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Traverse County Board of Commissioners
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From: BJ Bonin, Minnesota PG 47845
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Re: Aquifer map of Croke, Dollymount, and Leonardsville Townships, Traverse County, Minnesota.

Dear County Commissioners and citizens of Traverse County:
We at AECOM are pleased to present to you the sand and gravel aquifer map for Croke, Dollymount, and Leonardsville townships.

1.1 INTRODUCTION

The Traverse County Commissioners authorized AECOM to conduct an aquifer study at their regular meeting on April 4th, 2023. The county requested the study as a basis for determining responsible and sustainable use of drinking water resources within the County. This study focuses on the townships of Croke, Dollymount, and Leonardsville. By completing this study, the County will be positioned to make informed permit decisions with regards to drinking water availability, sustainability, and recharge potential.

This first part of this report, until the section that says “Technical Support Sections” is intentionally written in layman’s language for easier reading and understanding. The more technical data is contained in the section “Technical Support Data” and is intended to be the section used for professional scrutiny.

1.2 DEFINITIONS

Sand layers: Sand layers are a layer or band of sand underground. The layers can be at different depths. They are important because water that can be pumped lies in the spaces between sand grains. Since the sand has round particles that cannot be squished together, there is room in between the grains for water to be available.

Clay layers: Clay layers are a layer or band of clay or mostly clay. Clay particles are small, flat, expand when wet, and can be compacted together so that there is very little space for water between the clay particles. When compacted, clay particles can mold around other materials in a clay layer to eliminate space available for water to flow.

Aquifer: is a specific underground area that stores and transmits water. A common misconception of an aquifer is an “underground lake”, which might evoke an image of Lake Traverse underground. An aquifer is more like a saturated sponge. In this case the sponge is coarse sand. The larger the particles of sand and gravel, the more easily water moves around and can be pumped. A large and thick aquifer will have more water available for pumping than a small, thin aquifer, just like a large sponge holds more water than a small sponge.

Confining layer or aquitard: is a layer that seals an aquifer. Usually aquitards are clay layers. How effectively an aquitard can seal off an aquifer varies, as some are essentially watertight while others leak. Aquitards are what limits how fast an aquifer can recharge, but also protect aquifers from contamination.

Pumping Capacity: This is how fast water can be pumped from the ground. It is measured in gallons per minute. The more gallons per minute, the higher the pumping capacity. If water is pumped too rapidly, fine sand particles will be pumped with the water which wears out pumps and can damage equipment. Water can only be pumped at a rate that only brings in water. The size of particles of sand in the aquifer and whether or not these sand grains are cemented together determine the pumping capacity. Pumping capacity only measures how fast water can be removed from an aquifer, not how much water is there.

Recharge: Recharge is the opposite of pumping capacity. The recharge of any well or aquifer is how fast the water removed from an aquifer is replaced so that the water stays at the same level. If the water level comes back to the original level quickly after being pumped it has a good recharge. If it takes, days, weeks, months, years, or even decades, it has a slow recharge. A slow recharge means that water should be used carefully, and that water quality will become worse as the aquifer is pumped. The main consideration for how productive an aquifer can be is recharge, *not* pumping capacity. Whether or not an aquifer recovers from pumping is the measure of aquifer productivity that matters, as removing groundwater faster than it can flow back into the aquifer causes problems with water quality, water quantity, and the cost of using the water.

Reading the map: This map is a two-dimensional image of a three-dimensional feature. Please be aware that despite the apparent wide distribution of these aquifers on the two-dimensional map, in three dimensions these aquifers are best thought of as pancake shaped sand aquifers at different depths surrounded by clay layer aquitards that don’t readily transmit water.

1.3 SOME GENERAL NOTES ABOUT AQUIFERS AND DATA IN TRAVERSE COUNTY

This study was conducted using existing well record and water level data. As such, this study is a baseline, subject to both change and confirmation as new hydrogeological information is accumulated. Some key ideas to consider:

- **The whole mapped area is relatively water-poor**, with aquifers being isolated sand layers scattered around the subsurface surrounded by clay-rich sediment which only allow for slow recharge. The most widespread aquifer in the study area is the Cretaceous, and even this aquifer isn’t universally available in the mapped area.
- **The areas are relatively small and infiltration rates may be low**, especially compared to pumping rates, but these areas are important to the groundwater system as a whole and should be protected. The areas of recharge identified by this study are for planning and protection purposes.
- **Pumping capacity is not related to water availability**. Water can be pumped much more efficiently than an aquifer can recharge. The critical measure of an aquifer test is to measure how long it takes for an aquifer to recover after being pumped. Water levels in critical aquifers (public supply or domestic use) need to be monitored before, during, and after pumping to identify if water is being removed from an aquifer faster than it recharges.
- Areas with heavy water use, whether for agriculture, industrial use, or public water supply, should have observation wells installed to continually monitor water levels in the pumped

aquifers. Pumping an aquifer often changes how and where groundwater flows in an area. This means that high pumping rates in one area can adversely affect water levels or water quality in other areas, sometimes miles away from the pumped well. Observation wells are like smoke alarms, that identify groundwater problems if and when they occur. There are grants available to fund observation well and water level monitoring projects, especially if groundwater sustainability or monitoring are called out in local water plans.

- Based on the information available for Traverse County, it appears that the aquifers in the study area are confined- the aquifers are sealed off by aquitards. Overpumping the aquifers can alter the groundwater flow in these aquifers to create unconfined conditions in a normally confined aquifer. Changing a confined aquifer to an unconfined aquifer in any way is specifically prohibited per Minnesota Rule 6115.0630 Subp.16., as it affects other nearby water features and will change the water chemistry in the aquifer. This could release undesirable elements such as arsenic or can cause minerals to form in the aquifer that can reduce the pumping rate of the aquifer.
- This study does not address water quality. Each of the aquifers should have distinct chemistry that can be used to identify specific aquifers, interconnections between aquifers, recharge, and aquifer depletion. Regular testing of groundwater is recommended to establish a baseline for an area (e.g. Dumont) and to identify changes over time that would identify signs of contamination, rechange, and depletion. There are grants available to fund water chemistry projects, especially if groundwater quality or monitoring are called out in local water plans.
- The Minnesota Department of Natural Resources is the only party that regulates water use (appropriations) in the State. Minnesota does not have “senior water rights” like many states south and west of Minnesota. The State Constitution states that water is a public resource, and that all citizens have the right to use water for personal use. If any party wishes to use more than 10,000 gallons of water in a day, or 1 million gallons of water or more in a year, then a permit is required to do so, and having that permit does not allow that user to interfere with anyone’s personal water use. Details of how this works can be found on the DNR’s website or by calling your DNR Area Hydrologist in Fergus Falls.

1.4 OVERVIEW

This study was conducted to determine the location and extent of local aquifers to the extent that data exists. This study used existing regional aquifer data, well records, and water level elevations in those wells to identify local aquifers. Areas of possible interconnections between aquifers and connections to surface sand where recharge may occur were mapped. The study produced data for unconsolidated sand and gravel layers within the three townships along with some overlap into adjacent areas.
A search was conducted for the most comprehensive and up-to-date geological information available for Traverse County. Regional Hydrogeologic Assessment 6 Parts A and B (RHA6 – Harris 2006, Harris and Berg 2006) from the Minnesota Geological Survey (MGS) and Department of Natural Resources (DNR) were used as a base for geological mapping. Detailed examination of well logs was done to interpret the geology below the surface. The attached map (Figure 1) was prepared using this data to assess conditions within the area. The map shows the aquifers mapped in RHA6 with adjustments based on additional well data, including some new aquifers that were not mapped in RHA6. The general stratigraphy of the project area can be generalized as unconsolidated sediment, bedrock, and basement rock. A brief description of each of these is presented below.

Unconsolidated sediment is clay, silt, sand, gravel, and boulders that have not been consolidated into rock. These deposits were deposited by ice, water, and wind. Many different layers of these sediments exist in Traverse County. Sand and gravel layers can yield water with varying quantity and volume. Where unconfined or partially confined, sand and gravel can be vulnerable to contamination from surface sources (fuel, waste, chemicals, etc.). Silt- and clay- rich layers inhibit water flow on a local or regional scale and can confine buried sand and gravel layers. These layers can vary widely in thickness and extent. This study focused on finding water bearing sand and gravel layers in the project area. The sand and gravel layers were deposited by ice and water, with moving water from wave and stream processes removing clay and silt leaving concentrated sand and gravel behind.

Bedrock is layered sandstone, siltstone, and shale. Bedrock in Traverse County consists of Cretaceous age sediment that is barely lithified into rock. As a result, these sediments are often not identified as rock. These were deposited in shallow marine, littoral, fluvial, and onshore environments approximately 83-94 million years ago (Setterholm 1990). Most of the bedrock is shale and siltstone, including occasional seams of sub-lignite to lignite coal, beds of chalk and limestone, with some layers or lenses of water bearing sandstone. The bottom layer, often called saprolite, "sap rock", or "decomp" (for decomposed rock) is the 83- to 94-million-year-old weathering surface that is clay mixed with grains and crumbly lumps of the underlying basement rock (Setterholm 1990). Sandstone units can produce water in some volume, but that volume can vary greatly depending on the lateral extent of the sand or sandstone unit, changes in grain size, the degree of sorting, and degree of cementation that are present but unmapped in the area. Saprolite can yield water where the weathering process left a granular material instead of clay, but this is not common and is usually only dilled when there are no other shallower options. The Minnesota Geological Survey has just started the process of mapping Traverse County as part of the MN Geological Atlas program but mapping Cretaceous sediment has not yet been done as part of an Atlas anywhere in Minnesota.

Basement rock is coarse crystalline rock, such as granite or schist, that makes up the bulk of the earth's crust. In western Minnesota, these rocks represent the depth at which a well will not produce water unless a fracture can be intercepted. These rocks are exposed in the Minnesota River valley but are generally found at a depth of approximately 300 feet or greater in Traverse County.

1.5 AREAS OF RECHARGE AND INTERCONNECTION

This study identified several areas where recharge or flow between aquifers **may be** occurring. These areas are discussed further below:

- **MAP AREA 1** Dollymount Township, Section 17: Stream sand and gravel over 0-40 ft, 40-80 ft depth Otter Tail sand over 80-120 ft depth Western sand. Well 409254 in this area shows sand from 37-90 feet, which is almost certainly both sand units. Interestingly, this well is screened below 200 feet. Well 483135 located just to the northwest of this area shows sand layers at 81-82 and 108-122 feet, respectively, separated by clay. This area could slowly recharge multiple aquifers over a wide area and should be investigated further.
- **MAP AREA 2** Croke Township, Section 13 and vicinity: Otter Tail sand at 0-40 ft depth, located 8 feet from the surface in well 411966. Sand is not identified in well 812787 (a Cretaceous aquifer well), so the unit must be thin and/or near surface. This area is just west of the one discussed above, and is likely connected to it.
- **MAP AREA 3** Dollymount Township, Section 4 and vicinity: Otter Tail sand and Western sand at same depth intervals. Some logs show a thin (<5 ft) clay layer between sand layers, so there may be some isolation between these units. Gradual downward flow from the Otter Tail aquifer into the Western Aquifer may be assumed. The aquifer at Riverview Farms below 160 feet could be in direct contact with the deeper parts of the Otter Tail and Western sands. Pumping any one of the aquifers in the area could affect wells in the other aquifers.

- **MAP AREA 4** Clifton Township, Section 32, two areas: Otter Tail and Western Aquifers appear to be stacked in these areas, with some clay in between the two. Water chemistry data could be used to determine if the aquifers are interconnected in these areas.
- **MAP AREA 5** Walls Township, Section 1 and vicinity: Otter Tail sand and Western sand at same depth intervals were identified. This area is at the far margin of the project area and should be investigated further.
- **MAP AREA 6** Croke Township, Section 19 and vicinity: Otter Tail sand 0-40. There are no wells located in this area, but a beach ridge is mapped over the top of this shallow unit. Just to the west in Walls Township, the sands are deeper but the Otter Tail and Western Aquifers appear to be stacked in these areas, with some clay in between the two. Water chemistry data could be used to determine if the aquifers are interconnected in these areas. If they are, then this area could be a recharge area for both aquifers.

1.6 CONCLUSION FOR NON-TECHNICAL SECTION

- On average the aquifers in the mapped area range from 50 feet to 400 feet in depth.
- On average their recharge timeframe is decades to centuries- very slow.
- The best way to monitor aquifers to determine their health is to install observation wells in strategic areas. I can give you suggestions on where to put them.
- The aquifers can support household use, farms, and the city of Dumont. However, large volume use beyond that is probably not sustainable. I would recommend that pumping rates and water volumes from any large volume user be limited to the recharge of the aquifers they use. This way there is enough water available for future needs.
- There has been concern raised regarding tiling having the effect of depleting aquifers. In Traverse County, because the soil has so much clay under the topsoil, that is not a concern here. There are only a few places (the recharge areas mapped) where the soil composition allows surface water to recharge the aquifers, and these are generally high spots where water doesn’t accumulate.
- In Traverse County, the aquifers are recharged by water slowly flowing through the clay layers surrounding them. There are only a few areas where recharge is probably happening at a faster rate, and those are on the map and discussed in the previous paragraph.

2.0 TECHNICAL SUPPORT SECTIONS

2.1 AQUIFERS IN SOUTHEAST TRAVERSE COUNTY

There are several significant aquifers available in Traverse County. Unfortunately, none of these aquifers are uniformly available everywhere in the county. Some locations may have several of these available and other locations may have none of them. An introduction of each of these significant aquifers is presented below.

- Surficial sand and gravel- mapped in RHA6, either glacial lake beach ridges or stream-related sand and gravel deposits. These layers are generally less than 20 feet thick and lie at or near the land surface. This may be a local source of water, but is vulnerable to drought, overpumping, gravel mining, and contamination.

- Otter Tail- outwash and glacial-fluvial sand and gravel deposits deposited by the Red River lobe of glaciation. The younger of the two aquifers in the project area described in RHA6, associated with the Otter Tail Group of glacial sediments. There are two relatively small areas where this layer is either at the surface or in approximate contact with surficial sand and gravel with should be considered an area of potential recharge into the Otter Tail aquifer. It is unclear whether or not these two areas are a recharge source, but the potential is there and should be taken into consideration when making land use decisions.
- Western- outwash and glacial-fluvial sand and gravel deposits deposited by the Red River lobe of glaciation. The older of the two aquifers in the project area described in RHA6, associated with the James Group of glacial sediments. There are several areas in the project area where this aquifer is in approximate contact with the overlying Ottertail aquifer, which indicates a likely hydraulically link between the two aquifers. In these areas, pumping or recharging one of these aquifers has the potential to affect the other.
- Cretaceous- the deepest of the local aquifers, this general category includes water bearing sand/sandstone, silt/siltstone and granular weathering residuum of the underlying Precambrian crystalline basement rock. The Cretaceous sediments are not strongly lithified, so the sandstone and siltstone might not be cemented at all in places. Water bearing units in the area's Cretaceous strata vary widely, from multiple thick sandstone units to no sandstone at all. This unit is generally 180 feet deep and deeper. Water quality is often poor, with high TDS (etc.), and becomes worse to the west (Woodward and Anderson 1986). The water quality concerns and depth (which is the main factor in well construction cost) make this unit the aquifer of last resort. This is the most widely available aquifer in the county, but it has the worst water quality and has the lowest recharge potential.

Several new aquifers were identified by this study. New aquifers include:

- Dumont- a sand and gravel aquifer located near the town of Dumont, below and separate from the Western aquifer, that is identified in only a few wells but supports pumping for the Dumont municipal water system. This could be attributed to the James Group of glacial sediments, like the Western aquifer, or "Aquifer 1" as described in Grant County to the east, but it also could be a unique stratigraphic unit associated with the Gervais Formation, Old Hawley till, or Old New York Mills till. It isn't clear if this aquifer is sustainable, so water levels should be monitored over time.
- Unknown(s)- there are several aquifers mapped that have unknown attribution. These appear to each have sand layers within a specific interval and a common water level range, but data is unavailable to allow attribution to one of the named aquifers discussed above. Until shown otherwise, we recommend that these aquifers be considered isolated to ensure that domestic use is sustainable, as more research is necessary to determine if these aquifers can adequately recharge or connect to other nearby aquifers.

2.2 METHODS

Well information for both located and unlocated wells from the Minnesota Well Index (MWI) were imported into Geographic Information System (GIS) mapping software. The logs were interpreted, and each sand layer identified in a well log was noted with regards to thickness and depth. The screened interval was noted along with a static water level. The located wells were plotted in GIS and the location and depth of the various sand layers were compared to each neighboring well. The water levels were compared for the sand layers where water level data is available, considering that water levels are only available for a given sand layer if there is a well screen set in that layer. Sand layers of a similar depth over a given area were noted, and water levels compared. If the depths of the sand layers and water levels had a similar range, then they were grouped together as an aquifer. Using county parcel data, well data provided by the county, scanned records in the MWI, and MNTopo (online Minnesota topographic map http://arcgis.dnr.state.mn.us/maps/mntopo/), unlocated wells were mapped, and the same process was applied to verify the aquifers identified in the previous step. Modifications were made to the preliminary aquifer map. Once this was complete, the shapefile was constructed using RHA6 as a template- displaying the sand layers in 40-foot depth increments. Confidence was noted:

- High confidence: these aquifers were very similar or identical to existing maps such as RHA6, and the map user can be assured that the aquifer is present at that location,
- Medium confidence: these aquifers were not mapped in the original RHA6 but has many wells tapping it and a record of having a high pumping capacity over a long period of time; or there are aquifers mapped in the original RHA6 but several well logs indicated that modifications to that part of the RHA6 map were necessary. Map users should be aware that these aquifers have questions associated with them, whether that be if the aquifer is useable in that location, or if there are limitations to using that aquifer, or some combination of these.
- Low confidence: these aquifers were mapped using only a few wells over a relatively wide area, sharing a water bearing sand layer at a specific depth with similar water levels. The small amount of data makes these aquifers speculative. Map users should be aware that these aquifers may have significant limitations, such as pumping capacity or even if it is there at all.

Future well construction will verify these layers or show where modifications to the shapes are required.

Please note that the RHA6 shapes for the Ottertail and Western Aquifers are included in the shapefile produced for this project. There are notable differences between the two in the project area, but the RHA6 version covers nearly the whole county while the shapefile for this project only covers the three townships plus some adjacent areas. Where possible, the mapped aquifers were attributed to the ones mapped in RHA6- in this part of the County, the Western and Ottertail aquifers. However, an accurate comparison could not be made without additional data.

2.3 EXCEPTIONS

This project did not take into consideration water quality, except for the Cretaceous aquifer.

Not all aquifers can be pumped heavily for long periods of time. Overpumping an aquifer can result in sand pumping and removal of more water than can recharge. Pumping rate can be estimated for aquifers using a specific calculations, however, this was not done in this study. Pumping rate does not address how long an aquifer can sustain being pumped at that high rate. Pumping capacity can exceed the ability of an aquifer to recharge by a wide margin especially in western Minnesota.

Specific capacity (pumping rate per foot of water level decrease caused by pumping) can be calculated using data available in the MWI. Since specific capacity measures a combination of both aquifer characteristics *and* well efficiency, it takes many wells in an aquifer to see a pattern. There simply aren’t enough wells in any one aquifer within the project area to identify a pattern from the data, with the marginal exception of the Dumont Aquifer. In addition, a specific capacity analysis does not consider recharge at all. Specific capacity analysis ignores impacts on water quality and quantity over time.

2.4 REFERENCES

Harris, K.L.. (2006). Regional Hydrogeologic Assessment 6, Quaternary geology-Traverse-Grant area, west-central Minnesota [Part A]. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle.net/11299/59784.

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Figures

Figure 1 : Aquifer Map

Figure 1. Croke, Dollymount, and Leonardsville Township Aquifer Map