HOMES ON STILTS:

FARGO AREA CITIZENS FACE CONTINUED RESIDENTIAL FOUNDATION STABILITY ISSUES

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The cities of Fargo and West Fargo lie on top of the former lakebed of the expansive Glacial Lake Agassiz. The lakebed sediments that were deposited offshore in the areas of quieter water in the lake are laminated silty clays and soft expansive clays of the Brenna and overlying Sherack Formations. At the interface of these two units, when the deposition of lake sediments was halted for a brief period in the late Holocene, ancient rivers flowed across the Lake Agassiz plain and incised their way into the Brenna Formation clays. Over time deposition of lake sediments resumed and the laminated silts and clays of the Sherack Formation were laid down over the Brenna clays and the glaciofluvial sediments (formally called the Poplar River Formation) sandwiching these channel sands between the two clay units. When these units are saturated, they can have a "quick" component and can flow when placed under a load from the surface. Because of these potentially unstable conditions (fig. 1), some residents in Fargo have been forced to effectively elevate their residential foundations. This is done by advancing long piers or piles into the shallow subsurface to find an adequate load-bearing layer, sometimes as deep as 90 feet or more. The load-bearing layer is generally the first stable glacial till or boulder clay.

FIGURE 1.
A Fargo residence where foundation subsidence has occurred. This photograph was taken over 30 years ago, and the entire home can be seen tilting towards the backyard (Photo from NDSU Professor Emeritus Dr. Don Schwert, 1991). The slab foundation of this house is dipping about 5° towards the backyard.

The City of Fargo does not currently track residences that end up needing building permits for installing bracing piers to stabilize their sinking foundations. However, the City of West Fargo does track such information and from that, some interesting insights can be gained from the spatial relationship of the location of these homes that have required stabilization (fig. 2).

In West Fargo several of the homes that have required stabilization are located within topographically low areas to the west and east of the Sheyenne River (fig. 2). It is supposed that when water levels are high in the Sheyenne River the local water table is also very shallow, perhaps just a few feet below land surface. The localized high-water table keeps the laminated silts and clays of the Sherack Formation saturated and less able to bear the surface loads from homes placed upon it. The soft and expansive (i.e., smectitic) underlying lake clays of the Brenna Formation also add to this stability problem (fig 3).

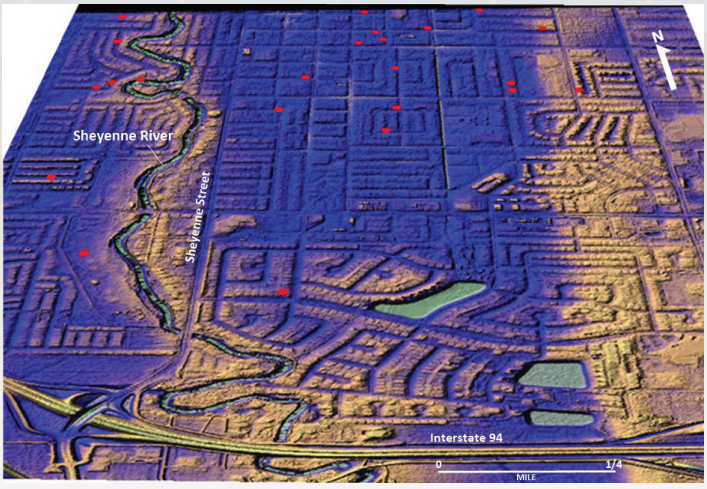


FIGURE 2.
Locations of homes in West Fargo (red dots) where foundation bracing has been implemented as a remedial measure to stabilize sinking foundations. As seen in this 3D LiDAR-based surface model all locations are located within localized low areas (shown in blue) presumably where shallow groundwater creates weaker clayey soil conditions between and within the Sherack and Brenna Formations.

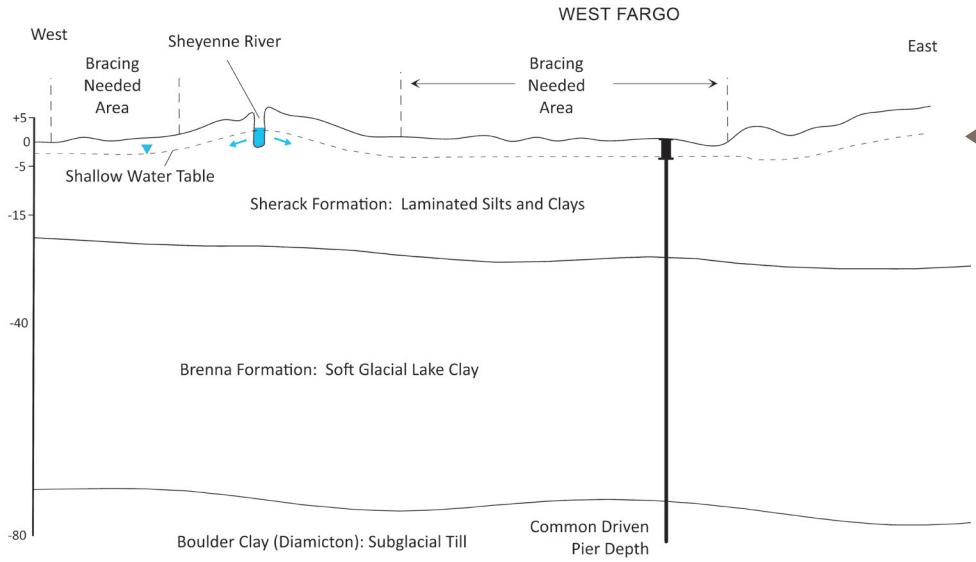


FIGURE 3.
Conceptual depiction of the shallow hydrogeologic conditions occurring in the West Fargo area between Sheyenne Street and 9th Street East. Surface topography modeled from available LiDAR data. Drilling records for this area do not show any shallow sands of the Poplar River Formation occurring in the shallow subsurface. Only the offshore glaciolacustrine silts and clays of the Sherack and Brenna Formations are described in this area.

Recently a homeowner contacted our offices about information related to this condition as they had been experiencing continued problems (figs. 4a and 4b) with a tilting and subsiding foundation. The problem had required repeated costly foundation stabilizing pier installations all around the base of the home (fig. 5). Costs for these kinds of remedial measures are often in the tens of thousands of dollars.

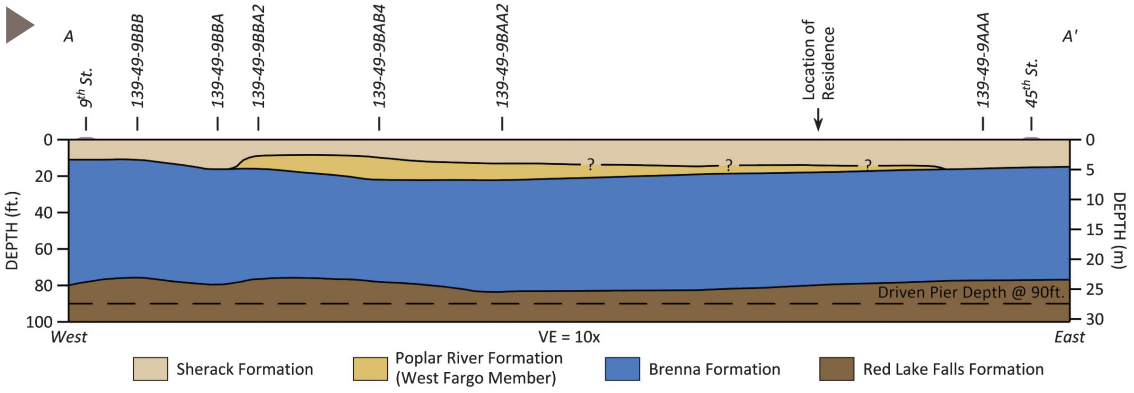
FIGURE 4.
Continual structural damage (shown at the locations of the white arrows) occurring within a northeast West Fargo home as the result of weak soil conditions. Cracks in the walls **(a.)** and basement slabs **(b.)** are found throughout this residence which has had several driven piers placed around the outside of the foundation in an attempt to stabilize the residence.

Glaciofluvial compaction ridges are found throughout the southern Red River Valley and in the greater Fargo area (fig. 6). These shallow sand bodies are the remnants of ancient rivers that flowed across the floor of a drained Glacial Lake Agassiz. Once the lake flooded again, additional lake sediments were deposited above these ridges which effectively "sandwiched" these deposits between the offshore clays (fig. 7).

From the regional perspective, the offshore silts and clays of the Brenna Formation are somewhat less extensive laterally in the Grand Forks area and slightly thinner, around 30 feet. In the Fargo area these soft lake clays are commonly around 70 feet thick, and much more laterally extensive (fig. 8). The Brenna Formation does, however, get dramatically thicker starting between Grafton and Drayton and on towards the border between Canada and the U.S. where it reaches its maximum thickness of over 110 feet.

Occurring together or separately (i.e., the compaction ridges and soft offshore lake sediments) these shallow geologic conditions will most likely continue to be problematic as rapid urban growth continues in both Fargo and Grand Forks. Sometimes, the rush to complete construction can lead to poor land preparation practices such as the filling in of old drainages and depressions that may have conveyed or contained water or saturated soils with poor quality or improperly placed backfill (fig 9).

FIGURE 5.
West to east cross-section of the shallow geologic units present in northwestern Fargo between 5th Street and 45th Street. Compaction ridge sediments of the West Fargo Member of the Poplar River Formation are present in this area of West Fargo and may extend for a considerable distance beneath the locations of homes where foundation settlement and stabilization have occurred.



It is also likely that the number of homeowners that have experienced these issues is much larger than what is currently known. Additional geologic investigations will likely be needed to better characterize the relationships and extent of these potentially problematic deposits that occur in our rapidly expanding urban environments in the Red River Valley.

REFERENCES

Harris, K.L., Manz, L.A., and Lusardi, B.A., 2020, Quaternary Stratigraphic Nomenclature, Red River Valley, North Dakota and Minnesota: An Update, North Dakota Geological Survey, Miscellaneous Series No. 95, 249 p.

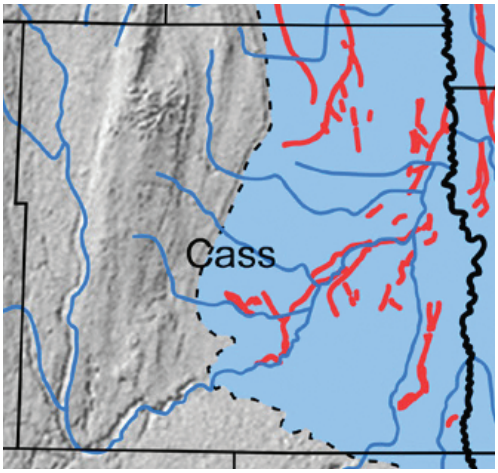


FIGURE 6.
Approximate extent of offshore lake deposits of Glacial Lake Agassiz (shaded light blue) in Cass County, North Dakota, and location of mapped glaciofluvial compaction ridges (shown in red). As detailed geologic mapping work continues in this area more of these types of features are being discovered since incorporating LiDAR surface models into the geologic mapping workflow (modified from Harris and others, 2020).

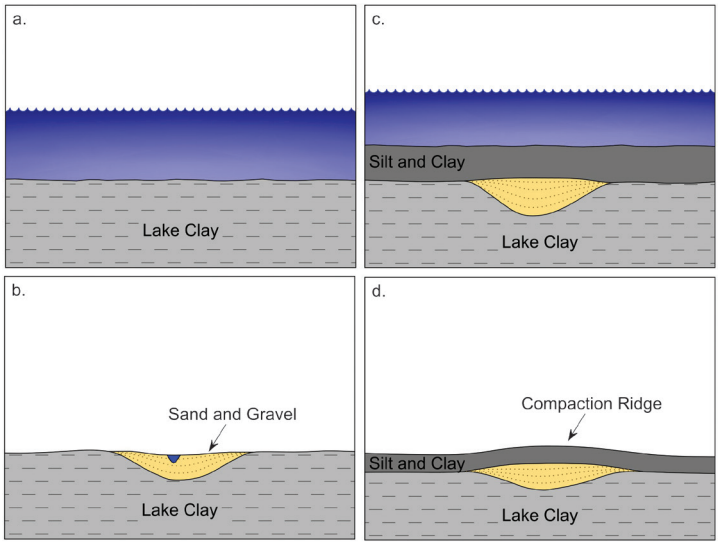


FIGURE 7.
Steps in the formation of a glaciofluvial compaction ridge on the former Glacial Lake Agassiz plain. Fine-grained clays (i.e. the Brenna Formation) are deposited in the offshore quiet waters (a.), once the ice retreats and the lake drains, the lake plain is exposed and shallow rivers and streams begin to flow across the lake plain towards the northeast incising into the former lake bottom (b.), the lake returns with the readvance of glacial ice and additional offshore lake deposits of the Sherack Formation are deposited (c.), followed by the final retreat of ice and lake drainage, dewatering of the lake bottom and subsidence of the land surface leaving the remaining compaction ridges as slightly elevated linear expressions (d.) on the landscape. These features when saturated can exhibit a "quick" component and be capable of flow in the shallow subsurface.

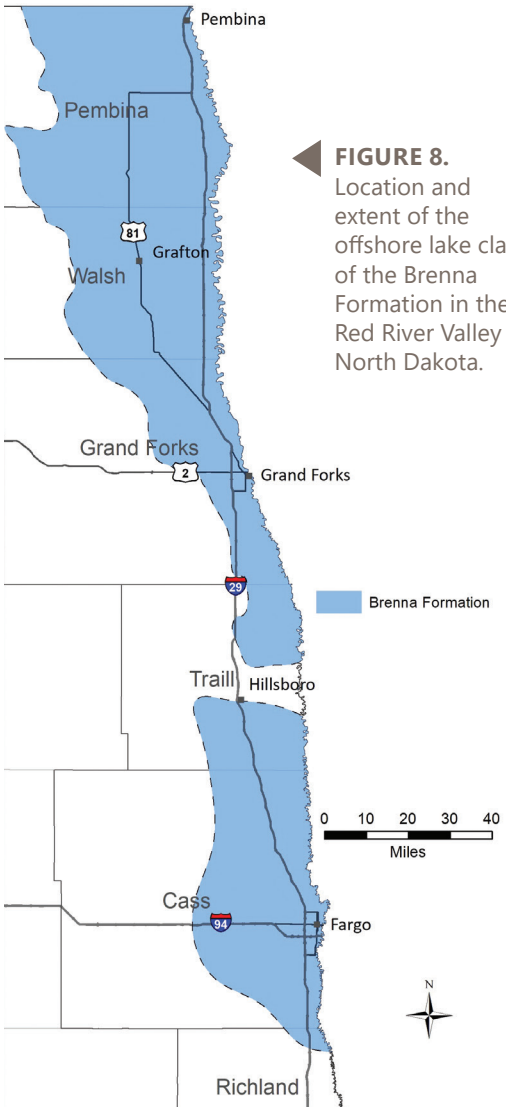


FIGURE 8.
Location and extent of the offshore lake clays of the Brenna Formation in the Red River Valley of North Dakota.

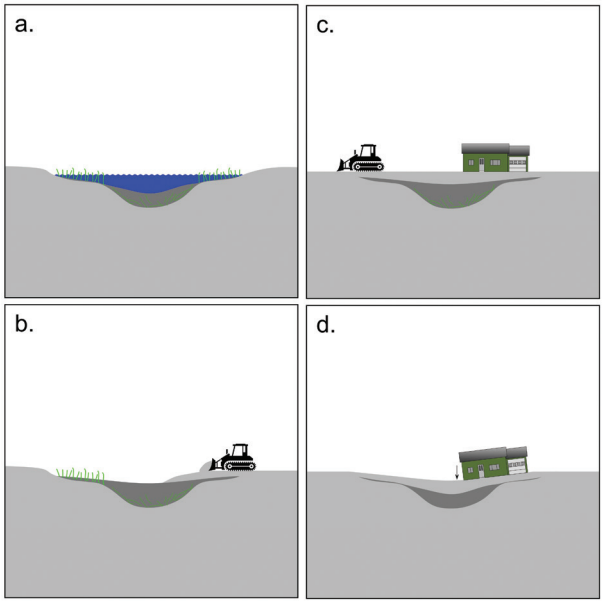


FIGURE 9.
Filling in drainages or old ponds and sloughs with improperly placed backfill can result in poor foundation conditions for residential development. Former drainage area prior to residential development (a), filling in old drainage or depression (b), construction above filled area (c), subsidence of structures over time as filled area dewaters and compacts (d).