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Establishment of a Groundwater Monitoring Network and Evaluation of Multi-Aquifer Wells in Campton Township, Kane County, IL

Letter Report to Kane County Division of
Environmental and Water Resources

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Introduction and Background

Campton Township in central Kane County, IL has one of the highest densities of domestic wells for any township in Illinois. Residents rely exclusively on groundwater to meet domestic needs, either from individual private wells, shared private wells, or wells operated by public water entities, such as in subdivisions. Residents rely on several aquifers to meet water needs and it is commonplace for wells to be open to multiple geologic units. The geology of the township consists of the following: 1) Quaternary glacial deposits at land surface, 2) the Silurian Dolomite and Maquoketa Shale at the bedrock surface, 3) the underlying Galena-Platteville Dolomite, and 4) the deep St. Peter Sandstone.

The glacial deposits have a range of particle sizes, but also contain thick and laterally continuous sand and gravel deposits that serve as important aquifers. The Silurian Dolomite is the youngest bedrock unit but generally thins towards western Kane County and is not laterally continuous due to erosion of the bedrock surface. It is considered a minor aquifer in the township. The Maquoketa Shale underlies the Silurian Dolomite and is an important aquitard in the region that under natural conditions limits vertical recharge to the lower geologic units. The Maquoketa Shale unit includes beds of dolomite, which could locally serve as a minor aquifer in the township. The Galena-Platteville Dolomite underlies the Maquoketa shale. It is a thick unit (several hundred feet) but has a relatively low hydraulic

conductivity. The St. Peter Sandstone underlies the Galena-Platteville Dolomite. The St. Peter Sandstone is a productive regional aquifer used by many municipalities and industries within the county.

A number of groundwater investigations in Campton Township have occurred since the early 1990's. These studies were conducted by the Illinois State Water Survey (ISWS) and the U.S. Geological Survey (USGS) in response to a growing population in the township, an increase in the number of private wells drilled, local cases of wells going dry, and the potential for the aquifers to not meet water supply demands in the long-term. Benson (1990) evaluated the hydraulic properties of the Galena-Platteville Dolomite and tested alternative well designs to reduce the likelihood of dry wells in areas of the township where the Maquoketa Shale was predominately being used for domestic water supplies. Kay and Kraske (1996) conducted a mass measurement of water levels in the various aquifers in the Township and evaluated whether each aquifer was being overutilized. This study was followed up by a modeling study by Kay et al. (2006) that evaluated change in water levels since 1995 and the sources of recharge to each aquifer. Meyer et al. (2009) conducted extensive groundwater flow modeling of Kane County, which included Campton Township. These studies indicate that:

1. The Galena-Platteville Dolomite has a low hydraulic conductivity and limited production. Wells that have open intervals that extend into the Galena-Platteville Dolomite have increased production, but this is related to the storage capacity of the borehole itself, and less on the transmissivity of the Galena-Platteville unit (Benson 1990).
2. The shallow bedrock units (the Silurian Dolomite and Maquoketa Shale) and the Galena-Platteville Dolomite are overutilized (declines of over 15 feet) in portions of the township whereas the shallow sand and gravel aquifers and the deep St. Peter Sandstone are not overutilized (Kay and Kraske 1996). This is related to the thickness and aquifer properties of those units. Since the shallow bedrock units are predominantly shale and dolomite and thinner in comparison to the deeper bedrock units, it is much more likely that these shallow bedrock units have limited groundwater availability. The Galena-Platteville unit is thick but has low hydraulic conductivity, which also limits groundwater availability.
3. Shallow recharge to the sand and gravel and upper bedrock units is derived from precipitation and there are areas of high recharge rates in the western portion of the township. This shallow groundwater does not generally flow into the deeper Galena-Platteville and St. Peter units because of the presence of the Maquoketa shale aquitard (Kay et al. 2006). Recharge to the deeper units occurs in north-central Illinois where those units are at the bedrock surface and are in direct connection with productive sand and gravel deposits.

Although these previous studies don't explicitly evaluate the potential of multi-aquifer wells to serve as flow pathways by bypassing the Maquoketa Shale aquitard, there has been anecdotal evidence in Campton Township of deep multi-aquifer wells (open to both the Galena-Platteville and St. Peter sandstone) causing nearby shallow wells to go dry. For example, in 1994 a high capacity St. Peter well was drilled for the Wasco Sanitary District. While the well was being drilled, water levels in several private wells in the Wideview subdivision (less than a mile away to the northwest) dropped below the elevation of the pumps, resulting in an interruption to water supply for the homeowners. Evaluation of this incident by Adrian Visocky at the ISWS indicated that this was likely due to lowered water levels in the Maquoketa Shale due to dry conditions, which happened to coincide with the timing of the St. Peter well drilling, as opposed to draining of the upper aquifers via the open borehole. However, this conclusion was not definitive. The issue was resolved by lowering the pumps at the affected wells.

Motivation of Study

Water levels in the St. Peter Sandstone aquifer have been declining in Northeastern Illinois since the early 1900s due to a long history of municipal and industrial use throughout the Chicagoland area. Drawdown in the St. Peter within Campton Township ranges from 300-400 feet (Figure 1). Under natural conditions, this decline in sandstone heads would not influence residential wells finished in the shallow bedrock aquifers above the St. Peter Sandstone because the low permeable Maquoketa Shale separates these two aquifers. Since the late 1980s, however, the number of residential wells being drilled into the St. Peter Sandstone has increased substantially in Campton Township (Figure 2). Many of these wells puncture the Maquoketa Shale, allowing for potential pathways for groundwater to drain from upper aquifers into the St. Peter Sandstone. If groundwater is flowing from upper aquifers to lower aquifers, this would potentially lower water levels in the shallow aquifers and force certain homeowners to set pumps to a deeper depth or even drill wells deeper.

After the 1994 Wideview subdivision issue, the Kane County Development Department established a policy for well drilling in Campton township in which new subdivisions using private wells (non-community supply) were required to have wells drilled to the St, Peter as part of the subdivision approval process. The policy did not apply to single lots that were not part of subdivisions. This policy change in the mid-1990s could be in part the reason for the increasing number of St. Peter wells in the township (Figure 2).

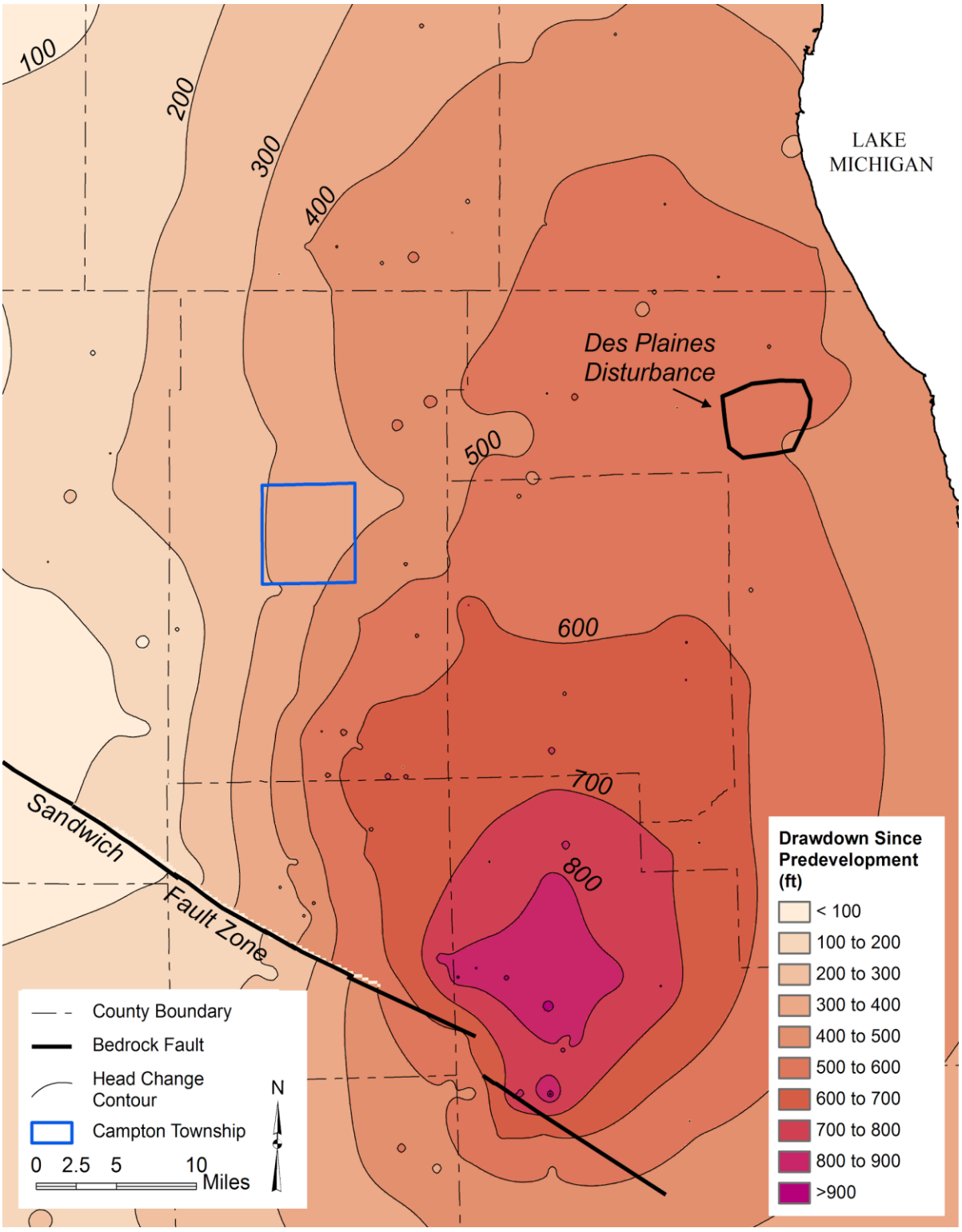

Figure 1: Drawdown in the St. Peter Sandstone aquifer since predevelopment conditions. Drawdown in Campton Township typically ranges from 300-400 feet.

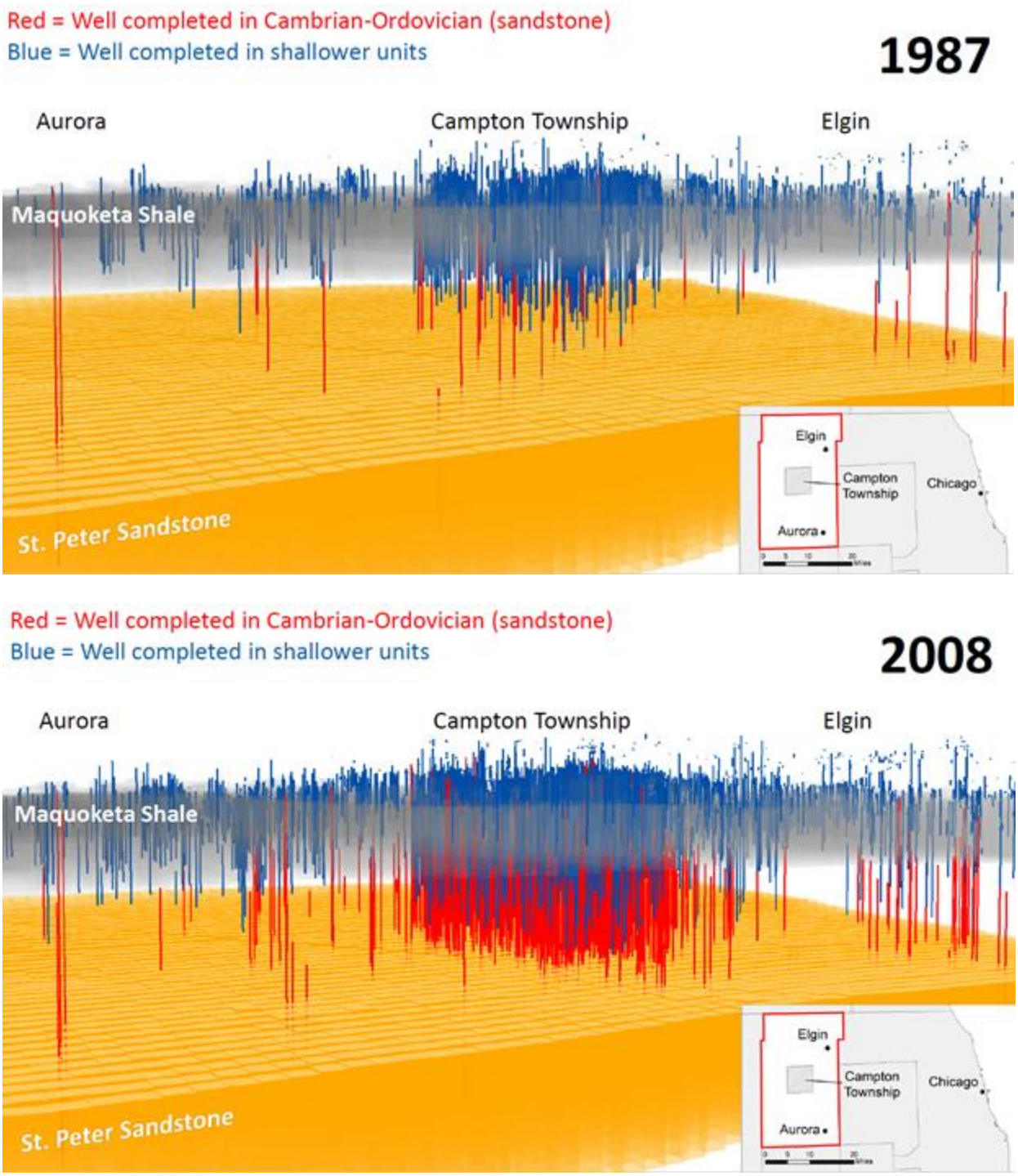

Figure 2: Shallow bedrock (blue) and St. Peter Sandstone (red) wells in the Campton Township area in 1987 and in 2008. Note the large increase in the number of wells drilled and the increase of wells being drilled into the St. Peter.

Residential well owners in Campton Township have the potential to be impacted by multi-aquifer wells that connect the sand and gravel and the shallow bedrock aquifers to the deeper sandstone aquifer. The severity of these impacts would be contingent on a variety of factors, including the proximity to neighboring wells, the open intervals of those wells, the permeability of the local aquifer, and the water level in the St. Peter Sandstone. To address the potential issues of multi-aquifer wells in Campton Township, we classified the types of multi-aquifer wells using ISWS and Illinois State Geological Survey (ISGS) records, mapped densities of wells open to specific aquifers, and deployed water level monitoring sensors to evaluate if withdrawals from multi-aquifer St. Peter wells affect water levels at wells finished in shallower aquifers.

Evaluation of Domestic Multi-aquifer Wells

The ISWS and ISGS maintain a well records database that consists of well logs submitted by drillers through public health departments. There are 2,638 domestic well records for Campton Township in the ISWS/ISGS well databases. Of those 2,638 records, 2,113 have well depth and casing information needed to evaluate what geologic units wells are open to. Using parcel data provided by the Kane County GIS department, we determined that there are 6,147 parcels coded as agricultural/residential use (Figure 3). We then subtracted the number of parcels (2,201) that are within the service areas of the Wasco Sanitary District, the Village of Elburn, and the Windings Subdivision, which have central water systems (Figure 3). This leaves 3,946 parcels that are not served by a central water system but instead presumably meet their water needs with private wells (self-supplied). Under this assumption, that means the ISWS/ISGS only has well records for 67 percent of the self-supplied parcels within the township. The percentage of parcels that we have reliable casing information in which to classify multi-aquifer wells is less (53.5 percent). The percentage of parcels the ISWS/ISGS has well records for in Campton Township is typical for the state.

Using the 2,113 well records with depth and casing information, we then used spatial analyst tools in ArcGIS to assign elevations to each well record point using LIDAR data and calculated the elevations of the top and bottom of the open intervals of each well. This was accomplished by subtracting the casing depth from land surface elevation and subtracting the total well depth from the land surface elevation. The elevations of the top and bottom open intervals at each well where then compared to bedrock geologic elevations developed for the Kane County groundwater flow model (Meyer et al. 2009), allowing classification of the aquifers that each well is open to. However, the locations of wells in Campton Township are often approximate and are based on the PLSS systems (Township, Range, section, Plot) as opposed to a Latitude/Longitude coordinate. Aquifer classification is based on the deepest aquifer the well is open to, but is approximate given the uncertainty in the locations of the well records. The results are shown in Table 1. Most wells are either finished in the Maquoketa Shale or Galena-Platteville Dolomite units. A smaller percentage (12.5 percent) are shallow sand and gravel wells. A substantial number of wells (22.8 percent) are finished in the deep St. Peter Sandstone.

Review of the water levels reported at the time of drilling (Table 1) indicates that there are head differences between the different aquifers (on average). Not surprisingly, heads are highest in the sand and gravel and shallow Silurian Dolomite aquifers and are subsequently lower as you move stratigraphically downward. There are large ranges of water levels, particularly in wells finished in the Galena-Platteville Dolomite. This is likely the result of drilling practices, which commonly consists of casing only the upper sand and gravel units and having long open intervals open to the Silurian, Maquoketa, and Galena-Platteville units. There is less deviation in water levels for wells open to the St. Peter, likely because it is more common for drillers to case through the Maquoketa unit when drilling such a deep well.

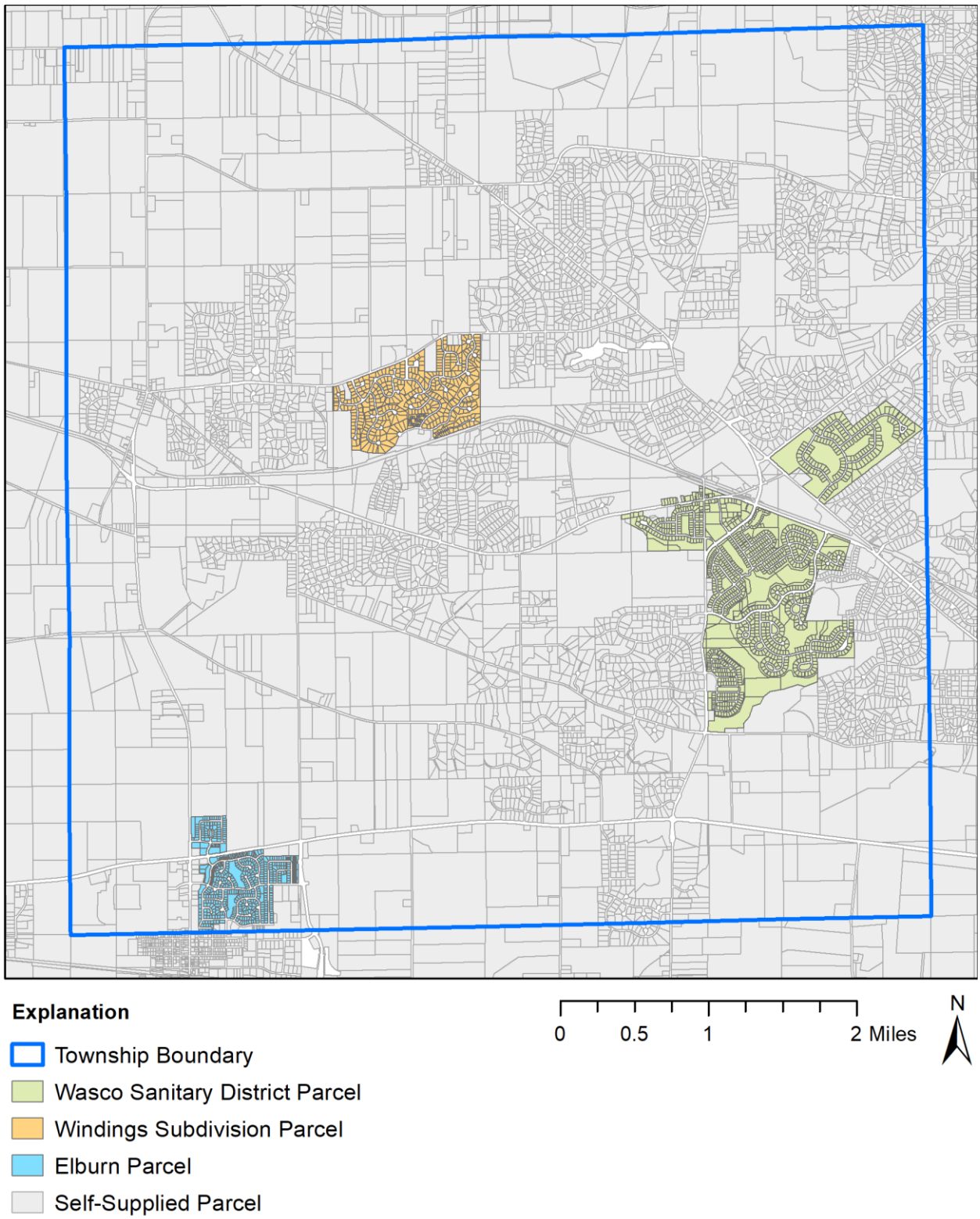

Figure 3. Map of parcel boundaries of Campton Township obtained through the Kane County GIS Department. Colored parcels are supplied by community water systems whereas gray parcels are considered self-supplied (i.e., these parcels obtain water through private wells).

Table 1. Summary statistics of reported water levels at the time of drilling for Campton Township wells, classified by aquifer type. Aquifer classification is based on the deepest aquifer the well is open to.

Deepest Aquifer Wells are Open to	Number of Wells	Percentage of Wells	Average Depth to Water (ft) when Drilled	Min Depth to Water (ft) when Drilled	Max Depth to Water (ft) when Drilled	Std. Dev. Depth to Water (ft) when Drilled	Average Head (ft AMSL)
Glacial Sand and Gravel	264	12.5%	69	3	170	39	810.5
Silurian Dolomite	12	0.6%	63	30	100	20	835.3
Maquoketa Shale	726	34.4%	81	8	230	41	768.1
Galena-Platteville Dol.	629	29.8%	275	20	550	115	581.5
St. Peter Sandstone	482	22.8%	349	100	550	62	519.4
Total	2113						

Review of the casing information and geologic unit elevations indicates that there are few deep wells open only to a single aquifer (Figure 4). Most St. Peter wells are open to the Galena-Platteville and a quarter are open to the Maquoketa Shale. Three St. Peter wells are open all the way through to the Silurian Dolomite unit. No St. Peter wells were open through to the glacial sand and gravel deposits. For wells classified as Galena-Platteville wells, only 16 percent are considered single aquifer wells, whereas 82 percent were also open to the overlying Maquoketa Shale. For wells that are classified as Maquoketa wells, the majority (82%) are only open to that unit, but there are 17 percent that are open to overlying glacial sand and gravel deposits. Given the ubiquity of multi-aquifer wells that are drilled through the Maquoketa Shale (some of which that are also screened into overlying sand and gravel deposits) there is potential for shallow water in the glacial sand and gravel aquifers to flow into deeper aquifers.

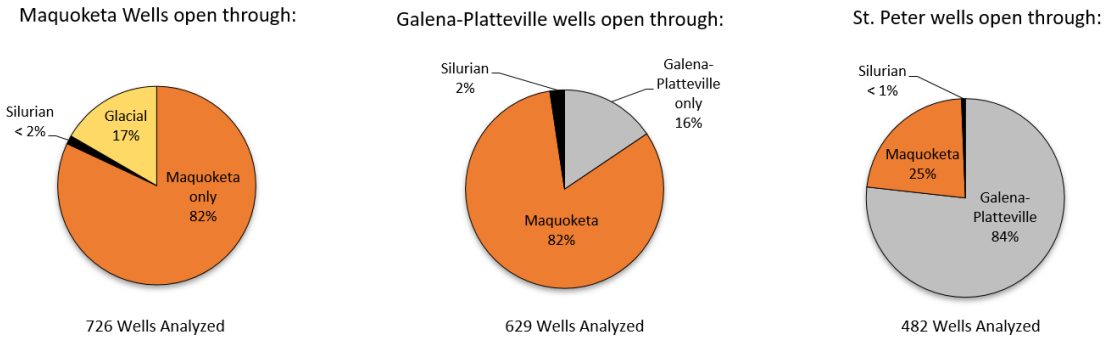

Figure 4. Pie charts showing the open intervals of wells in Campton Township. Wells are classified by the deepest aquifer the wells are drilled to and are further characterized by what overlying geologic units the wells are also open to.

We also reviewed the domestic well records to determine if any wells previously drilled have been re-drilled to access deeper aquifers. Many well deepening records would indicate that water supplies are not meeting domestic needs in a given area. Review of the well records indicates that only 8 wells have been re-drilled to a deeper depth (Table 2). Five of the eight wells were previously open to the Galena-Platteville Dolomite and were deepened to the St. Peter Sandstone. The few records of wells being deepened indicates that few homeowners in Campton Township have experienced inadequate water supply from their domestic wells.

Table 2. Summary statistics of reported domestic wells that have been re-drilled to a deeper depth.

Site	Year first drilled	Previous aquifer type	Previous depth	Year deepened	Current aquifer type	Current depth	Section number
D1	2002	GP	400	2010	SP	740	11
D2	1994	GP	170	-	GP	645	13
D3	1995	GP	580	1996	SP	660	24
D4	1992	SP	660	2001	SP	720	25
D5	1978	GP	320	1988	SP	725	10
D6	1993	GP	185	1993	GP	530	25
D7	1993	GP	600	2007	SP	740	10
D8	1989	GP	505	2012	SP	740	18

MQ: Maquoketa Shale, GP: Galena-Platteville Dolomite, SP: St. Peter Sandstone

We used ArcGIS spatial analyst tools to create rasters that represent the densities of domestic wells in Campton Township by aquifer type. Results are reported in number of wells per square mile. Online versions of the density maps area available in an interactive web application (https://univofillinois.maps.arcgis.com/apps/webappviewer/index.html?id=e364cd4c39d847f3ba4f794986a85883). Densities of private wells are obviously higher where there are large subdivisions that are not supplied by a community water supply system. There is a corresponding lower density of private wells where there are parcels served by the Windings, the Wasco Sanitary District, and the Village of Elburn central water systems, and in more rural parts of the township (Figure 5). There is a high density of sand and gravel wells in discreet areas within the township (Figure 6) which roughly correspond to areas where glacial drift is thicker or where the St. Charles Bedrock valley Aquifer is present. There is a higher density of Maquoketa wells (Figure 7) in the eastern half of the township, particularly in the northwest corner and the south-central portions. For Galena-Platteville wells (Figure 8), there is a high density in the east-central portion of the township and in a band that extends from the Lily Lake area towards the central portion of the township, and up to Silver Glen Road. The map of St. Peter well density (Figure 9) indicates numerous St. Peter wells in the subdivisions northeast of Lily Lake.

These maps indicate local areas of high aquifer productivity for each of the aquifer units in the township, since usually drillers stop drilling if they have encountered a productive enough area for domestic water supply. If a driller has not encountered a productive enough unit, they will continue to drill into deeper formations. These maps can also indicate where there is higher risk of aquifer flow between upper and lower aquifer units (i.e., sand and gravel aquifer water flowing through the Maquoketa Shale via multi-aquifer wells into the deeper bedrock units). This would be in areas where there is a large number of wells open through the Maquoketa Shale in close proximity to Galena-Platteville and St. peter wells, such as in the northeast quadrant of the township and to a lesser degree the southeast quadrant of the township (Figures 7 and 8).

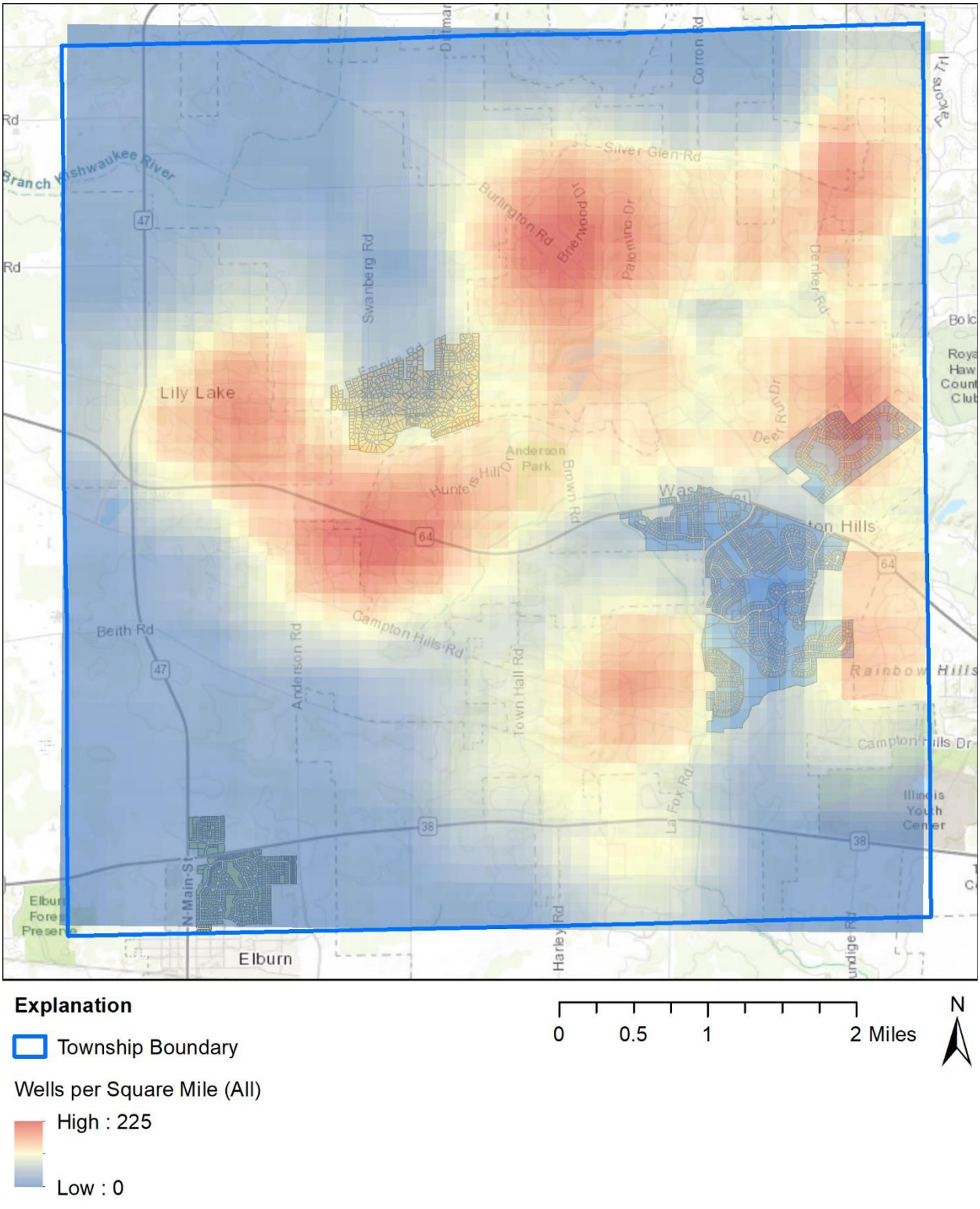

Figure 5. Map of well density for all private wells in Campton Township in relation to areas that are on central community water supply systems.

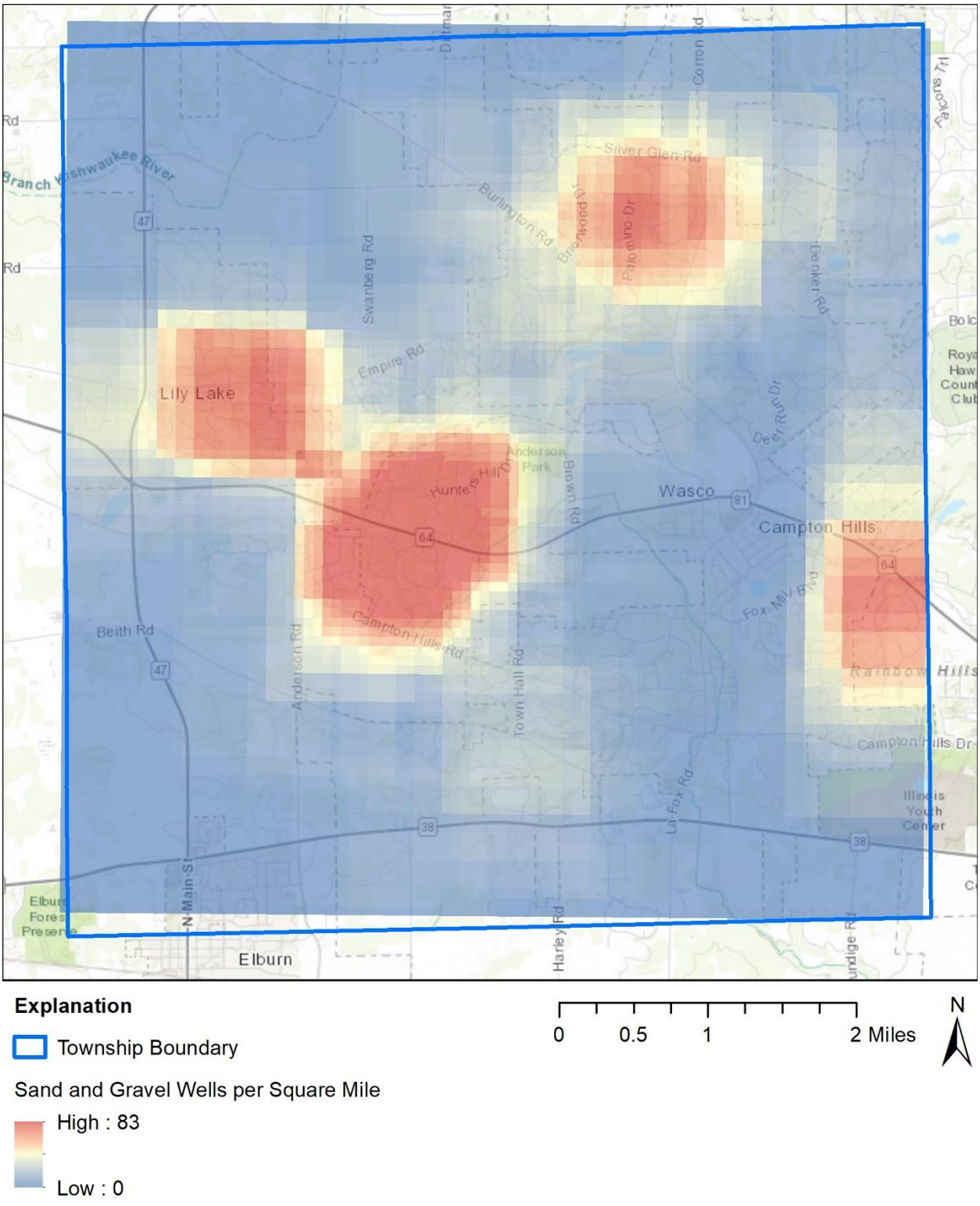

Figure 6. Map of well density for glacial sand and gravel wells in Campton Township.

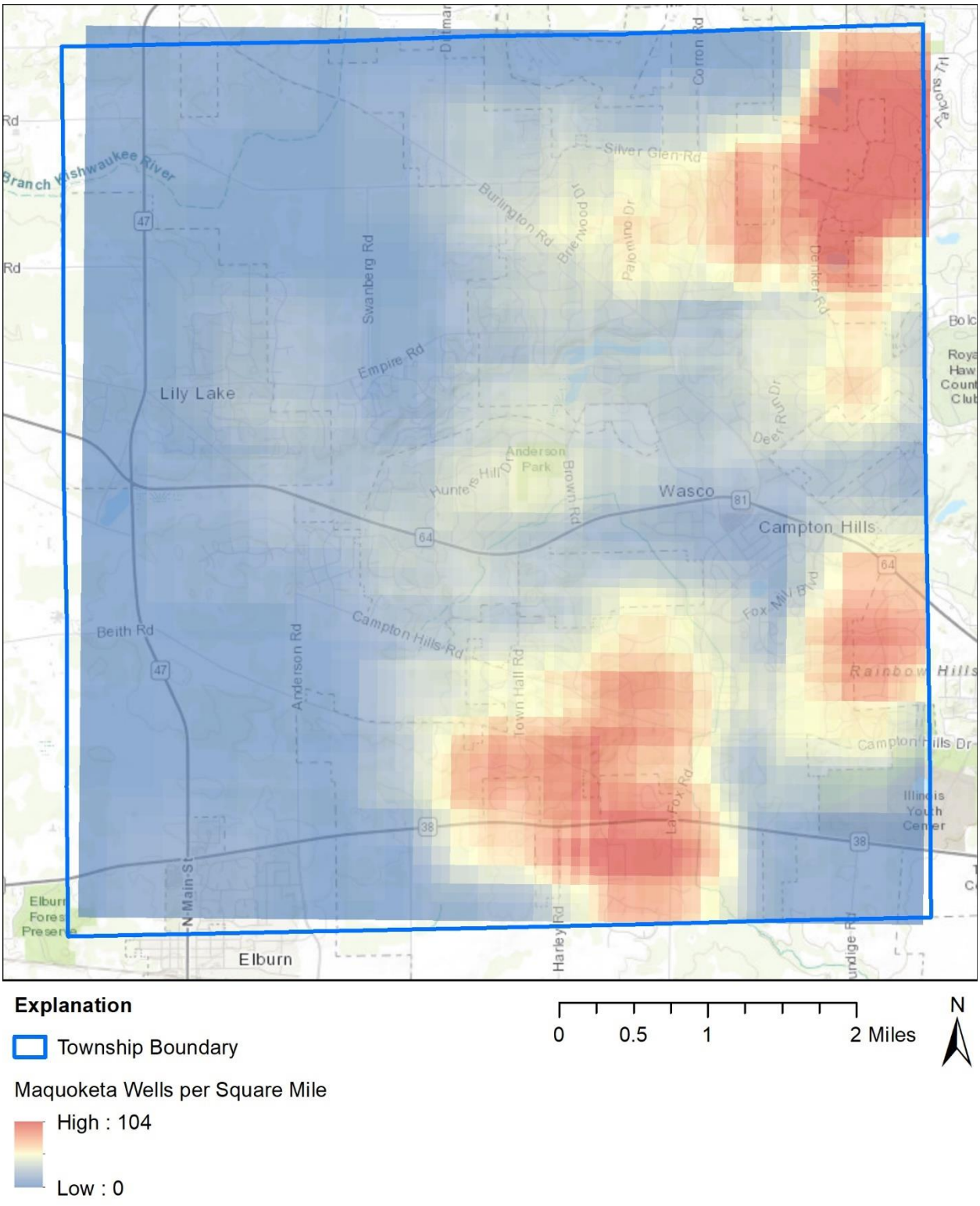

Figure 7. Map of well density for Maquoketa Shale wells in Campton Township.

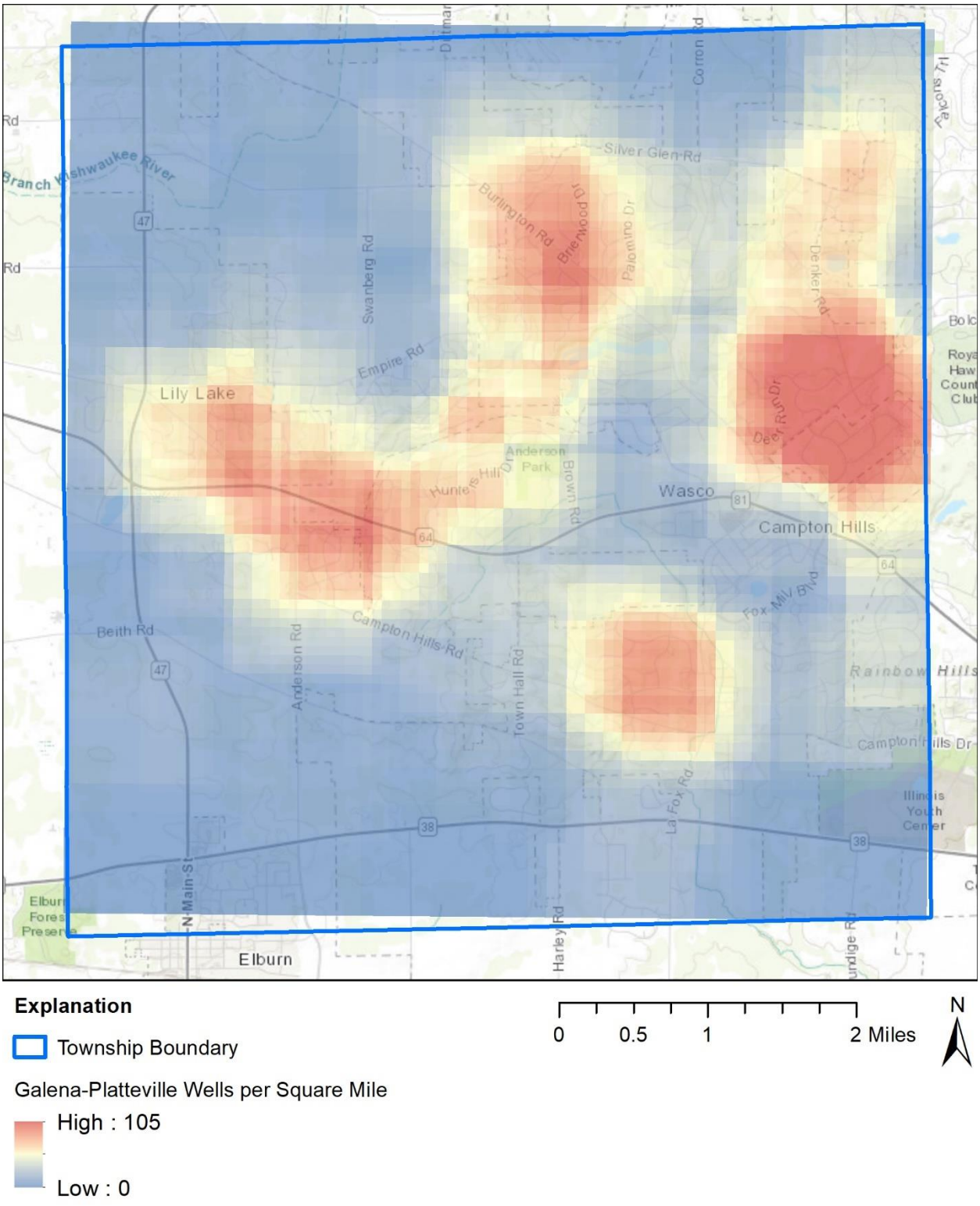

Figure 8. Map of well density for Galena-Platteville Dolomite wells in Campton Township.

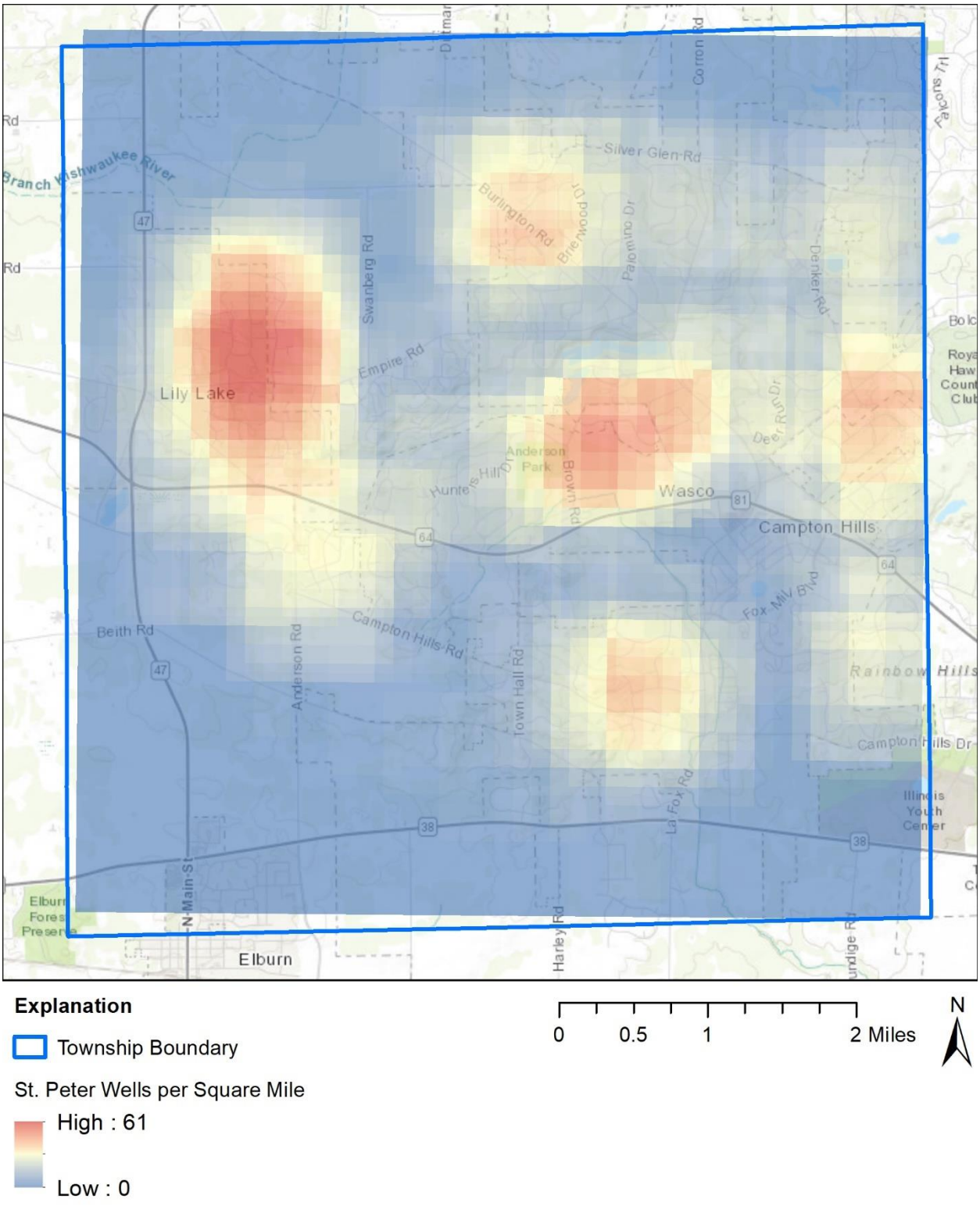

Figure 9. Map of well density for St. Peter Sandstone wells in Campton Township.

Establishment of a Groundwater Monitoring Network

To evaluate water levels and potential multi-aquifer groundwater flow in domestic water wells, four study areas were selected (Figure 10) in which to deploy eight acoustic water levels sensors (Table 3). Each study site consists of one well that is open to the Maquoketa Shale and Galena-Platteville units and one well that is open down to the St. Peter Sandstone. Well pairs are at neighboring houses and are thus in very close proximity to each other. The goals of this part of the project were specifically to:

1. Evaluate if water levels have changed significantly since drilling.
2. Determine if withdrawals from St. Peter wells cause a corresponding drawdown in the neighboring well open to the upper aquifers.
3. Note seasonal changes in water levels.

Acoustic sensors (Wellntel brand) were used because they do not require hanging pressure transducer cables which may interfere with and get caught on the installed pumps, thus minimizing the risk to homeowners. These acoustic sensors operate by sending an acoustic sound pulse down the well, which hits the water surface in the well casing and bounces back up and is detected by a small microphone. The travel time of the sound wave is converted to a depth to water. The readings are sent from the sensor to the homeowner's modem via a radio signal and readings are uploaded to the Wellntel website. The sensors also detect when the well is turned on/off via a current reader which prompts the sensor to take a reading at the start and end of a pumping cycle. When the pump is not running, timed readings are taken every 4 hours by default. However, several sensors initially took readings on an hourly basis.

Although the acoustic sensors are a non-invasive method for water level detection, it is a relatively new technology that has several limitations:

1. Acoustic signals can be noisy resulting in anomalous readings. For example, the acoustic waves may not be read by the microphone upon first return, resulting in water levels that are much deeper than the true water levels. Conversely, acoustic waves can bounce off pump cables, ledges, or other protrusions and send a signal back too early, resulting in water level readings that are too shallow. These anomalous readings result in noisy hydrographs for certain sites. We also observed many instances of "pump off" readings that were higher than static water levels, even though these reading should be recording the lowest water levels during the pumping cycle. This indicated that the timing of pump on/off readings may be off for certain sites.
2. Short battery life caused several disruptions to data collection. Some batteries only lasted several months before being drained to a point where measurements were not being taken.
3. Interruptions to the internet service at the participating households, particularly at Site 1a, resulted in disruptions to data collection since the acoustic sensor could not communicate to the Wellntel website. Attempts at manual downloading of data in the field and uploading of that data to Wellntel's website were not successful due to Wellntel software issues.

Table 3. List of monitoring well sites and static water level change since well was drilled. Static levels are compared with the average static levels as recorded by the acoustic sensors over the duration of the study period. Sites designated as “a” are the shallow wells, whereas as “b” sites are deep St. Peter wells.

Site	Subdivision	Well Depth	Well Open Interval	Year Drilled	Static depth to water (ft) when drilled	Static head (ft AMSL) when drilled	Avg. static depth to water (ft) current	Avg. static head (ft AMSL) current	Head Change (ft)
1a	Brookhaven Lane, Brookhaven Subdivision	440	MQ-GP	1995	180	647	85	742	95
1b		680	GP-SP	2002	220	612	53	779	167
2a	Ridgeview Court, Arbor Creek Subdivision	600	MQ-GP	1993	350	463	130	683	220
2b		660	MQ-SP	1993	400	416	360	456	40
3a	Sanctuary Trail, Hazelwood Subdivision	540	MQ-GP	1992	340	556	320	576	20
3b		700	GP-SP	1996	340	558	325	573	15
4a	Saddlebrook Drive, La Fox Woods Subdivision	520	MQ-GP	1995	340	527	390	477	-50
4b		700	GP-SP	1996	300	547	405	442	-105

MQ: Maquoketa Shale, GP: Galena-Platteville Dolomite, SP: St. Peter Sandstone

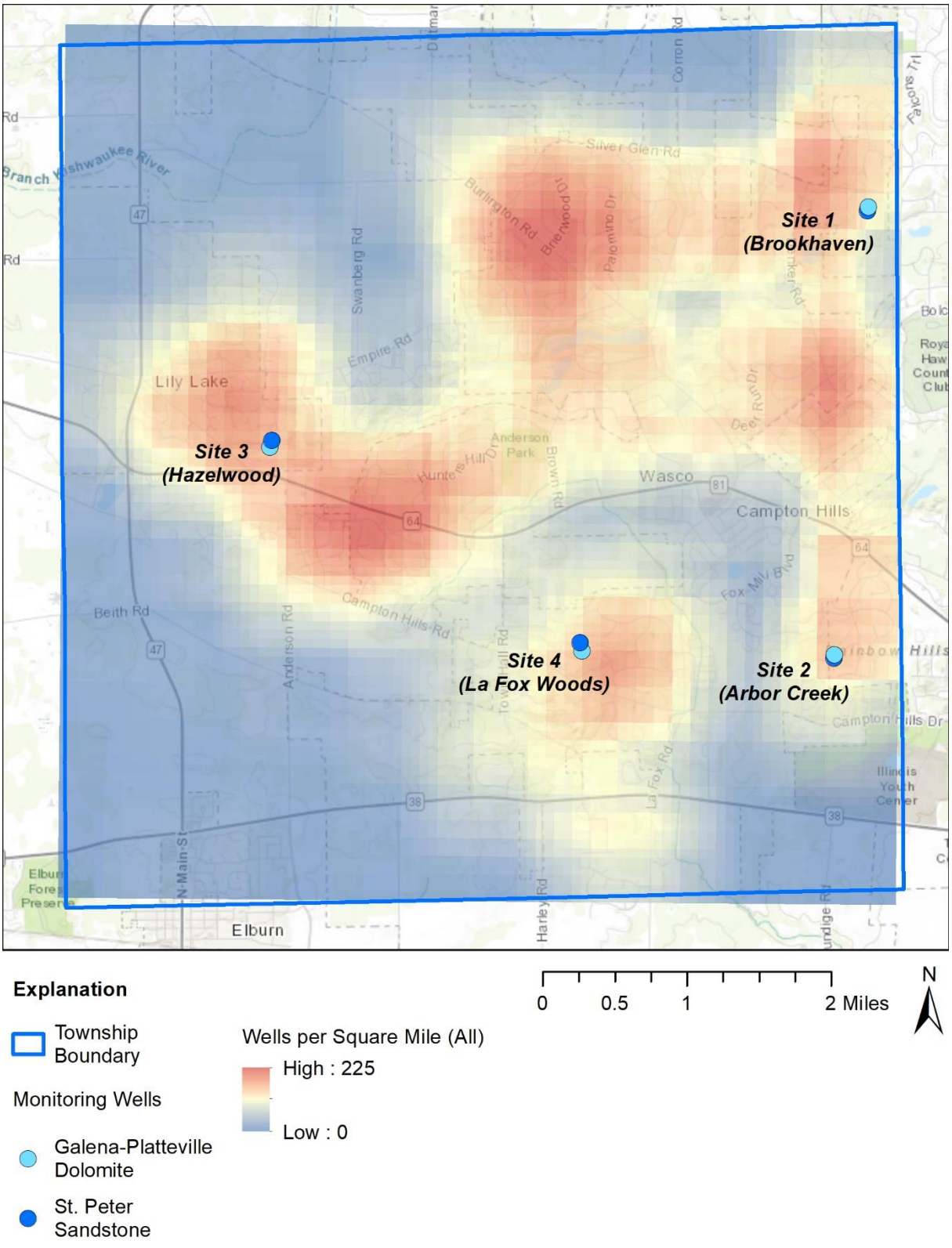

Figure 10. Map of the 4 monitoring well study sites in Campton Township in relation to overall well density. Each site consists of two well pairs.

Monitoring Well Hydrographs and Water Level Change

The hydrographs for each site are presented in Figures 11-14. All the hydrographs show fairly consistent static levels through time and frequent drawdown and recovery events as a result of homeowner's pumps turning on and off. Drawdowns in these wells varied greatly depending on the site, indicating the variability in aquifer productivity. For example, there was only around 20 feet of drawdown at Sites 4a and 4b when pumps were running (Figure 14), whereas at Site 2a, there was up to 200 feet of drawdown (Figure 12).

At Site 1, in the northeast portion of the township, heads in the St. Peter well are higher than heads in the well open to the shallower Maquoketa and Galena-Platteville units. The head difference between these two wells is around 35 feet which is a surprising result considering that historic water level measurements of the St. Peter sandstone indicate that heads are lower in comparison to shallower aquifer units. The average water level in St. Peter wells, according to drillers logs, also indicates a lower head in comparison to upper aquifer units (Table 1). There were also large head increases at both wells since they were drilled. At Site 1a and 1b, heads increased by 95 feet and 167 feet, respectively (Table 2). Considering that the St. Peter aquifer is being depleted regionally and there has been 300-400 feet of drawdown since predevelopment conditions (Figure 1), this is a very surprising result. One plausible explanation for this large increase in St. Peter heads at this location is the very high density of Maquoketa wells in this region of the township (Figure 7) which may be allowing groundwater to be flowing through this aquitard via open boreholes and increasing recharge to the underlying Galena-Platteville and St. peter units. The hydrographs at Site 1 indicate that static water levels may have increased by several feet since March 2018.

At Site 2, in the southeast section of the township, heads in the shallower well open to the Maquoketa and Galena-Platteville units were around 225 feet higher than heads in the St. Peter well (Figure 12). At Site 2a, heads increased by 220 feet since it was drilled (Table 2). However, we were not able to get successful hand measurements at Site 2a due to the presence of a pitiless adapter that blocks tape down measurements. Therefore, the acoustic sensor readings cannot be verified. If the sensor readings are correct, this would indicate a substantial head increase in the Maquoketa and Galena-Platteville units at this location. At site 2b, there was a head increase of around 40 feet since it was drilled (Table 2). We are more inclined to believe the acoustic readings at Site 2b since several attempts to get a hand measurement indicated that water levels are at least 300 feet, and the acoustic readings generally show depth to water readings of around 360 feet. The increase in water levels at this location since the time of drilling may also be indicative of enhanced recharge through the Maquoketa shale via open boreholes, as this is also a location that has a somewhat high density of wells open through the Maquoketa Shale (although to a lesser degree compared to site 1) (Figure 7). There was a large amount of "noise" at Site 2b, indicating very frequent pump cycles. Overall, static water levels do not show a significant trend either up or down since the sensor installations in April 2019.

At Site 3, in the west central portion of the township, heads in the shallow well open to the Maquoketa and Galena-Platteville units were very similar (within three feet) to heads in the deeper St. Peter well (Figure 13). The drilling records also indicate that heads were similar to within a few feet when the wells were drilled (Table 2). When comparing acoustic readings to the drilling records, there has only been 15-20 feet of head increase since the time both were drilled (Table 2). Both hydrographs at this site show the same small changes in static levels, but overall static levels have not trended up or down since the sensors were installed in April 2019. Given the similar heads in these two wells, and that water levels have not changed substantially since the time of drilling, there may not be enhanced recharge through the Maquoketa Shale to the same degree that may be occurring at Site 1 and Site 2. The Maquoketa well density map (Figure 7) shows very few Maquoketa wells in the western half of the township.

At site 4, in the south-central portion of the township, heads in the shallower well open to the Maquoketa and Galena-Platteville units were around 35 feet higher than heads in the St. Peter well (Figure 14). Review of the drilling records indicates that there was a similar head difference of around 40 feet when the wells were drilled, but that water levels have dropped in both wells since then. When comparing acoustic readings to the drilling records, there were static water level decreases at Site 4a and Site 4b of 50 feet and 105 feet respectively since the wells were drilled (Table 2). Site 4 is the only site where water levels have decreased since the date of well installation, however we do not have a definitive reason for this observation. Withdrawals from the Wasco sanitary district (which is about a mile away) may be a factor, but a similar decline was not observed at Site 2, which is a similar distance away (1.5 miles). Both hydrographs at Site 4 show the same small changes in static levels, but overall static levels have not trended up or down since the sensors were installed in February 2020. It is interesting to note that static water levels follow the same small trends in response to recharge rates, indicating that these aquifers are hydraulically connected, yet there is 40 feet of head difference between them. We were unable to get successful hand measurements at either of these sites due to pump cable and casing obstructions.

We also reviewed the well pair hydrographs to determine if withdrawals out of the St. Peter wells influence water levels at neighboring shallow wells. We specifically looked for larger than usual pumping cycles at each St. Peter well during times when the adjacent shallow wells were not running to see if drawdowns occurred in the shallower wells in response to these St. Peter withdrawals. Upon review, we have not noted any large or significant influence of St. Peter withdrawals on neighboring shallow wells. For example, at Site 1 there were several pumping events in the St. Peter well on April 8-9th 2018 (Figure 15). During those events, the neighboring shallow well collected timed readings, which do not show any significant response or change in static water level. Even at site 3, where heads in the St. Peter and overlying aquifer units are very similar, we did not note any significant drawdown from one well affecting water levels in the neighboring well.

The lack of any significant influence of withdrawals at neighboring wells is likely due to these pump cycling events being small (in terms of amount of water withdrawn) and short in duration (domestic pumps turn on just long enough to fill pressure tanks inside the home). However, we do not want to preclude this possibility, which could feasibly happen in other parts of the township.

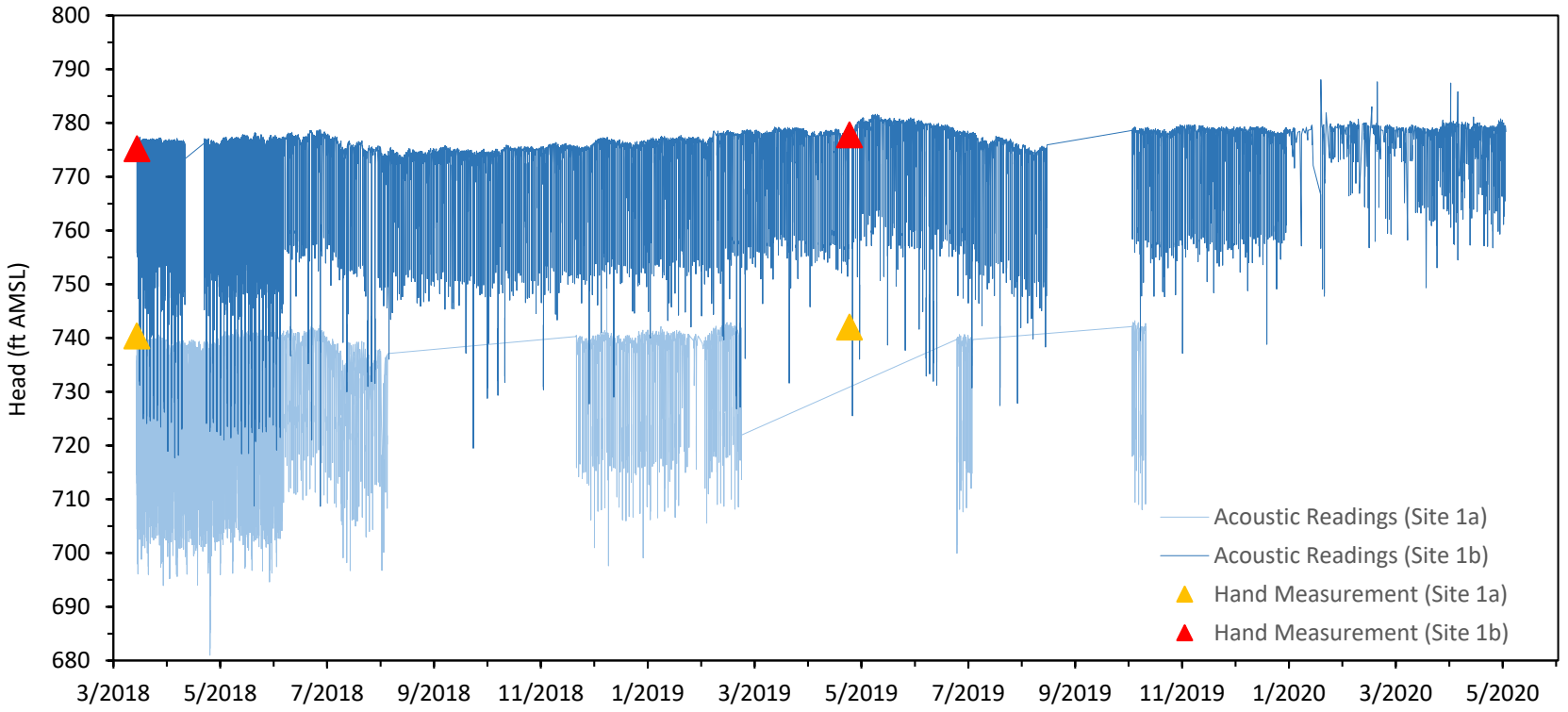

Figure 11. Hydrographs at Site 1 (Brookhaven subdivision well pair). Large gaps in data collection, particularly at Site 1a, were due to battery failures and internet connectivity issues. The "a" designation refers to the shallower of the two wells, whereas the "b" designation refers to the St. Peter well.

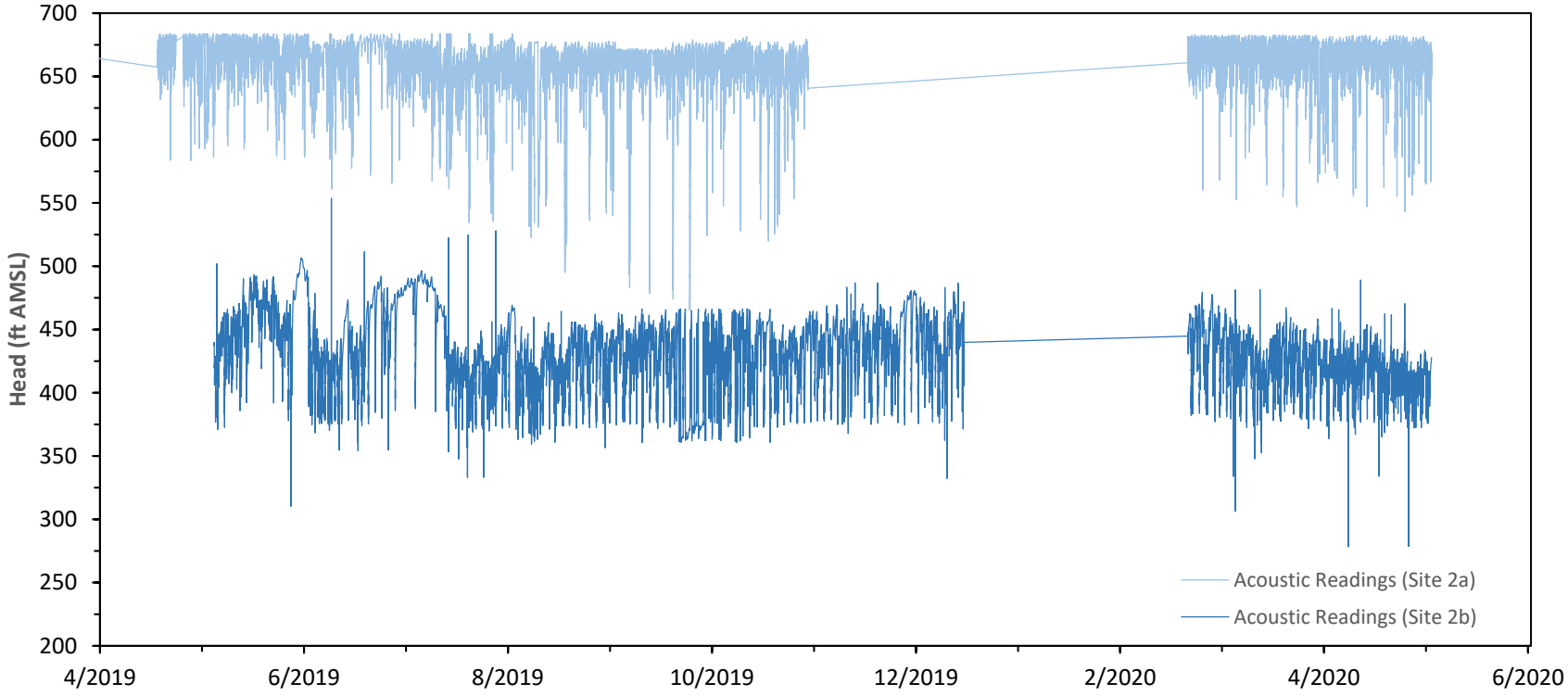

Figure 12. Hydrographs at Site 2 (Arbor Creek subdivision well pair). No hand measurements were successfully taken at these two sites. Large gaps in data collection were due to battery failures and internet connectivity issues. The “a” designation refers to the shallower of the two wells, whereas the “b” designation refers to the St. Peter well.

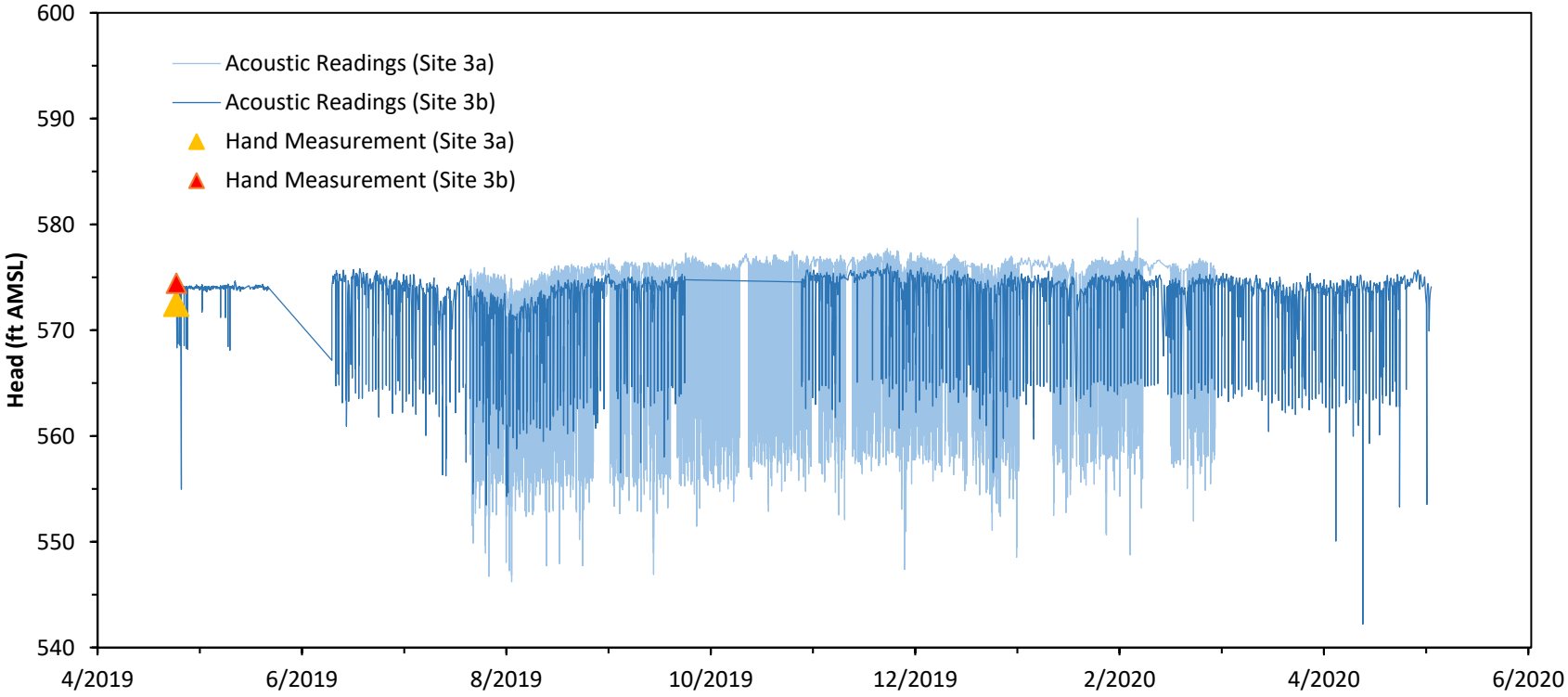

Figure 13. Hydrographs at Site 3 (Hazelwood subdivision well pair). Large gaps in data collection were due to battery failures and internet connectivity issues. The “a” designation refers to the shallower of the two wells, whereas the “b” designation refers to the St. Peter well.

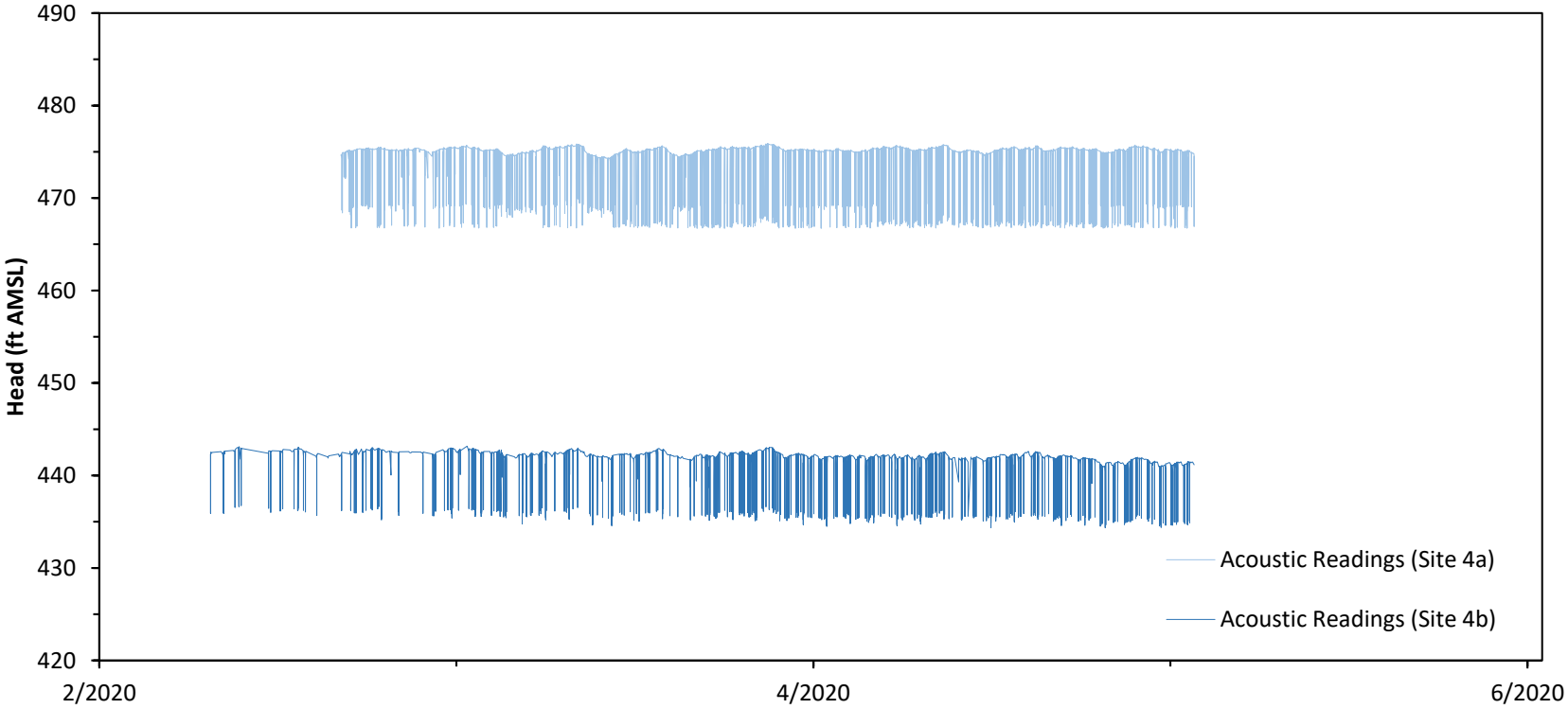

Figure 14. Hydrographs at Site 4 (La Fox subdivision well pair). No hand measurements were successfully taken at these two sites. The “a” designation refers to the shallower of the two wells, whereas the “b” designation refers to the St. Peter well.

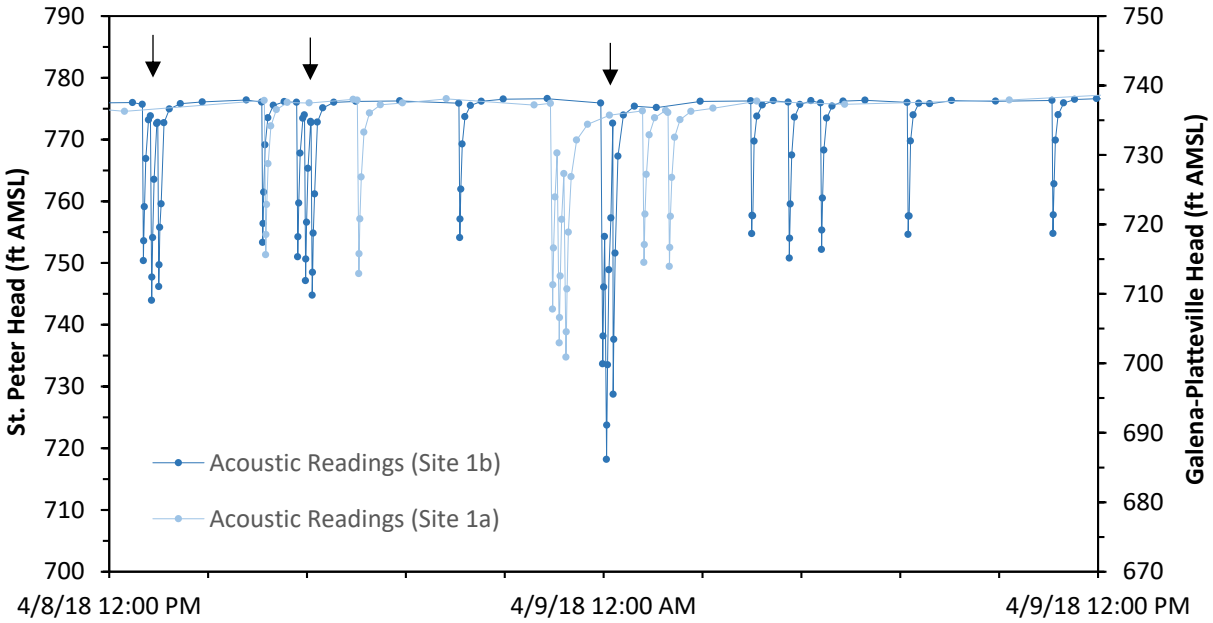

Figure 15. Section of hydrographs at Site 1 showing several large pumping events (denoted by arrows) and small pumping events from the St. Peter well. There is not a corresponding drawdown in the neighboring well open to the Maquoketa and Galena-Platteville units. Note that hydrographs are plotted on different axes for easier comparison.

Conclusions and Recommendations

Analysis of the hydrographs and comparisons with water levels recorded at the time of drilling indicate a large degree of variability in head change in the aquifers and head separation between aquifer units. Based upon the review of drilling records, mapping of well density by aquifer type, and the analysis of acoustic data collected at 8 domestic wells, we conclude the following:

- Multi-aquifer wells are ubiquitous in Campton Township. For example, 17 percent of wells finished into the Maquoketa Shale are also screened in the overlying sand and gravel aquifer; 82 percent of wells finished into the Galena-Platteville Dolomite are also open to the overlying Maquoketa Shale; 25 percent of wells finished in the St Peter Wells have open boreholes that extend into the overlying Maquoketa Shale. These wells with long open intervals can act as conduits for shallow groundwater to flow into deeper aquifers.
- Groundwater level change in Campton Township is highly variable, likely due to the unequal distribution of multi-aquifer wells. Campton Township may therefore have “pockets” of enhanced recharge where there are high densities of these multi-aquifer wells.
- The high density of Maquoketa wells and Galena-Platteville wells in the northeast quadrant of the township may be allowing a large amount of shallow aquifer water (i.e., water in the glacial sand and gravels) to flow into deeper aquifer units (i.e., the Galena-Platteville and St. Peter units) via open boreholes that penetrate the Maquoketa aquitard. The substantial increase in heads at Site 1 since the time of drilling would support this hypothesis and may be indicative that this region of the township is an important component of recharge to the St. peter sandstone system in Kane County.

- In general, multi-aquifer flow may be more common on the eastern half of the township due to the higher density of wells open through the Maquoketa Shale.
- Historically there has been head separation between the aquifer units, but for certain parts of the township heads have merged due to the loss of the natural aquitard.
- We see little evidence at the four sites of St. Peter withdrawals affecting wells open to shallower aquifer units during pumping cycles, however pump cycling is small in magnitude and duration. The hydrographs indicate that the homeowners that participated in this project are not in any immediate risk to disruptions to their water supply either from nearby withdrawals from neighbors or due to seasonal changes in recharge.
- Drilling new multi-aquifer wells in areas that have not been developed yet may cause more change in aquifer levels (and subsequent merging of heads between the aquifer units) than withdrawals out of already existing domestic St. Peter wells.

Based on the above conclusions regarding multi-aquifer wells, we recommend the following for future well construction practices and avenues of future research to understanding groundwater flow at domestic wells in Campton Township:

- We strongly recommend that any new domestic wells drilled in Campton Township adhere to the following to minimize the impact of bypassing the Maquoketa Shale aquitard: 1) Wells screened into the shallow sand and gravel aquifer shouldn't also be drilled into the underlying Maquoketa Shale to a substantial degree (i.e., screen should not extend more than a few to tens of feet into bedrock). 2) Wells that will be open to the Maquoketa Shale and rely primarily on this unit for water should have the casing extend well into the formation as to avoid overlying sand and gravel water from entering the well. 3) Wells drilled into the deeper Galena-Platteville and St. Peter units should not be left open to the Maquoketa Shale. In other words, the casing should extend all the way through the Maquoketa Shale formation when drilling a deep well. These recommendations could perhaps be formalized by the Kane County Division of Environmental and Water Resources and the Kane County Public Health Department for new well construction permits.
- Correction and improvement of well locations for Campton Township would benefit future groundwater research. This would take a concerted effort by the ISGS and ISWS and would consist of merging well record databases, correcting and verifying well locations based on addresses and parcel boundaries, and comparing corrected well records with existing geologic models. Correcting well records would not only improve the geologic models of Kane County, but would also improve the maps of well densities for the township and aid in future groundwater flow modeling.
- To determine the true impact of drilling deep multi-aquifer wells, acoustic sensors could be installed on Maquoketa or Galena-Platteville wells in an area prior to a new St. Peter well being drilled. This would only work if no other St. Peter Sandstone wells are present in the area and would require considerable forethought and knowledge of where a future domestic St. Peter well is going to be drilled. Working with the county public health department would be needed to set up a means to flag anticipated drilling of domestic St. Peter wells.
- Isotope sampling of wells in the northeastern quadrant of the township, where there are likely high recharge rates to the St. Peter sandstone, could determine whether shallow glacial water is in fact flowing into deeper aquifer units. The isotope ratios could indicate what proportion of recharge to the deeper aquifer units is derived from precipitation (entering the shallow aquifers) versus lateral flow within the aquifer itself.

References:

Benson, C.R. 1990. *Evaluation of Water-Supply and Well Designs for Campton Township in Kane County, Illinois*. Illinois State Water Survey Contract Report 494, Champaign, IL.

Kay, R.T., L.D. Arihood, T.L. Arnold, and K.K. Fowler. 2006. *Hydrogeology, Water Use, and Simulated Ground-Water Flow and Availability in Campton Township, Kane County, Illinois*. United States Geological Survey Scientific Investigations Report SIR2006-5076, United States Geological Survey website.https://pubs.usgs.gov/sir/2006/5076/..

Kay, R.T., and K.A. Kraske. 1996. *Ground-Water Levels in Aquifers Used for Residential Supply, Campton Township, Kane County, Illinois*. United States Geological Survey Water-Resources Investigations Report 96-4009, DeKalb, IL.

Meyer, S.C., G.S. Roadcap, Y.F. Lin, and D.D. Walker. 2009. *Kane County Water Resources Investigations: Simulation of Groundwater Flow in Kane County and Northeastern Illinois*. Illinois State Water Survey Contract Report 2009-07, Illinois State Water Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign website.https://www.isws.illinois.edu/pubs/pubdetail.asp?CallNumber=ISWS+CR+2009%2D07..