Surficial Geology of the Raymond 7.5 Minute Quadrangle

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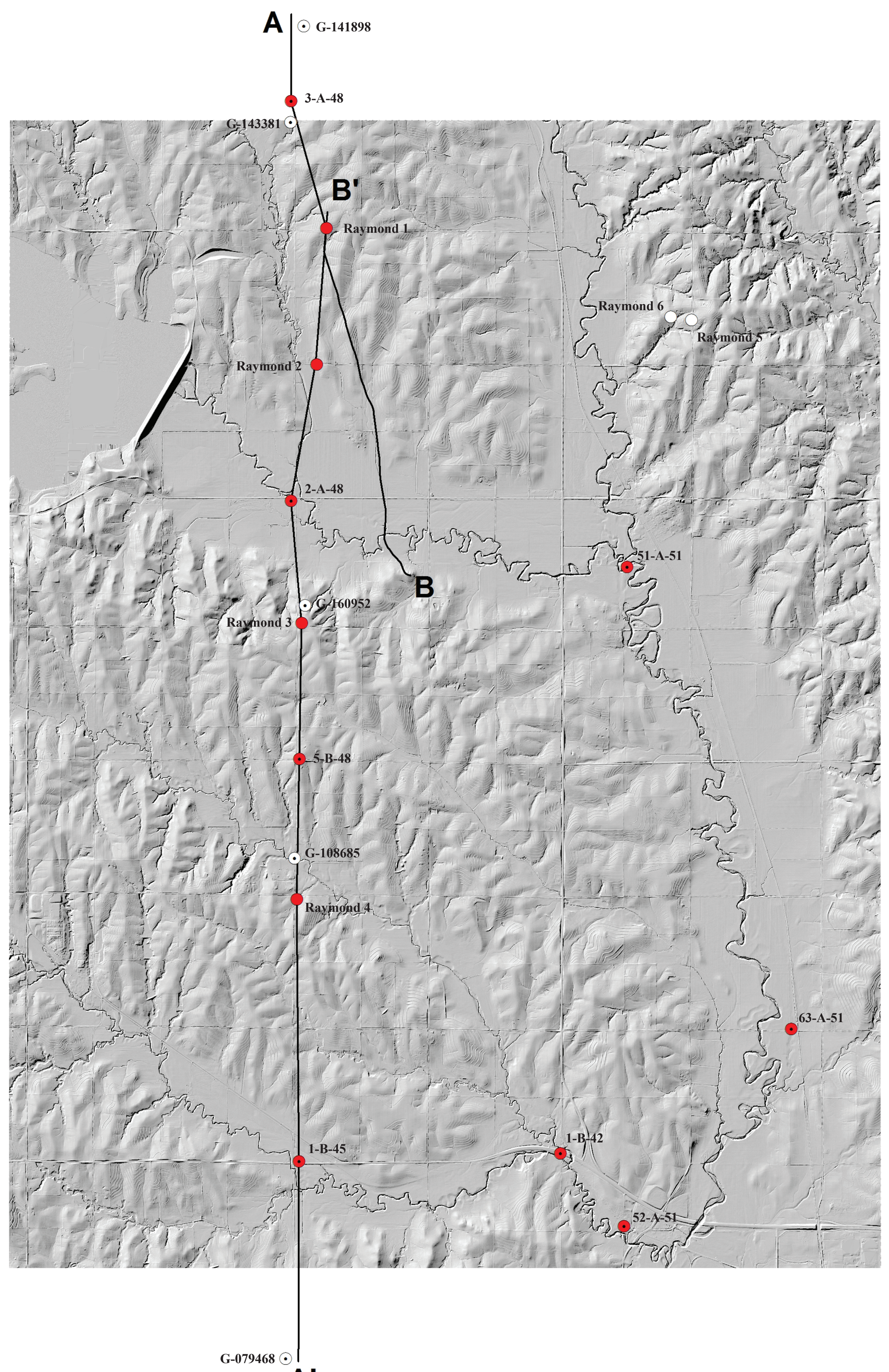

Fig. 1- Hillshade created from 2m resolution LiDAR data. Heavy black lines represent paths of cross-sections. Red dots show locations of new test holes drilled during the 2015 mapping season. Red and black dots are historic test holes drilled by the Conservation and Survey Division with the last two digits representing the year drilled. White dots show the locations of cores obtained during the 2015 mapping season and detailed core descriptions are shown in Figure 2. Black and white dots show the locations of registered wells used in the cross section.

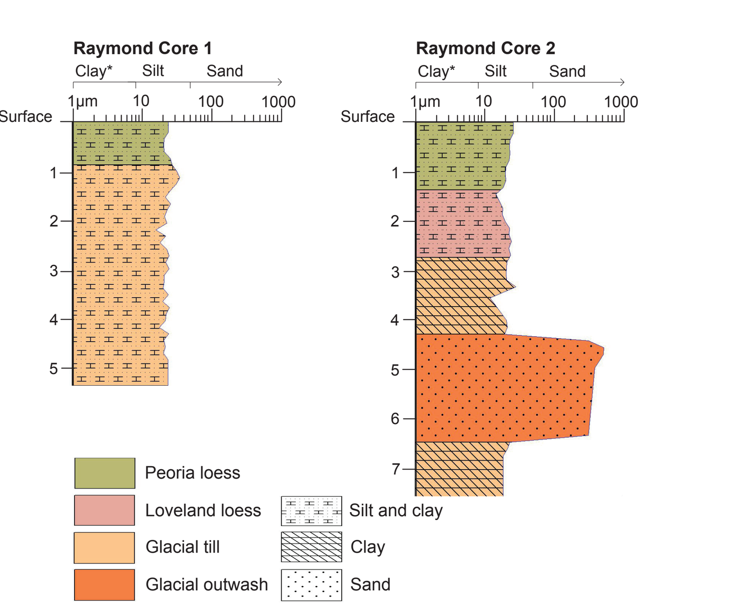

Fig. 2- Stratigraphy and particle size analysis of cores taken during the 2015 mapping season. Mean particle sizes on x-axis are given in microns (μm) (1μm=1x10^-6m). Particle size was analyzed on a Malvern Mastersizer 2000 lazer particle size analyzer. The silt-clay boundary has been moved to 8μm to correct for assumptions used in lazer particle size analysis based on known standards.

Geologic Setting

The Raymond Quadrangle is located in eastern Nebraska in an area dominated by heavily dissected rolling hills. In the mapped area, Quaternary deposits can be greater than 50 meters thick above Cretaceous bedrock. Through much of the Quaternary Period, deposition and modification of sediments by ice, water and wind have resulted in two distinct landscapes: (1) dissected rolling hills, (2) the broad, flat Oak Creek valley. These features can be seen in Figure 1.

Dissected Rolling Hills

Southeast Nebraska was glaciated during pre-Illinoian times between ~2,600,000 and 640,000 years ago (Roy et al., 2004; Balco et al., 2005), a period when much of the northern portion of the North American continent was covered by glacial ice. As the glaciers receded, glacial sediments in the form of till (Qt) and glacial sands (Qs) were deposited. Glacial till consists of brown, reddish tan or blue clays with varying amounts of sand, gravel and boulders. In some locations, the till contains sand lenses, which are important sources of water for some domestic wells. Glacial sands mapped at the surface are likely glacial outwash, and consist of silty, fine to coarse, oxidized sand, which are weakly carbonate cemented in some locations. Two cores were obtained from a mixture of glacial till and glacial outwash. Descriptions of the cores and particle-size information are summarized in Figure 2. Following the retreat of the glaciers about 640,000 years ago, the landscape was deeply dissected by a dense network of streams and tributaries. During the mid to late Pleistocene, the landscape was subsequently draped with multiple layers of windblown dust, known as the Loveland (Ql) and Peoria loesses (Qp). Much of the loess has been eroded away on steep drainages and valley walls, exposing the underlying glacial till.

Oak Creek Valley

The Oak Creek valley is a broad, flat valley extending from north to south through the eastern part of the map including the east-west valleys of smaller tributaries. The valley was deeply incised during the Pleistocene, and subsequently filled with a thick layer of sands and gravels. The thickness of alluvial sands and gravels are variable in the mapped area. In the valley to the east of Branched Oak Lake, alluvial sands and gravels can have a thickness greater than 20 m. In the valley south of the town of Raymond, test holes are shallow and do not completely drill through the alluvial sediments. However, in most locations alluvial sands and gravels are at least 5m thick. Alluvial sands and gravels are capable of supporting irrigation wells in these areas, although salt water intrusion is a concern (see discussion below). Above the sands and gravels, the most recent valley fills consist of a layer of alluvial silts and clays. Recent alluvial silt and clay in test holes 51-A-51, 52-A-51, 63-A-51 and 1-B-42 range from 4.5-10m thick.

The fine sediments of the uppermost alluvium and surrounding sediments restrict the infiltration of water, which allowed for the creation of Branched Oak Lake in the Oak Creek River Valley. During the late 1960's, a 25m high earthen dam was constructed on Oak Creek. Water impounded behind the dam covers approximately 1800 acres, and is surrounded by Branched Oak State Recreation Area.

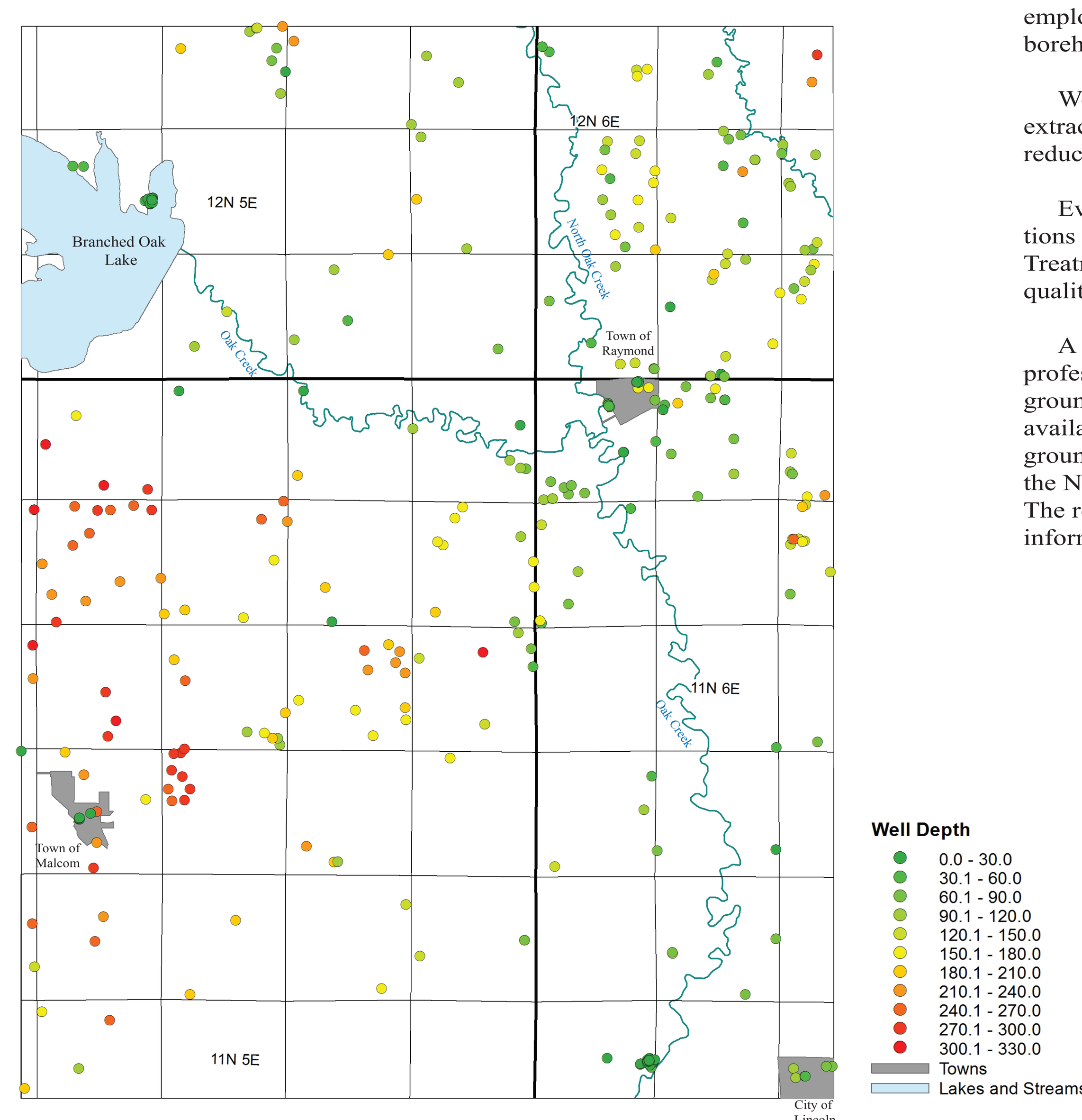

Fig. 3- Registered well locations and well depths in the Raymond Quad as of Spring 2016.

Natural Resources

Soils

Soils in the mapping area range from regions of high soil fertility to areas of poor soil fertility. Land use in the wide valleys is generally cropland. Soils formed in fine grained alluvium are thick, and have high soil fertility. Fertile soils combined with the availability of groundwater for irrigation make the Oak Creek River Valley prime cropland. Land use in the dissected rolling hills is predominately pasture land. Although soils formed in loess and some soils formed in glacial till have high soil fertility, steep slopes and high erosion potential limit non-irrigated row-crop agriculture to flat ridgetops and gently sloping hillsides. Outcrops of glacial sands generally have poor fertility and may be visible in crops as spots of stunted or dead plants.

Groundwater Resources

Groundwater availability and water quality should be a primary consideration by those seeking to locate housing developments, purchase land for a rural residence, or plan other developments in the Raymond Quadrangle. Groundwater is the only viable source of water for rural residents in this area. Public rural water has not been developed in this part of Lancaster County, so residents must rely on private wells to supply water for drinking, livestock, and other household uses. However, groundwater supplies are limited and natural water quality varies considerably.

There are more than 300 registered groundwater wells in the Raymond Quadrangle. Locations and depths of Registered wells are shown in Figure 3. Domestic wells account for 217 of this total, and only 13 are irrigation wells. The majority of the other wells are monitoring wells and geothermal wells. Well depths range from 30 – 327 feet. The deepest wells are located in uplands west of Oak Creek valley where a bedrock low exists. Most wells in this area are greater than 150 ft deep. Well depths are generally less than 150 ft north and east of Oak Creek valley where there is a bedrock high.

Aquifers are present in alluvium, Quaternary glacial sediments, and Cretaceous bedrock (See Figure 4). Almost all of the irrigation wells in the mapped area are in alluvium (Qal). Although bedrock aquifers may yield large quantities of water, salinity issues restrict their use for irrigation. Glacial sediments and bedrock generally do not yield sufficient water for large-scale irrigation. In upland areas, glacial sediments and bedrock are the primary aquifers for domestic wells. Fine to medium sands in glacial sediments (Qs) yield small quantities of water for domestic purposes locally, but the location and thickness of these sediments is difficult to predict. Medium to coarse sands are present atop the bedrock surface in some locations and these aquifers generally yield sufficient water for domestic purposes.

Sandstones in the Dakota Group (Cretaceous) are present in many areas at depth, but water quality may be a concern. Natural water quality in the Dakota aquifer varies from fresh to saline. The vertical chemistry profile may be complex, but often there will be a change from relatively fresh water near the top to saline water at depth. The possibility of encountering saline water increases with depth, so drilling significantly deeper than surrounding wells in search of groundwater is not recommended. A common strategy employed by drillers is to screen the first saturated sand or sandstone encountered in the borehole.

Wells screened in low-yield aquifers may be susceptible to drought and over-extraction. A properly designed storage and water delivery system may help eliminate or reduce water supply problems (Woldt and Benson, 2013).

Even if a suitable quantity of fresh groundwater can be found at a site, high concentrations of iron and manganese may restrict the use of the water for domestic purposes. Treatment may be required in these locations. Nitrate is not known to be a major water quality concern in this area, but problems may exist locally.

A basic recommendation for any groundwater development in this area is to have a professional water well contractor drill a test hole on a property to determine the potential groundwater availability. It is best to obtain as much information about groundwater availability and water quality before purchasing a property in this area. Information on groundwater quality is often sparse, but some information can be gained by contacting the Natural Resources District or by talking to local residents with private water wells. The reader is referred to Divine (2014), and the references contained therein, for more information about groundwater in Lancaster County.

Sands and Gravels

There are currently no known active gravel mining operations on the Raymond Quadrangle. There are no known outcrops of sands and gravels, or Dakota formation bedrock in the areas mapped. Glacial sands (Qs), where mapped are generally too fine, silty and limited in extent to be of economic importance.

Key Findings

Both the availability and quality of groundwater in the Raymond Quadrangle are highly variable. When considering land for purchase, it is advisable to drill a test hole on the property to determine the availability of clean drinking water.

Sediments in the mapping area are highly variable, both at the surface and at depth. Sediment variability can cause potential problems for agriculture uses, building sites and locating potential groundwater sources.

Processes associated with the geologic evolution of the Raymond area are complex. Forming conclusions about glacial sediments or the sequence of glacial events in the mapping area is difficult due to the age and subsequent modification of glacial sediments.

Methods

Surficial geology was interpreted from soil surveys (NRCS-USDA, 2016) in addition to field investigations. LiDAR imagery (NRCS-USDA, 2016) was used to identify breaks in slopes and other geomorphic features while mapping. Near-surface sediment cores were collected with hand augers and a Giddings soil probe. Deeper subsurface data was obtained using the mud rotary drilling technique at sites Raymond 1-4. A Geoprobe coring machine was used at sites Raymond 4-5. Other subsurface data was obtained from historic CSD test holes, as well as geologic logs from registered water wells. Particle size data was determined using a Malvern Mastersizer 2000tm laser particle size analyzer.

Acknowledgements

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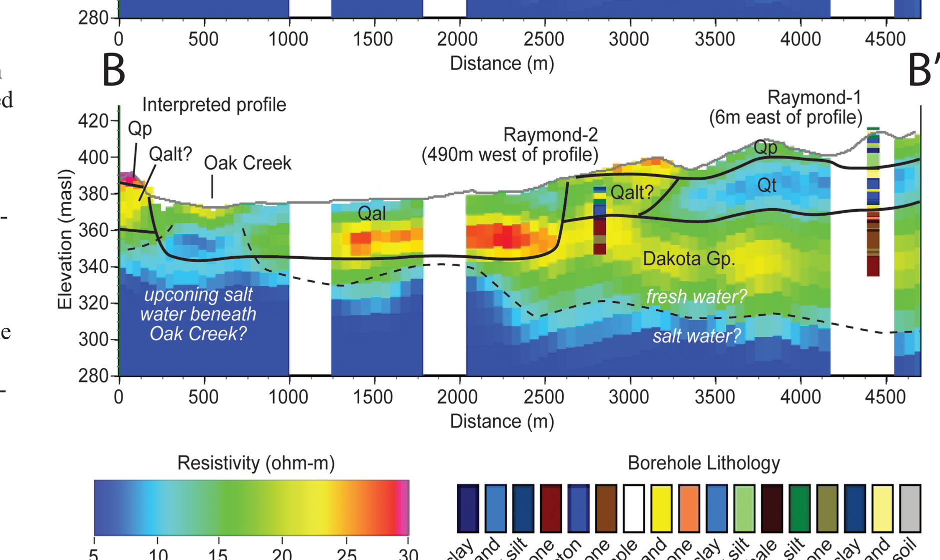

Fig. 4-This diagram shows a resistivity-depth profile from an airborne time-domain electromagnetic survey conducted in 2014 by the Eastern Nebraska Water Resources Assessment (Carney et al., 2015). Test holes drilled in 2016 for geologic mapping are superimposed on the profile. Note that the borehole elevations do not match the profile elevations because they are offset from the location of the profile (distance shown in label). Interpreted geology (bottom) is based upon resistivity contrasts, borehole lithology, and surficial geology. The dashed line shows the suspected fresh/salt water interface, but this interpretation cannot be confirmed because data on groundwater chemistry are lacking in this area. Nonetheless, salt water is known to occur at shallow depths in Lancaster County (Divine, 2014).