Memo

Date: Monday, February 12, 2024

To: Lori Myott, Lansing Board of Water & Light

From: Lara Zawaideh, HDR Michigan, Inc.

Subject: Erickson Power Station CCR Units

Groundwater Flow Direction Update and Shale/Boron Correlation

The Lansing Board of Water & Light (BWL) Erickson Power Station (Erickson) completed numerous tasks in 2023 to physically close the three CCR ash impoundments by removal of ash and to expand the monitoring network to further characterize the impact to groundwater. These tasks included the installation of 10 new wells to evaluate the extent of groundwater exceedances. New data collected in 2023 verifies findings that have been previously described and also updates some of our findings, specifically:

- Groundwater from under the impoundments does not appear to flow to the private wells. The groundwater flow direction from Erickson flows east under the impoundments and then turns north under the wetland on the east side of Erickson. Groundwater between Creyts Road and the wetland on the east side of Erickson is flowing west.
- Background wells continue to plot upgradient of the impoundments and therefore are representative of background conditions.
- There is a correlation between shale bedrock and boron concentrations. A well that is placed in a section of bedrock with more shale (and less sandstone) has groundwater with higher boron concentrations.

A full description of this analysis follows.

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

Background

Erickson contained a single coal-fired generator that was capable of producing 165 megawatts of electricity. It was permanently shutdown November 2022. Erickson has three CCR impoundments: the Forebay, Retention Basin, and Clear Water Pond (CWP) (**Figure 2**). The three CCR impoundments are currently inactive. The BWL implements both a federal and state groundwater monitoring program concurrently to comply with both the federal Coal Combustion Residuals (CCR) Rule and Michigan Part 115 Solid Waste rules. BWL is currently in the process of expanding the monitoring network and has completed numerous tasks in 2023 to physically close the impoundments by ash removal and expand the monitoring network to further characterize the impact to groundwater for the assessment of corrective measures, including the following tasks:

- Approval of the Closure Work Plan for the CCR surface impoundments;
- CCR impoundments dewatering and ash removal;
- Installation of ten monitoring wells including on-site and off-site perimeter/characterization wells, and multi-level wells to evaluate the plume extents horizontally and vertically;
- Submitted wetland permit applications for installation of additional monitoring wells in the wetlands on the eastern edge of the BWL property;
- Sampling of downgradient private wells completed in the bedrock aquifer at the request of private well owners, and an evaluation of this data reported under separate cover;
- Monthly monitoring of groundwater levels for monitoring wells and control points; and
- Sampling and analysis associated with semiannual assessment monitoring as well as higher frequency background monitoring of newly installed wells.

New data gathered from these tasks are significant observations and therefore this memo is presented to BWL for addition to the public website to communicate recent data findings.

Monitoring Well Network

The certified monitoring system for the ash impoundments includes the following wells (**Figure 1**):

- Glacial aquifer background (upgradient) wells: MW-1, MW-4, MW-11, and MW-12.
- Glacial aquifer downgradient compliance wells: MW-2, MW-5, MW-6, and MW-14.

Perimeter and Characterization Wells

The groundwater monitoring system includes additional wells installed to evaluate groundwater further downgradient of the impoundments in response to identification of concentrations of constituents at statistically significant levels (SSLs) over groundwater protection standards (GPS) in the compliance wells (**Figure 1**):

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

- Glacial aquifer wells to evaluate extent of SSLs: MW-3, MW-7, MW-7C, MW-8, MW-9, MW-10, MW-13, MW-14, MW-15, MW-16A, MW-16B, MW-100A, MW-100B
- Bedrock aquifer background (upgradient) wells: MW-11B, MW-12B
- Bedrock aquifer wells to evaluate extent of SSLs: MW-7B, MW-16C, MW-16D, MW-100C, and MW-100D

Ten of these wells (MW-14, MW-15, MW-16A, MW-16B, MW-16C, MW-16D, MW-100A, MW-100B, MW-100C, and MW-100D) were installed in 2023. Well MW-14 was installed immediately east of the CWP to further characterize impacts originating from the CWP. To further delineate the northern extents of the exceedances in groundwater, MW-15 was installed north of MW-3. Similarly, the multi-level glacial and bedrock well series at MW-16(ABCD) and MW-100(ABCD) were installed to the east and south, respectively to further delineate the eastern, southern, and vertical extents of the plume. Additional wells are planned for the wetland area close to the BWL eastern property boundary and are pending the wetland permit.

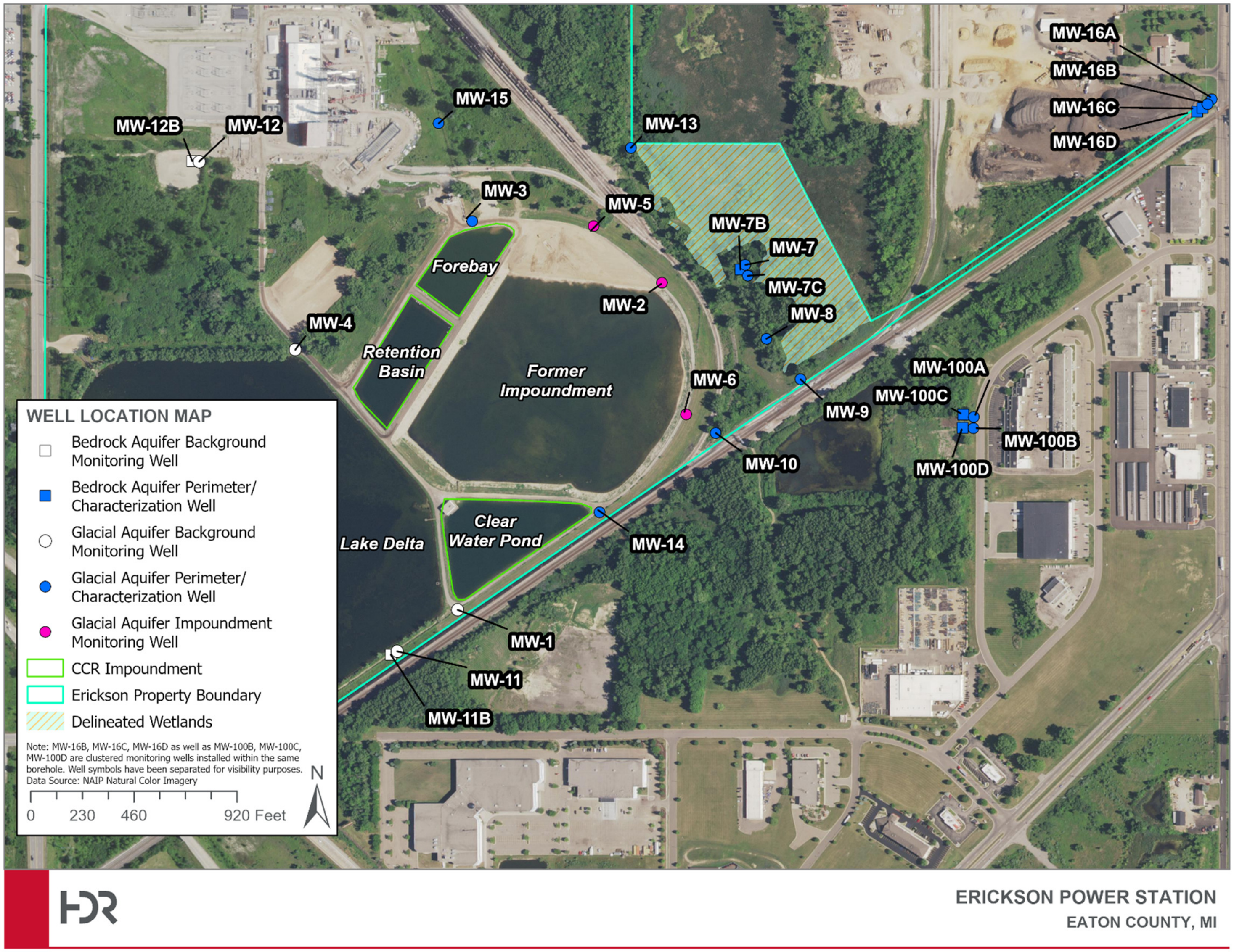


Figure 1. CCR Units and Monitoring Wells

hdrinc.com

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

Update to the Groundwater Flow Direction

Water levels for Erickson Power Station are depicted in the hydrographs in **Figures 2 and 3**. Groundwater beneath the area of the impoundments is between 863 to 875 feet above mean sea level (amsl). As shown in **Figures 2 and 3**, bedrock well MW-16D does not appear to be hydraulically connected to the other wells within its multi-level well series (MW-16A, MW-16B, and MW-16C) or to any other wells installed at Erickson Power Station. As displayed in the figure, MW-16D does not demonstrate seasonal fluctuations similar to those observed at other glacial or bedrock wells and has a substantially lower groundwater elevation than other wells, despite being completed at a similar elevation and lithology as bedrock wells MW-11B, MW-12B, MW-7B, and MW-100D. This lack of similarity in the groundwater fluctuation and much lower groundwater elevation implies that the water measured at MW-16D is not connected to the water measured at all of the other wells and therefore cannot be compared. The groundwater at that well is likely from a deeper source and may be isolated. This lack of connection makes it very unlikely that the groundwater at MW-16D could be impacted by the Erickson CCR Impoundments.

Because the groundwater elevations differed slightly between glacial wells and bedrock wells, two separate sets of potentiometric contour maps were developed, one for wells screened in the glacial aquifer and one for the wells screened in the shale/sandstone bedrock aquifer. Potentiometric surface maps were developed for the glacial and bedrock aquifers for 2023 water level measurement dates. Maps displaying the groundwater elevations at the wells and the groundwater contours and are provided in **Appendix A**. Bedrock groundwater contour maps include well MW-16C (and not well MW-16D) due to the apparent MW-16D disconnection described above, whereas well MW-100D is included on the map (as opposed to MW-100C) due to the similar screened elevation as the onsite bedrock wells (MW-7B, MW-11B, and MW-12B).

The water levels and contour maps continue to confirm that the glacial and bedrock groundwater flow direction immediately under the impoundments is to the east and is consistent year-round. This also confirms that the wells used for development of background water quality values are upgradient of the CCR impoundments. Data collected from the newly installed wells MW-16A, MW-16B, and MW-16C have groundwater at higher elevations than wells MW-7, MW-8, MW-9, MW-13, and MW-100A, which indicate that groundwater in the vicinity of these wells flows west towards Erickson Power Station. At this time, data collected from MW-16A and MW-16B as well as surface water points collected from Carrier Creek to the north indicate that groundwater within the glacial aquifer likely flows north under the wetland on the east side of Erickson, which is consistent with the Carrier Creek Subwatershed boundary. The subwatershed boundary is displayed on the groundwater contour maps in **Appendix A**. Therefore, glacial groundwater that flows under the CCR impoundments flows east under the impoundments and when it reaches the wetland topographic low area, it turns north, consistent with the surface water flow and Carrier Creek Subwatershed.

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

Data collected from MW-16C is also a higher elevation than the bedrock well MW-7B and MW-100C, which suggest that groundwater in the shallow bedrock aquifer flows west towards Erickson Station. Therefore, groundwater in the shallow bedrock likely flows northward and follows the Carrier Creek drainage to the north.

These findings are also consistent with a groundwater study from the Reith Riley Construction Company property located adjacent to Erickson on the east between the wetland and Creyts Road. As reported in the Comprehensive Remedial Investigation and Risk Evaluation Report, prepared for the site in May 2003 by Prein & Newhof obtained with a Freedom of Information Act request, shallow groundwater was flowing west under the Reith Riley property between Creyts Road and the wetland on the east side of Erickson (**Figure 4**) (Prien & Newhof, 2003).

The property owner east of Erickson has declined to allow for any monitoring on their property. BWL has designed and submitted permit applications for proposed multi-level wells and supporting access paths in the wetland on the eastern Erickson property boundary. Data from these proposed wells will help further define the groundwater flow directions. The permit to construct these wells within the wetland was submitted to EGLE on April 21, 2023 and the permit is still under review.

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

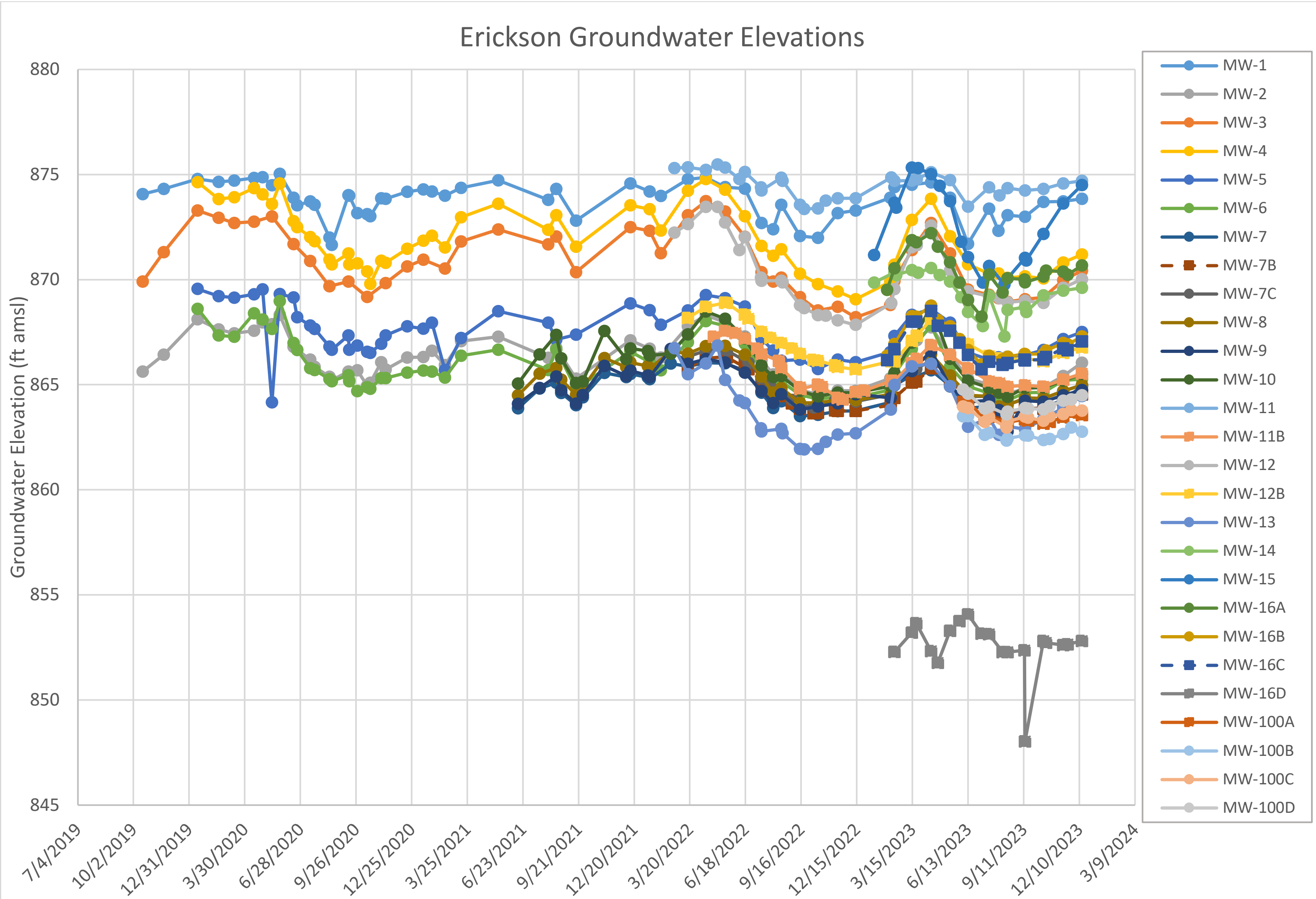


Figure 2. Erickson Power Station Groundwater Elevations

hdrinc.com

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

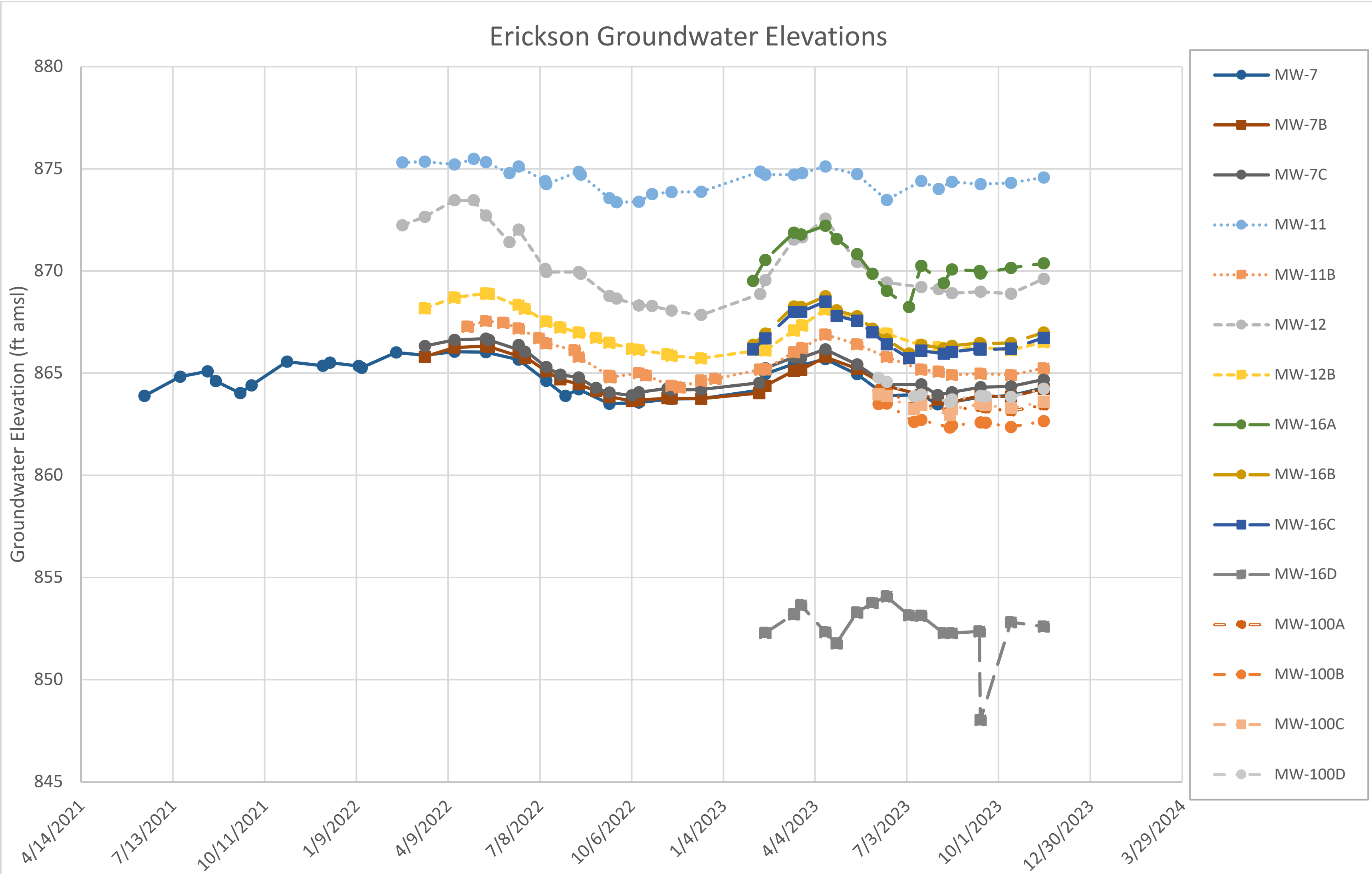


Figure 3. Erickson Power Station Paired Glacial and Bedrock Well Groundwater Elevations

hdrinc.com

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

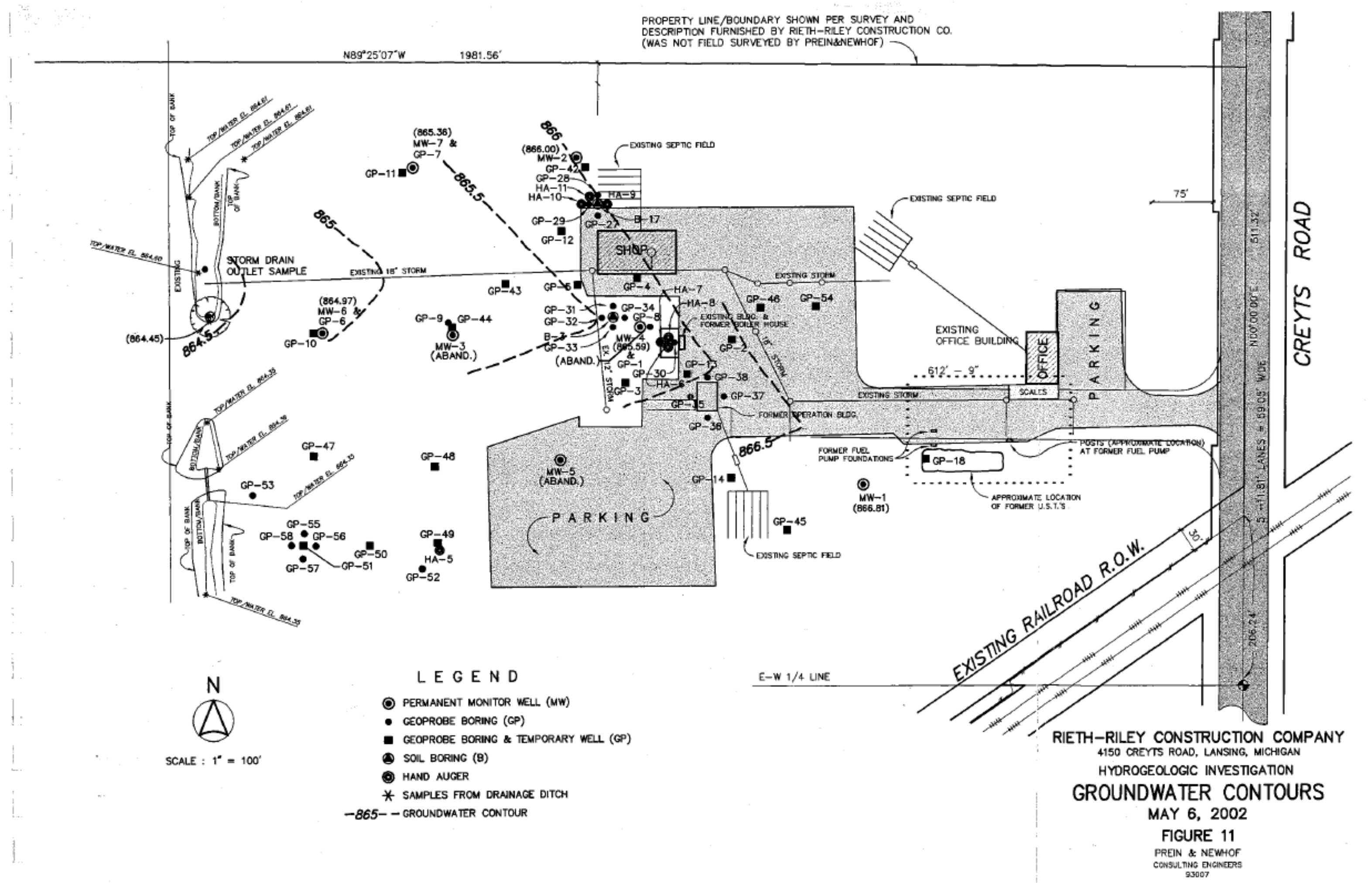


Figure 1. Groundwater Contours for Shallow Groundwater Wells on the Adjacent Reith Riley Property demonstrating groundwater flow under that property to be westward towards the wetland and Erickson (Prien & Newhof, 2003)

Bedrock Groundwater Quality Update & Boron/Shale Correlation

As described above, new bedrock well MW-16D appears to be hydraulically disconnected to the other wells at Erickson Power Station. In addition, a review of the impacted wells closer to the impoundment show a consistent set of parameters that exceed groundwater protection standards, not solely boron as is the case with MW-16D. For example, at the glacial wells with statistically significant increases (SSIs) and SSLs over groundwater protection standards (e.g. MW-2 and MW-5), the parameters that exceed the groundwater protection standards include calcium, lithium, sulfate, and Total Dissolved Solids (TDS) in addition to the boron. However, at the MW-16D bedrock well, only boron exceeds the groundwater protection standard. This is similar to the findings observed in the private wells completed in bedrock and described in the Private Well Report. This is further data supporting the boron in the bedrock to be naturally occurring.

A Piper diagram (**Figure 4**) divides water into four basic types according to their placement in the different sections or quadrants of the diagram (e.g. blue, yellow, green, purple). Waters that plot in different sections on the diagram in **Figure 4** imply the waters are different types of waters. Water quality from Erickson wells and Private wells were compared on this diagram to determine if they are similar or different from each other. A review of where the wells plot on the diagrams (**Figure 4**) shows the water quality at bedrock well MW-16D plots similarly to bedrock wells MW-7B, MW-12B, and MW-100D, and plots in a different quadrant than bedrock wells MW-16C, MW-11B, and MW-100C, and in a different quadrant than impacted glacial wells MW-3 and MW-7C, indicating they are different water quality classes of waters. The water quality “groupings” of bedrock wells can be observed in the piper diagram in **Figure 4**.

Wells that plot together on the diagram in the Sodium Bicarbonate Section (purple section)	Wells that plot together on the diagram in the Calcium Bicarbonate Section (blue section)	Wells that plot together on the diagram in the Calcium Sulfate Section (yellow section)
MW-7B	MW-11B	MW-3
MW-12B	MW-16C	MW-7C
MW-16D	MW-100C	
MW-100D		

The bedrock wells that plot nearest each other on the piper diagram, MW-7B, MW-12B, MW-16D, and MW-100D, are also the same group of bedrock wells that have the higher concentrations of boron (3.0 mg/L and up). This same group of wells also have higher sodium levels, very low water hardness, and higher pH. These same group of four wells also have the highest percent of shale in the well screened interval. Specifically, these four wells have 80-100% of the well screen is in shale and 0-20% of the screen in sandstone (**Figure 5**). The other group of bedrock wells that plot near each other on the piper diagram, MW-11B, MW-16C, and MW-100C, all have lower concentrations of boron ($\leq$1.45 mg/L) and two of the three have well screens with less shale (7-40% of the well screen is in shale and 60-93% of the screen in sandstone) (**Figure 5**). **Figure 5** displays that there is a correlation between the amount of shale in the bedrock screened zone and the boron concentration from that well. The shale appears to be a naturally occurring source of the boron in bedrock groundwater. This is also consistent with the findings of Rowe (2022):

> *"Four wells had levels of boron above the average level of 0.472 ppm and above what is normally seen in this region, or above 1.00 ppm. One well demonstrated a water chemistry often seen in the Williamstown Township area of Ingham County, where several wells are also testing for boron above 1.0 ppm.* ***These wells usually have a naturally softened water chemistry with high sodium levels, very low water hardness, fluoride levels above 1.0 ppm, boron above 1.0 ppm, and pH levels above 8.0, (Rowe, Garry, 1986). The naturally soft water chemistry is due in part to the high percentage of shale bedrock from a process called shale membrane filtration, (Slayton, D.E., 1982), (Long, D.T., and Larson, G. J., 1983).*** *… The boron levels found in these 4 bedrock wells is considered to be naturally occurring."*

This same exercise shown in **Figure 5** plotting the percent shale for a well has not been possible in the private wells due to the driller well logs that were produced when each private well was drilled. The private well logs lump the bedrock lithology instead of logging it separately. For example, private well logs state "shale and sandstone" for bedrock intervals instead of separating shale intervals from sandstone intervals.

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

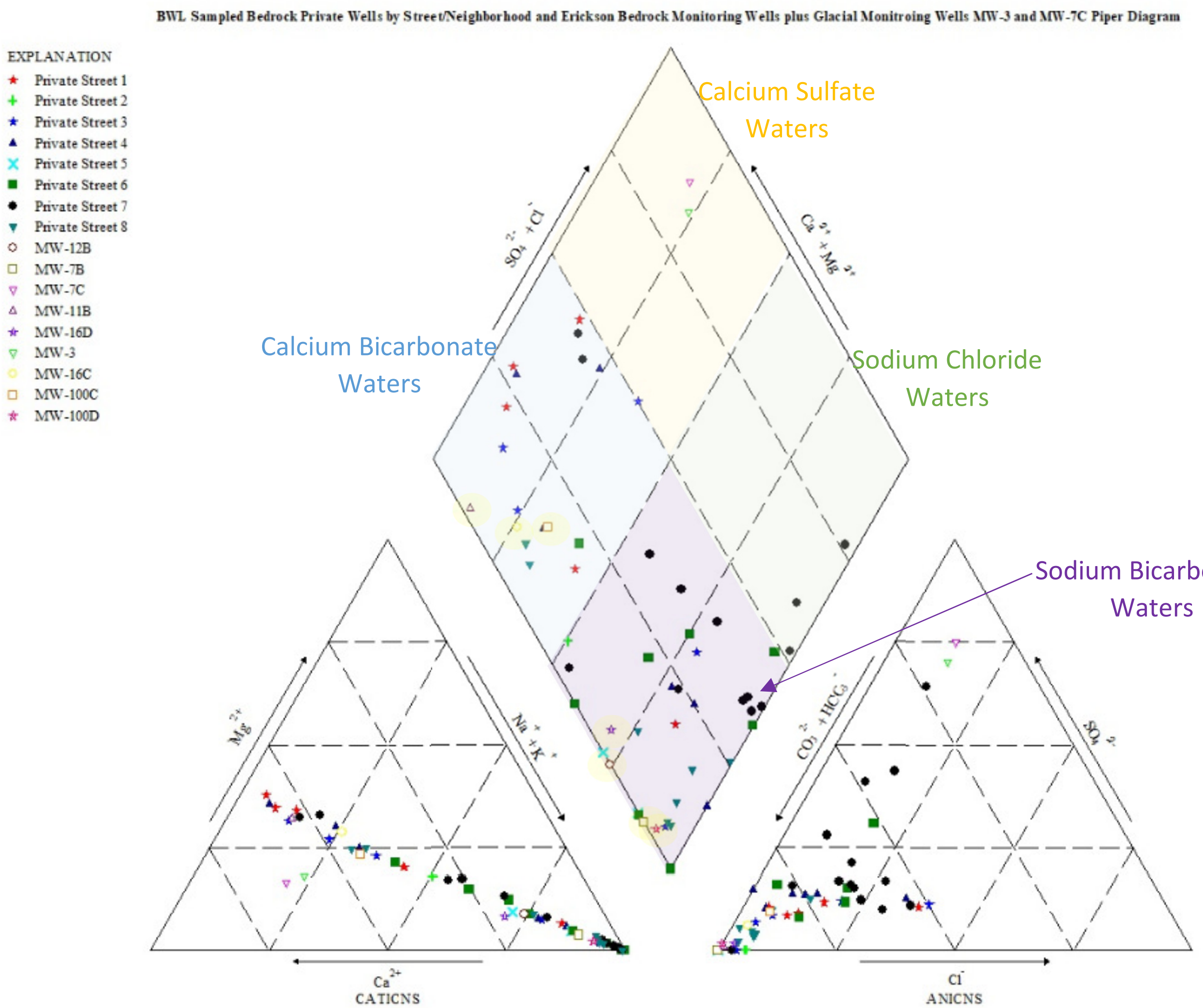
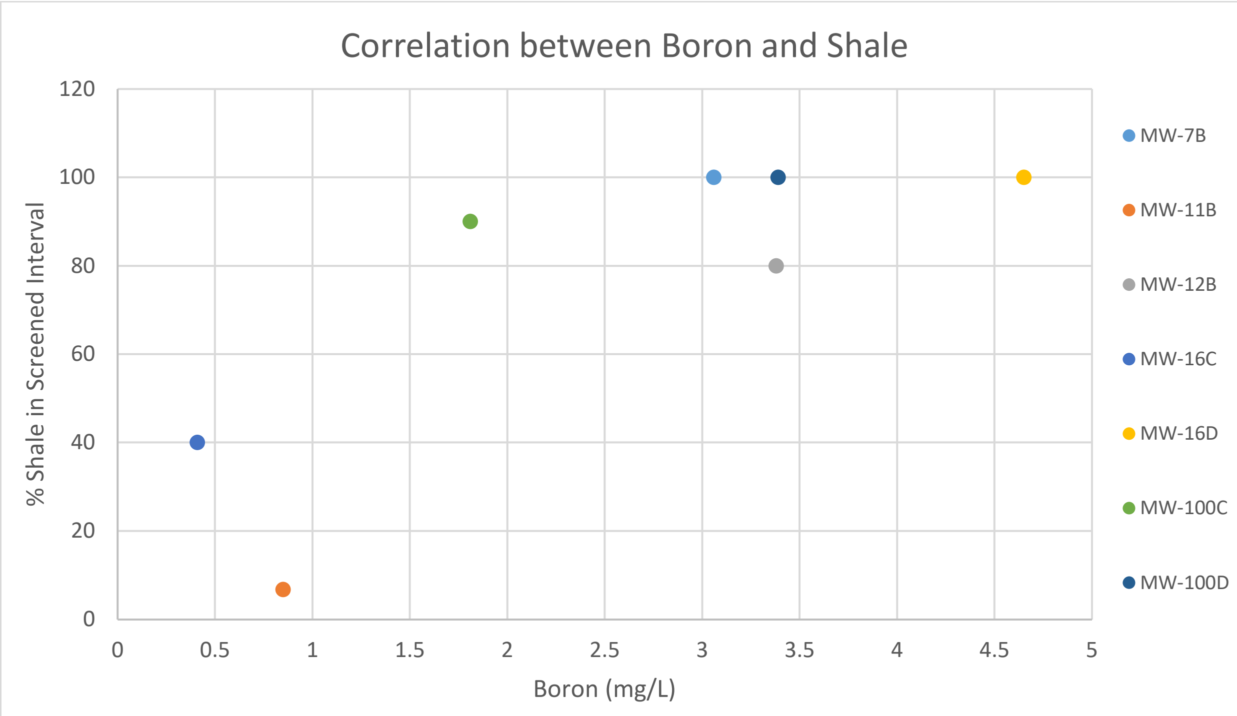


Figure 4. BWL Bedrock Wells, Private Wells, and Glacial Wells MW-3 and MW-7C Piper Diagram



*Concentrations of boron from the August 2023 Assessment Monitoring Event.

Figure 5. Erickson Bedrock Well Screened Shale Percentages and Boron Concentrations in Groundwater

References

Prein & Newhof, 2003. Comprehensive Remedial Investigation and Risk Evaluation Report (1993-2002). May, 2003.

Ruhl, L. S., Dwyer, G. S., Hsu-Kim, H., Hower, J. C., and Vengosh, A, 2014. Boron and strontium isotopic characterization of coal combustion residuals: Validation of new environmental tracers. *Environmental Science & Technology*, *48*(24), 14790–14798.

5405 Data CourtDrive, Ann Arbor, MI 48108-8949
(734) 761-9130

Appendix A
Groundwater Contour Maps