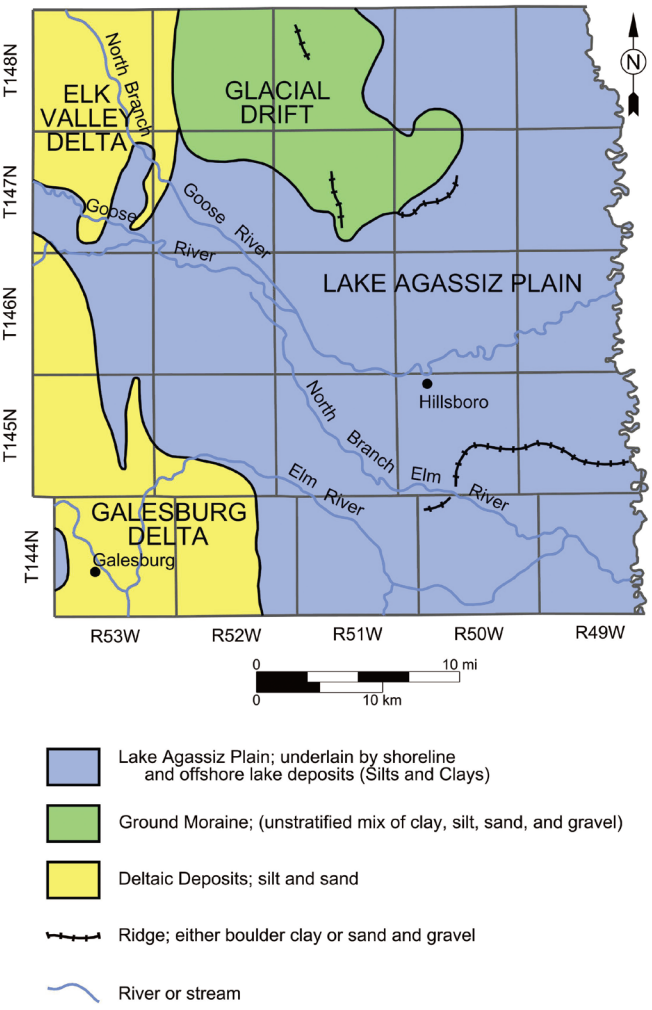

FIGURE 8.
The generalized geology of Traill County, North Dakota (modified from Bluemle, 1967).

FIGURE 9.
The City of Galesburg, in eastern North Dakota, will be updating their water and sewer infrastructure in 2023, replacing old worn-out clay piping with newer PVC or HDPE lines like these from a recent sewer upgrade project in Larimore (Image courtesy of AE2S, 2021).

increasing production demands. Since 2015, over 2,563 miles of pipeline corridor have been reviewed for geologic suitability, most importantly that these corridors are free of landslides and unstable areas. One of the more recent oil pipeline projects to be reviewed is the Bridger 16-inch crude oil line proposed to traverse across southern McKenzie and northwestern Golden Valley counties. By using our landslide mapping information in the route planning process, this 80-mile route bypasses the heavily landslide populated Little Missouri Valley. Choosing instead, a route where topographic and geologic conditions are more suited to pipeline placement (fig. 10). Areas that have potential to be problematic for pipeline placement are generally bypassed by route realignment during the design phase or by using directional drilling methods during construction, if rerouting is not possible.

ELECTRICAL GENERATION AND TRANSMISSION

The siting of electrical transmission lines, often associated with wind farm development, are also reviewed in our program. One of the more interesting electrical projects of late is the Harmony Solar project, proposed for construction in northeastern Cass County. When completed, this facility will be capable of adding 200 MW of electrical generating capacity, enough to supply the annual energy needs of

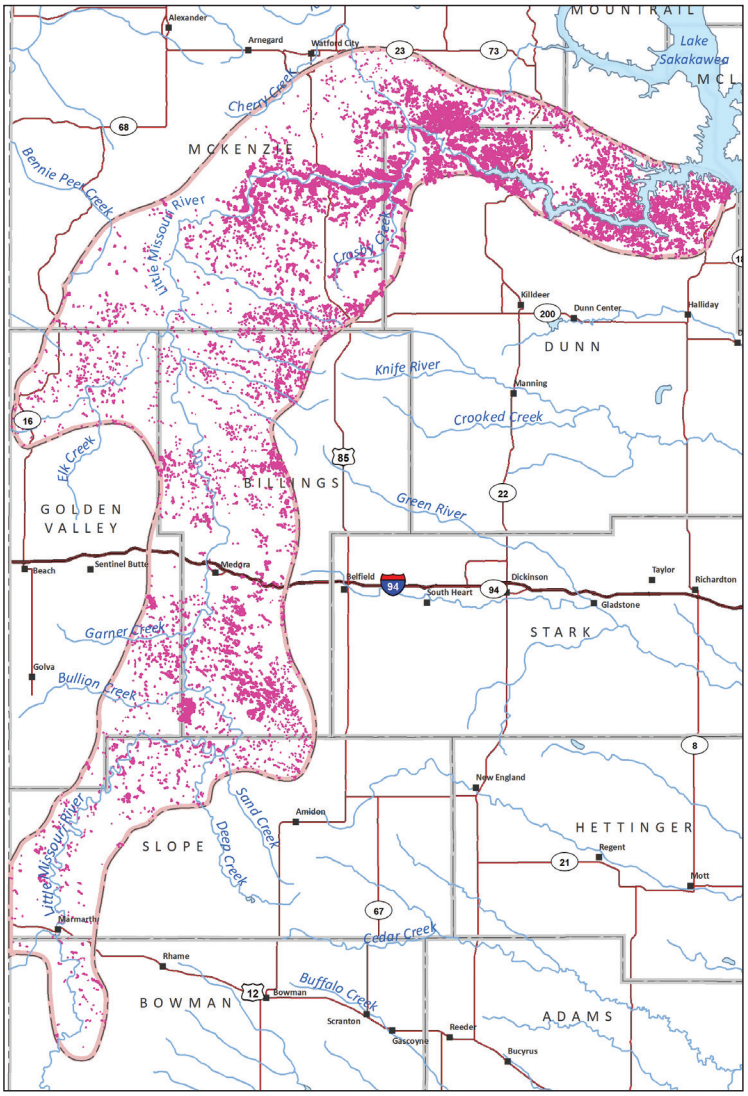

FIGURE 10.
The Little Missouri Badlands physiographic province (boundary as modified from Clayton, 1980) contains the highest density of landslide areas in North Dakota. As of this writing, over 10,490 landslides covering 97,600 acres (or 5.2% of this area) have been mapped. As updated maps are completed in this area, these numbers will continue to increase.

potentially tens of thousands of homes (Harmony, 2018). This solar energy facility is to be located just four miles northeast of Casselton in the southwestern portion of the Lake Agassiz plain (fig. 11). The soft and expansive offshore lacustrine clays of the Brenna Formation were noted in the shallow subsurface in this area during the review process. Since these clays are known to be problematic for construction projects throughout the Red River Valley, an extensive geotechnical evaluation of this area was completed as a part of the design and siting application process.

Survey geologists continue to review an increasing variety and number of civil and energy construction projects. These reviews serve to increase our state's mitigation effectiveness and efficiency, significantly reducing the potential costs associated with costly remedial measures that are required when projects are sited in geologically undesirable areas.

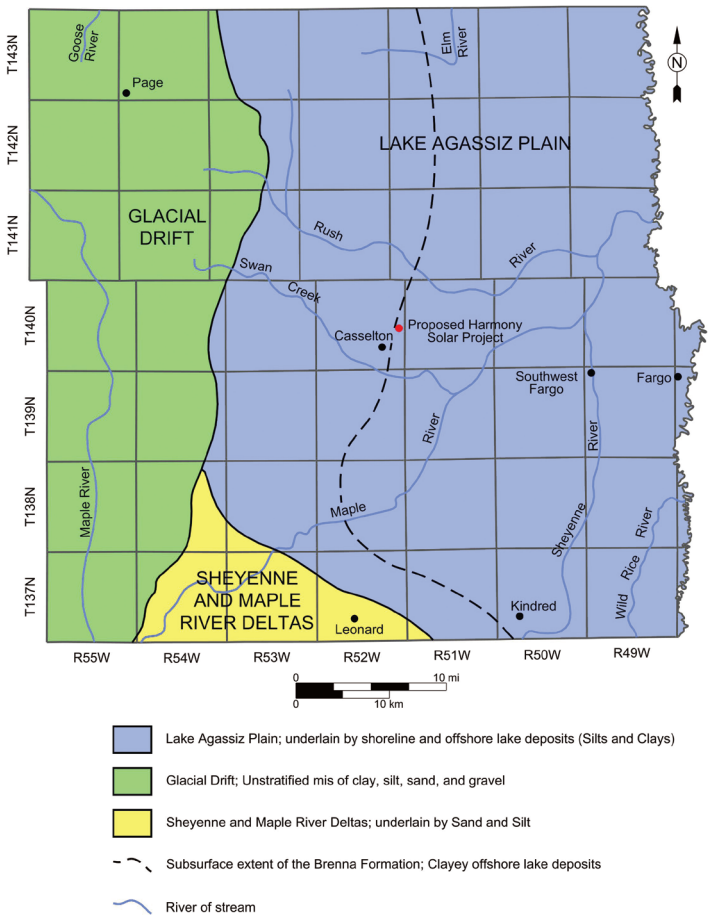

FIGURE 11.
Generalized surficial geology and extent of the offshore lake clays of the Brenna Formation in the southwestern Red River Valley (modified from Klausing, 1968).

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