

# Black Earth Creek Headwaters Hydrologic Study

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Dane County Land & Water Resources Department

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## Study Background and Objectives

Many homes in the Hidden Oaks neighborhood in Middleton, Wisconsin have experienced ongoing basement water intrusion since the flood of August, 2018. Residents of Hidden Oaks requested assistance with identifying the causes of the ongoing water intrusion, and if necessary, modifying water management on adjacent properties to address the water intrusion problem. Dane County owns a large (179 acre) parcel of land immediately south and west of Hidden Oaks that is currently managed as the Black Earth Creek Headwaters Natural Resource Area. Because water management on this property is a potential contributing factor to the Hidden Oaks water intrusion problem, Dane County Land & Water Resources Department offered assistance to the neighborhood by conducting this study.

The objectives of this study are:

1. Understand neighborhood water concerns by conducting a survey of residents
2. Understand controls on groundwater levels by monitoring surface and groundwater levels
3. Recommend management actions to:
  - a. Reduce water intrusion into Hidden Oaks basements
  - b. Improve habitat in the Black Earth Creek Headwaters Natural Resource Area
  - c. Protect Black Earth Creek

This report presents results and preliminary recommendations after one year of monitoring, from October 2020 to October 2021, which was a period with below-average precipitation. Water monitoring will continue to assess water level response to wetter periods that are likely to occur in the future and to help plan water level management in the Black Earth Creek Headwaters Natural Resource Area.

## Study Area Description and History

The Hidden Oaks neighborhood is located on the west side of the City of Middleton, WI in the headwaters of the Black Earth Creek watershed. Much of this area was historically a shallow lake, named Mud Lake on an 1861 map of Dane County.<sup>1</sup> In the early 1900s, a drainage district (Dane County District 19) was formed to drain the area for farming. The ditch created by the district drained Mud Lake and extended Black Earth Creek upstream of what is now Highway 14.

Around the 1970s, Richard Hinrichs built an earthen berm across Black Earth Creek just upstream of Highway 14 and installed a pump upstream of the berm. The pump moved water from the upstream (north) side of the berm to the downstream side, where gravity carried it through the culvert under

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<sup>1</sup> Maher, L. J. 1998. The early history of the Pheasant Branch watershed, Middleton, Wisconsin. Department of Geology and Geophysics, University of Wisconsin-Madison. <http://geoscience.wisc.edu/~maher/history.html>



Figure 1. Map of study area. Aerial photograph was taken in April of 2020.



Highway 14 and downstream, thus draining cropland on the Hinrichs farm. In 1994, the south side of the Hinrichs farm was sold to Dane County, though the Hinrichs family continued to farm it and operate the pump in cooperation with the neighboring Hellenbrand farm to the west.

Development of the Hidden Oaks neighborhood began in 2007. There are two primary stormwater management facilities in the neighborhood: Outlot (O.L.) 8, located in Hinrichs Family Farm Park, and O.L. 4 in the southeastern corner of the neighborhood. Both facilities are detention basins underlain by a network of drain tile and the O.L. 4 basin has a drawdown pipe that was designed to be used only during construction. The basins were designed to drain completely within 3 days of even large rain events. O.L. 4 drains to an open water wetland that was created as part of the Hidden Oaks stormwater management plan. This wetland drains into the headwaters of Black Earth Creek.

On August 20-21, 2018, 11.6 inches of rain fell in Middleton over about 12 hours, producing extensive flooding. The flood damaged the pump near Hwy 14 and it has not operated since. The flood also caused basement flooding in many houses in Hidden Oaks. After the flood receded, many houses experienced ongoing basement water intrusion, even during dry periods. The area that was historically drained by the pump and berm was inundated up to the level of the berm, forming an approximately 40-acre open water wetland. In addition, both detention basins in Hidden Oaks failed to drain and held standing water between 2018 and 2021.

## Survey of Hidden Oaks Residents

A survey of Hidden Oaks residents was conducted in fall 2020 to better understand the basement water intrusion problem. The survey was conducted online using Survey123. Notification of the survey was mailed to all Hidden Oaks residents (Appendix A) and the Homeowner's Association promoted participation.

### Survey Results

The survey was completed by 49 out of 125 addresses in Hidden Oaks. The main survey question was:

Which of these statements best describes the behavior of your basement sump during summer 2020?

| Response  | Number of responses |
|---|---------------------|
| a. The sump pump never runs unless I add water to test it.                              | 29                  |
| b. The sump pump only runs for a period of hours to a few days after large rain storms. | 7                   |
| c. The sump pump runs frequently, even during periods with little rainfall.             | 6                   |
| d. The sump pump runs almost continuously.  | 7                   |

Basement floor elevations were estimated by subtracting the basement depth as measured by the resident from the ground elevation (from 2017 Dane County LiDAR digital elevation model) on the side of house where the basement depth was measured. All but one of the 13 houses with ongoing water intrusion problems (responses c and d) have basement floor elevations between 926 and 928 ft. above sea level. All of those respondents also indicated that their basement sump pump rarely or never ran before the 2018 flood.

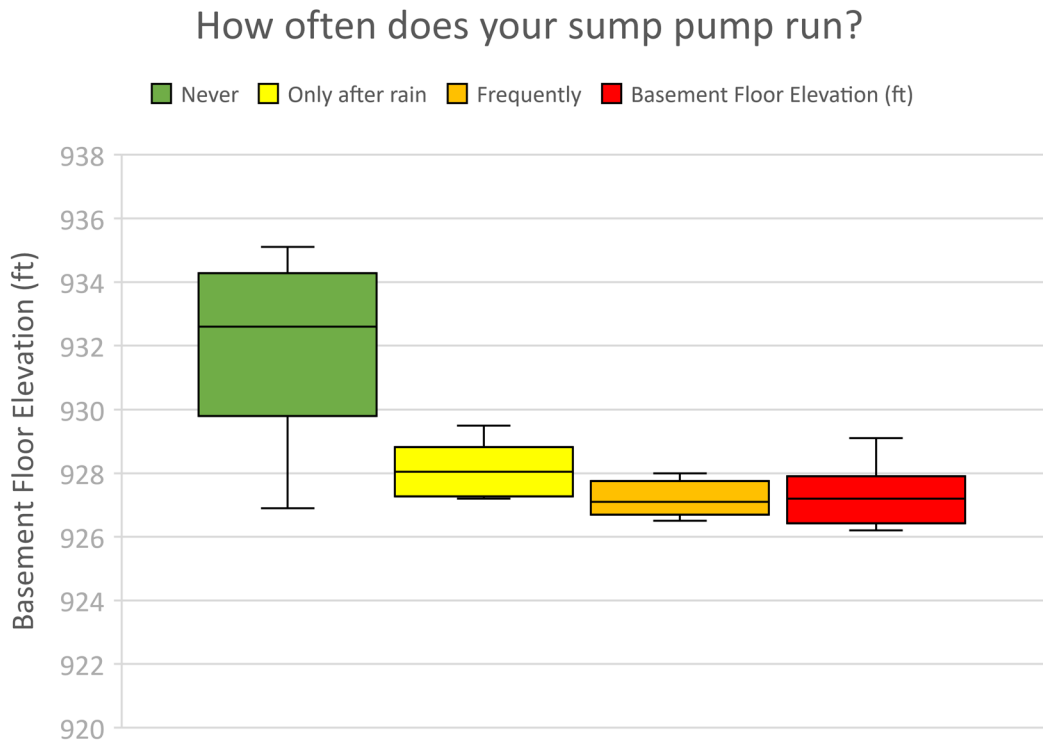


Figure 2. Estimated basement floor elevations of Hidden Oaks houses grouped by sump pump running frequency.

## Water Level Monitoring

### Monitoring Methods

Seven water level loggers were deployed from October 15, 2020 to October 19, 2021 in the Black Earth Creek headwaters in and around the Hidden Oaks neighborhood to identify controls on groundwater levels in the neighborhood. Logger 1 was deployed in a monitoring well and the other six loggers were deployed in surface water bodies (Figure 1). The surface water loggers were suspended from inelastic braided fishing line in perforated steel pipes driven into the ground. All loggers recorded pressure and temperature at 15-minute intervals. Absolute pressure was converted to water pressure by subtracting barometric pressure measured by a logger deployed in the air near site 5. Water pressure was then converted to depth using the temperature-adjusted density of water. Water depth was then converted to water surface elevation from surveyed elevations and logger-recorded water depth on October 28, 2020, April 22, 2021, June 16, 2021, and October 18, 2021. All elevations are above sea level. The elevation of a few of the loggers appeared to drift over time, probably because they were initially deployed in a depression created by installation of the pipes, and sediment filled in the depression over time. The sensor elevations of these loggers were adjusted by linearly interpolating between survey dates to match surveyed elevations.

## Monitoring Results

### Precipitation

Precipitation was well below average during the monitoring period, in strong contrast with the previous several years (Figure 3).

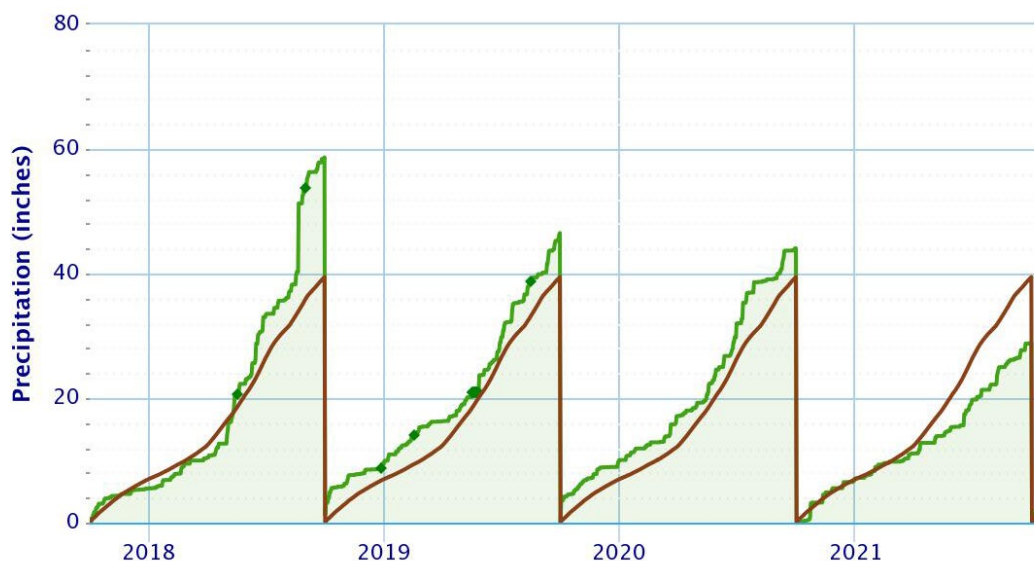


Figure 3. Accumulated precipitation for water years (starts October 1) 2018-21 at Middleton, WI from NOAA Online Weather Data. Green lines are actual, brown lines are average.

### Site 1 – Groundwater well in Hinrichs Family Farm Park

Groundwater level in Hinrichs Family Farm Park dropped almost 4 ft. over the 1-year monitoring period from 928.2 feet to 924.4 feet. Groundwater at site 1 was 0.7 ft. higher than the surface water level in O.L. 8 in October 2020, dropped to equal to O.L. 8 by March 2021, and was 0.3 ft. lower than O.L. 8 by October 2021.

### Site 2 – Outlot 8 Detention Basin

The O.L. 8 detention basin at the east end of Hinrichs Park had 3 ft. of standing water in October 2020, and even during dry periods, water level dropped very slowly, approximately 0.1 ft. per week. Water level in O.L. 8 followed a similar pattern to groundwater over the monitoring period, with some brief higher levels from rain events. This pattern indicates that the standing water in O.L. 8 is likely caused by groundwater movement, but the drain tile system (invert elevation = 924.5 ft.) also appears to not be functioning. From mid-June through the end of August 2021, the City of Middleton inspected and cleared the drain tile systems for the O.L. 4 and 8 detention basins. These efforts appear to have been effective, because the basins drained much more quickly following subsequent rain events. For example, following a 1.46 inch rainfall on August 8, 2021, the water level in O.L. 8 dropped by 1.3 feet in 24 hours (Figure 5).

### Site 3 – Outlot 4 Detention Basin

Water level in O.L. 4 followed a similar pattern to O.L. 8 until Nov. 30, 2020, when it suddenly dropped by 1.3 ft. in two days. The cause of the drop is unknown, but may be related to release of a blockage in

the drain tile system or drawdown pipe. The O.L. 4 level then remained constant throughout the winter while the uphill O.L. 8 level continued to decrease. The minimum water elevation in O.L. 8 was 925 ft., which is 2 ft. higher than the drain tile outlet that is designed to drain the basin, indicating that the drain tile system was not functioning. Similar to O.L. 8, after the City's drain tile maintenance in the summer of 2021, O.L. 4 began draining much more quickly after rain events. From August to October 2021, both basins have been dry except for a few days after rain events, which is how they were designed to function.

#### Sites 4 and 5 – Dane County property

Water level on the County property at the wetland below O.L. 4 and above the berm near Hwy. 14 remained relatively constant over the monitoring period. The water level dropped by 0.4 feet from June to October 2021, probably because of decreased groundwater inputs, high summer evaporation, and some erosion of the berm near Hwy 14. The groundwater recession rate at site 1 has remained high, approximately 1 foot per month, over the monitoring period, even as the water level difference between sites 1 and 4 has decreased.

#### Sites 6 and 7 – Hwy 14

The water level difference between sites 5 and 6 during dry conditions dropped from 1.3 ft. in October 2020 to 0.9 ft. in October 2021. Erosion of the berm crest was noted during site visits. There is no difference in water level across Hwy 14 during dry conditions. The culvert under Hwy 14 is probably a hydraulic control during runoff events because it is mostly full of sediment, but the backwater is not high enough to flood Hidden Oaks basements.

## Discussion

Groundwater level in Hinrichs Park in October 2020 was higher than the basement floor elevations of all but one of the houses that reported ongoing basement water intrusion. The cause of the high groundwater level at that time and likely since 2018 is abnormally high precipitation. In general, groundwater levels in Wisconsin respond to cumulative variations in precipitation over multi-year time spans.<sup>2</sup> The flood of 2018 was an extreme event that coincided with the start of the ongoing basement water intrusion, but it was part of a five-year period of above-average precipitation that ran from 2016 to 2020 (Figure 4). This perspective on precipitation also helps explain why the geotechnical exploration that was conducted in 2004-2006 as part of the planning for development of Hidden Oaks found much lower groundwater levels. Low precipitation since fall 2020 has led to a rapid drop in the moving average precipitation (Figure 4). The period of high groundwater coincided with moving average monthly precipitation over approximately 3.8 inches. Continued tracking of this variable may provide some ability to forecast groundwater levels, although ongoing monitoring of the well in Hinrichs Park provides a direct measure.

The location of Hidden Oaks relative to the surrounding terrain probably also exposes it to high fluctuations in groundwater. The neighborhood is located at the foot of a hill that is capped with deep glacial sand deposits. These deposits are very efficient at infiltrating precipitation, which then moves downslope through the subsoil.

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<sup>2</sup> Smail, R.A., Pruitt, A.H., Mitchell, P.D. and Colquhoun, J.B., 2019. Cumulative deviation from moving mean precipitation as a proxy for groundwater level variation in Wisconsin. *Journal of Hydrology X*, 5, p.100045.



Figure 4. 5-year moving average monthly precipitation at Hidden Oaks (data from PRISM Climate Data Explorer).

We were fortunate in two ways to have abnormally low precipitation during the monitoring period. First, the dry weather allowed the groundwater to drop relative rapidly. Because the groundwater level is now lower than the lowest known basement elevation in the neighborhood, it is likely that most basement water intrusion has stopped. Sump pump usage during summer 2021 is currently being assessed through a survey of residents by the City of Middleton. Given that basement sumps are approximately 1.5 feet lower than basement floors, groundwater elevations above 924.7 feet are likely to cause sump pumps to run in houses with the lowest basements. Second, the dry weather made it possible to determine if groundwater recession would decrease as groundwater level approached that of potential controls, including the detention basins and the wetland on the County property. Recession remained high and constant, approximately 1 foot per month, over the monitoring period, even as the water level difference between sites 1 and 4 has decreased.

This pattern indicates that the current water level on the County property is not significantly influencing groundwater levels in the Hidden Oaks neighborhood. The wetland on the County property is probably acting as a relatively constant head boundary for groundwater recession in Hidden Oaks, but the head gradient remained high enough over the monitoring period that it did not slow the recession rate. It also appears that the high water levels in the O.L. 8 basin in 2020 were caused by groundwater seepage, although the drain tile system probably would have drained the basin if it were functioning properly at that time. Water levels in the O.L. 4 basin appear to be more influenced by the function of the drain tile system. It is likely that the improved function of the drain tile systems under the detention basins since

the summer 2021 maintenance will help drain groundwater from around the basins, but it is unclear how far that drainage will extend laterally, and it is unlikely to significantly reduce basement water intrusion when groundwater levels are high.

## Recommendations

1. Dane County will continue water level monitoring at least until the next period of above-average precipitation that lasts at least six months and will update this report following that period.
2. Dane County will develop a water level management plan for the Black Earth Creek Headwaters Natural Resource Area. Any water control structures should not exceed an elevation of 923 ft. to ensure free drainage of the O.L. 4 basin.
3. The City of Middleton is continuing to investigate the performance of the detention basins in outlots 4 and 8 and has allocated funds for rehabilitation of the basins. The City is conducting an additional survey of residents on sump pump usage during the summer of 2021.
4. Homeowners in Hidden Oaks who experienced basement water intrusion since 2018 should be prepared for water intrusion to occur again. Improved drainage by the neighborhood's detention basins may not prevent basement water intrusion in the next extended period of wet weather. Dane County Emergency Management has a list of actions that homeowners can take to reduce flood risk: <https://em.countyofdane.com/hazards/flood-damage/flood-risk>.
5. No maintenance is recommended by Dane County Drainage District 19 for the purpose of draining groundwater from the Hidden Oaks neighborhood. This study did not assess the need for maintenance of the district ditch downstream of Hwy 14 for agricultural drainage.



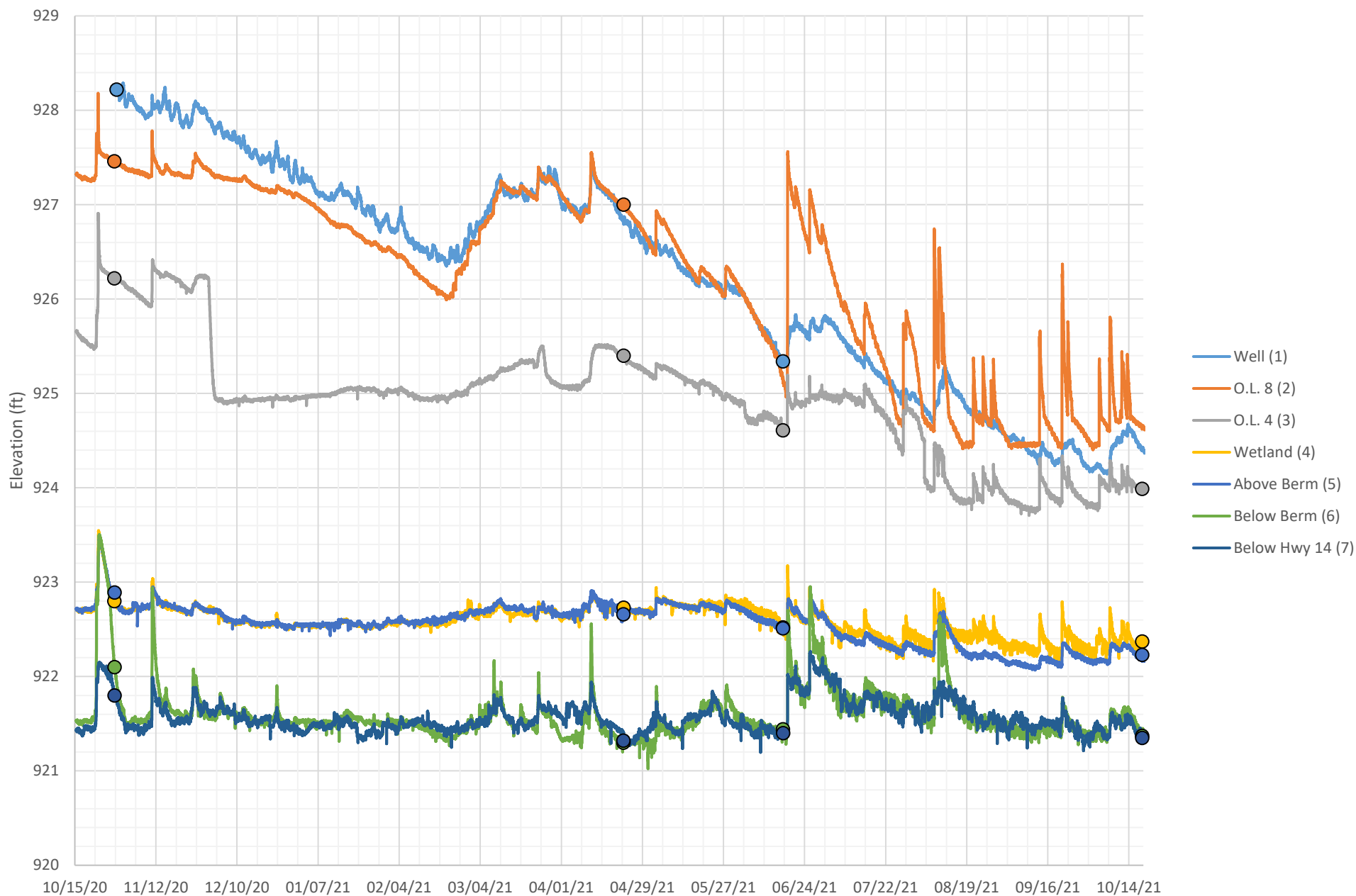


Figure 5. Water surface elevations at seven sites in and around the Black Earth Creek Headwaters Natural Resource Area. Lines are at 15-minute intervals from water level loggers. Points were surveyed with a Trimble R6 GPS unit.

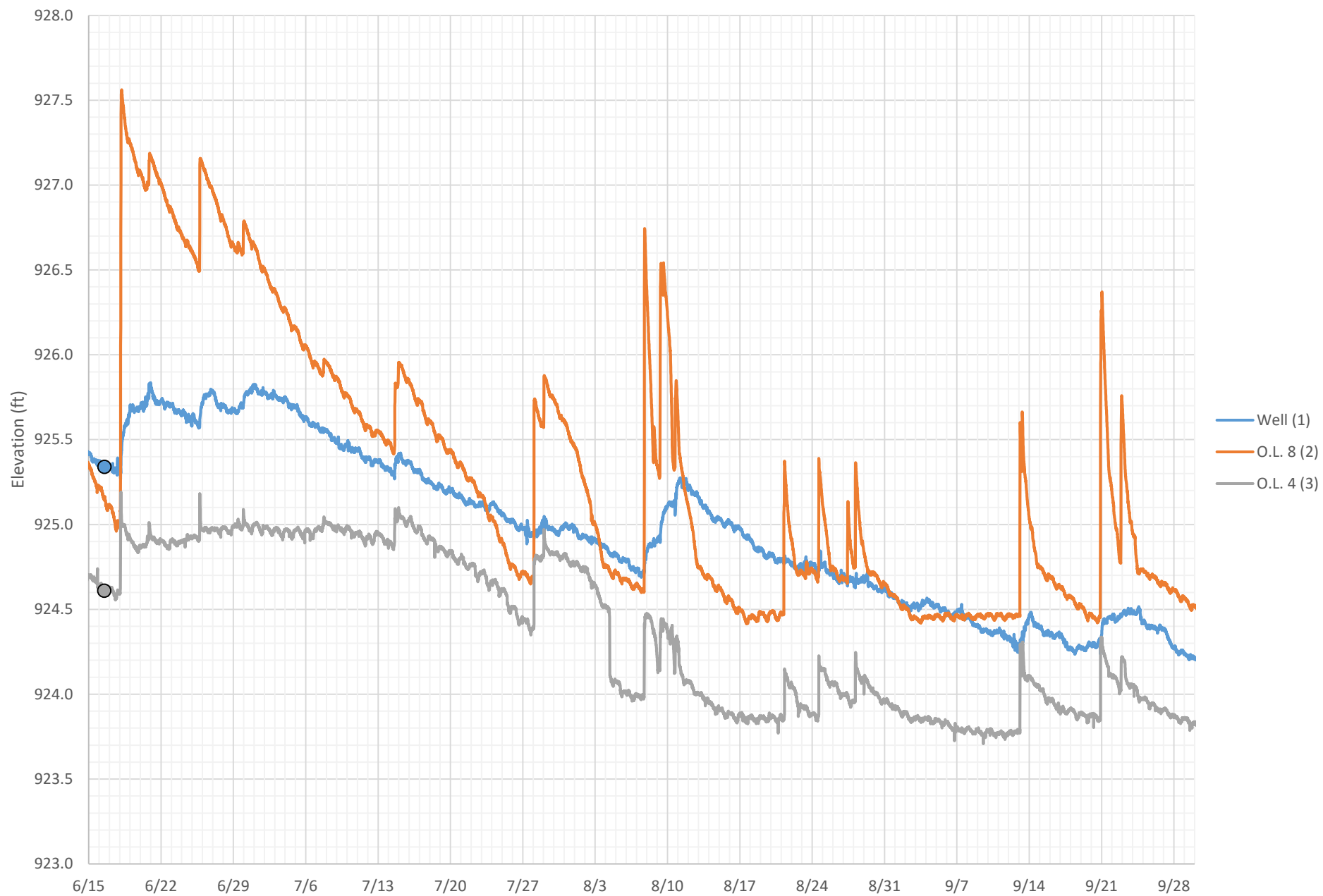


Figure 6. Summer 2021 water surface elevations at three sites in the Hidden Oaks neighborhood.