Barton Springs
Edwards Aquifer
CONSERVATION DISTRICT

Preliminary Report on the Installation of Two Multilevel Monitor Wells Near Jacob's Well

Technical Memo 2022-0831
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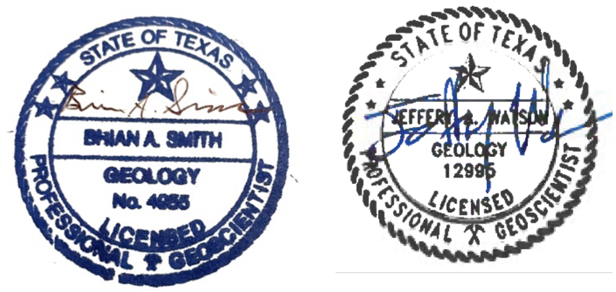
Brian A. Smith, Ph.D., P.G., Jeffery A. Watson, P.G., and Justin Camp



Introduction

Between March and April 2022, the Barton Springs/Edwards Aquifer Conservation District (BSEACD) installed two monitor wells upgradient of Jacob's Well in Hays County. These wells were installed with the cooperation of Hays County, Hays Trinity Groundwater Conservation District (HTGCD), and Wimberley Valley Watershed Association (WVWA). The purpose of these wells is to better characterize the Trinity Aquifers in central Hays County and to understand the flow relationships between the distinct hydrogeologic units of the Trinity. A better understanding of these units will allow for better management of the Trinity Aquifers. The main target of these wells is the Middle Trinity Aquifer which is the main source of the groundwater that flows from Jacob's Well and to many water-supply wells in the area. Additional tasks that are a part of these Interlocal Agreements (ILAs) are installation of transducers in these and other monitor wells, water-level measurements, dye tracing, and water-quality analyses.

ILAs between Hays County and the BSEACD and between the HTGCD and the BSEACD were signed on October 10, 2019, and May 12, 2020, respectively. The principal goal of the studies associated with these ILAs was the installation of two monitor wells, one is a dual completion well and the other is a multiport well. Construction of these wells was postponed until the outcome of a grant application that included the monitor well funding as a matching component. Amendments to the ILAs were agreed on by all parties with a new completion date of August 31, 2022.

Background

Hydrogeology

The geologic units that make up the Trinity Aquifers in the study area (Figure 1) are largely limestones and dolomites of Early Cretaceous age (Hunt et al. 2020; Wierman et al., 2010). These sediments were deposited on a broad shelf that separated the deeper water of the Gulf of Mexico to the southeast and land of the Llano Uplift to the northwest. Major faulting occurred during the early Miocene along the Balcones Fault Zone which consists of a series of en-echelon normal faults, with down-to-the southeast displacement. These faults and associated fractures provide pathways for groundwater movement and the development of solution conduits which are a key feature of karst aquifers such as the Middle Trinity Aquifer.

Units that make up the Trinity Aquifers in the vicinity of Jacob's Well are from top to bottom: lower member of the Glen Rose limestone, Hensel formation, Cow Creek limestone, Hammett shale, Sligo limestone, and Hosston sandstone (Figures

2 and 3) (Smith et al., 2015). The Middle Trinity Aquifer consists of the lowermost section of the Lower Glen Rose, the Hensel and the Cow Creek. However, the Hensel over much of this area acts as a confining unit that separates the Middle Trinity Aquifer into two sub-aquifers. The Lower Trinity Aquifer consists of the Sligo and Hosston formations with the Hammett shale acting as a confining unit separating the Middle Trinity Aquifer from the Lower Trinity Aquifer. The Upper Trinity Aquifer consists of portions of the upper and lower members of the Glen Rose limestone, but the Upper Glen Rose is not present in the immediate vicinity of Jacob's Well (Figure 1).

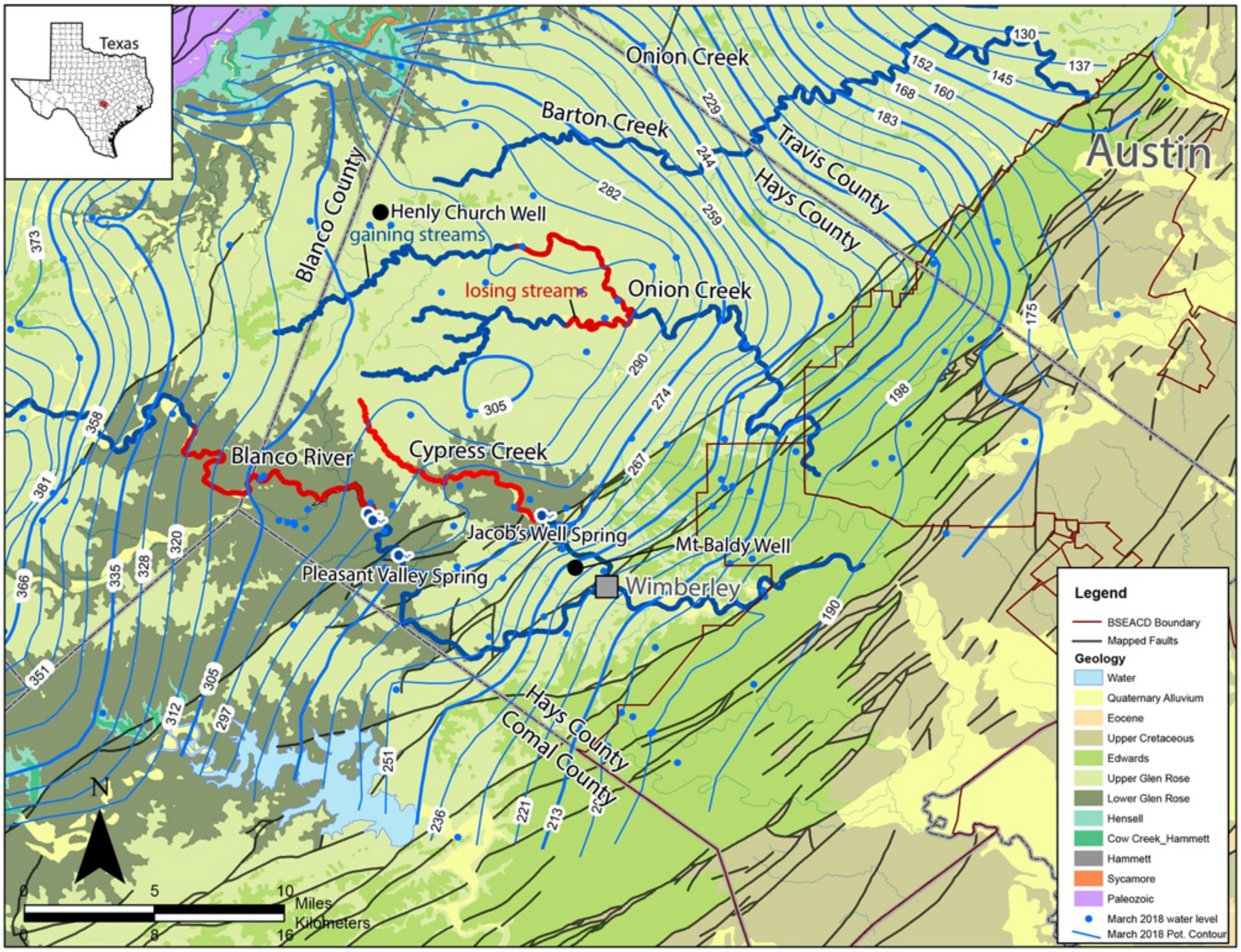


Figure 1. Geologic map of Hays County and surrounding areas showing county boundaries, major surface streams, locations of wells for water-level measurements, and potentiometric (water level) contours from 2018. Jacob's Well is located near the center of the map.

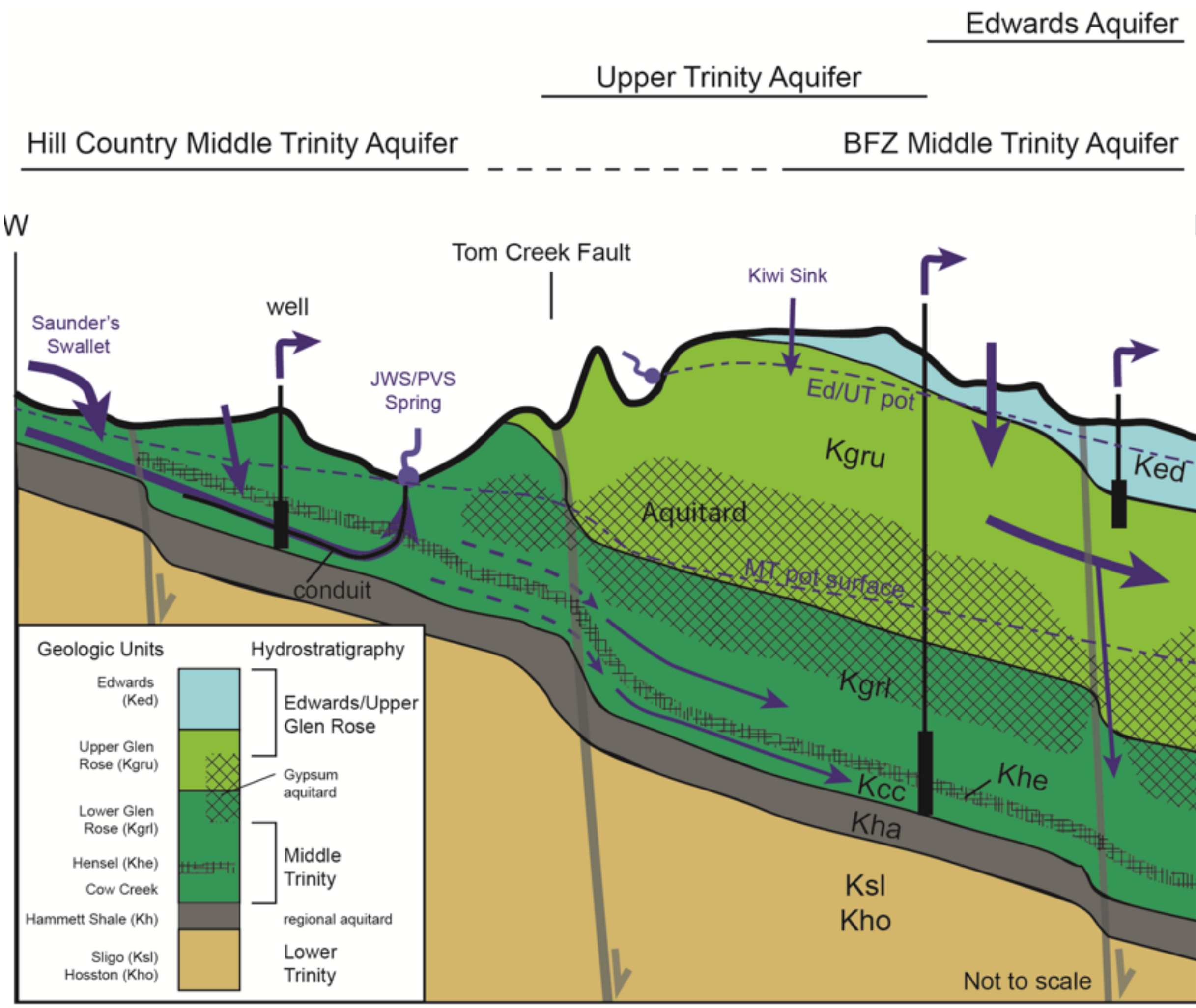


Figure 2. Schematic cross section and stratigraphic column of the aquifers and geologic units discussed in this report (Smith et al., 2018). JWS is Jacob's Well Spring. PVS is Pleasant Valley Spring which is located about 5 miles west of Jacob's Well.

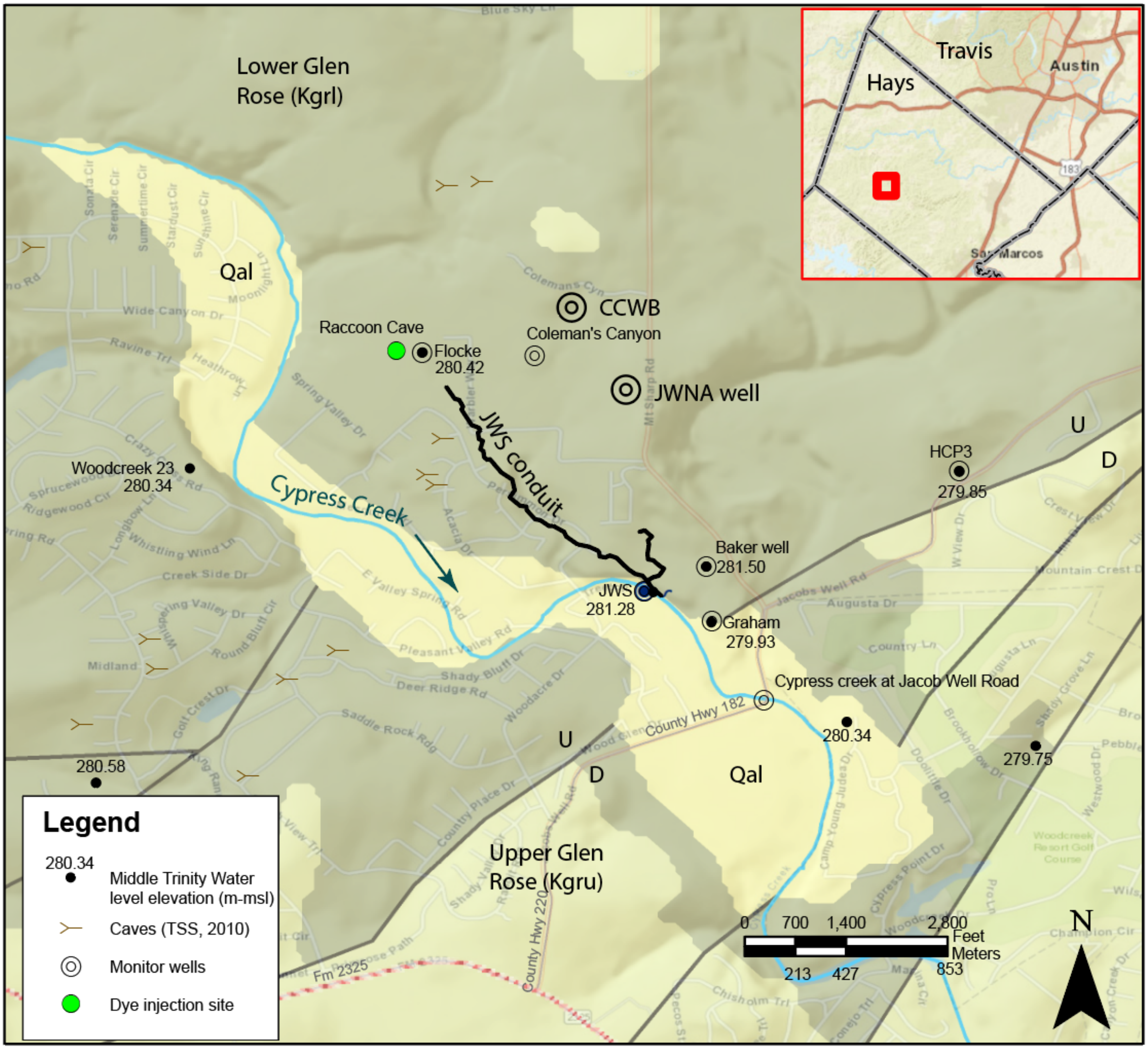


Figure 3. Geologic map of the area around Jacob's Well (JWS) including the conduit (cave passage), shown with a heavy black line, which directs much of the flow to Jacob's Well. The multiport well at Coleman's Canyon (CCWB) and the dual completion well (JWNA- Jacob's Well Natural Area) are shown to the north of Jacob's Well. Gray lines are faults.

Water Supply

Much of central Hays County depends on the Trinity Aquifers for water supply since surface water is very limited. Other than the Blanco River, surface streams in the area are often dry other than during average and above average rain conditions. The Middle Trinity Aquifer is the most prolific of the three aquifers. Although it is only about 90 to 100 ft thick, it has good porosity and permeability owing to primary porosity and karstic features such as conduits. The Middle Trinity Aquifer has very good water quality over most of central Hays County. Very few wells tap into the Lower Trinity because of greater depth, lower yields, and poor water quality. However, yields and water quality in the Lower Trinity can vary significantly over central Hays County.

There is very little firm data for the number of water-supply wells in the area and even less for the amount of extraction from these wells. Considering that there is very little surface water available in the study area, increases in groundwater extraction should coincide with changes in population. According to the U.S. Census Bureau (2021), Hays County is the fastest growing county in the United States for counties with populations greater than 100,000 for the census period 2011 to 2020. The population of Hays County increased by 53% since 2010 to 241,067 people. These trends in population growth and groundwater extraction suggest that unreasonable impacts, such as significant lowering of water levels and cessation of springflow, are likely to happen in the not-too-distant future. Recent studies have shown that in portions of southwest Travis County, the Middle Trinity Aquifer is depleted of groundwater such that new wells are being completed into the Lower Trinity Aquifer (Hunt et al., 2020). A study to delineate a groundwater management zone for the Jacob's Well area showed that pumping from large-capacity water-supply wells close to Jacob's Well caused springflow to decrease (Gary et al., 2019). During periods of drought, this pumping can cause flow from Jacob's Well to cease.

Methodology

Most aquifers are very complex in both their horizontal and vertical properties. Multilevel monitor wells allow for monitoring subunits within an aquifer or of multiple stacked aquifers in a single borehole. Data from these wells provide insight to the differences in hydraulic head (water levels or pressures) between the different hydrogeologic units. Collection of groundwater samples for water-quality testing provides information about the variation in chemistry between these units. And hydraulic conductivity testing indicates the permeability of each unit and how likely vertical flow might be between these units. Since 2008, the BSEACD has installed two types of multilevel monitor wells to investigate the Edwards and Trinity Aquifers: multiport and dual completion wells.

Dual Completion Wells

A dual completion well consists of a standard monitor well completion in which the open borehole for the deepest part of the well constitutes the lowest monitor zone, then a piezometer, consisting of a PVC pipe, is inserted in the annular space above the open borehole section (Figure 4). The annular space between the riser pipe and the borehole wall is filled with cement except near the base of the piezometer. A second monitor zone is established where the PVC is slotted, then sand or gravel is packed into the annular space around the slotted section. Water levels can be measured in each of these zones either periodically with elines or continually with transducers. As part of this study, a dual completion well was installed in the northeast portion of Jacob's Well Natural Area to a depth of 280 ft. This well was completed with a standard monitor zone in the Cow Creek and a nested piezometer in the Lower Glen Rose (Figure 4).

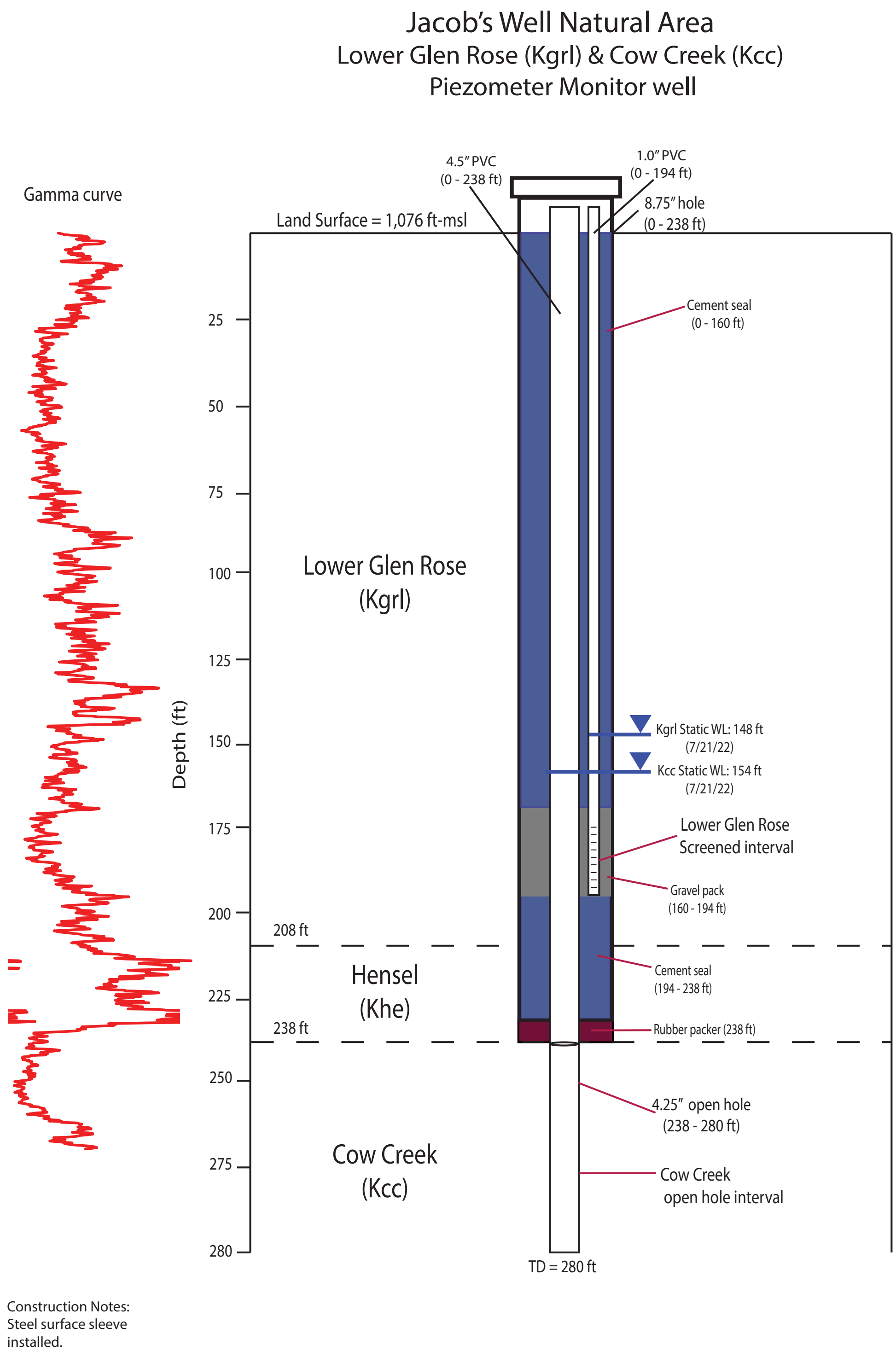


Figure 4. Construction diagram for JWNA dual completion well including gamma ray log.

Multiport Monitor Wells

Multiport monitor wells have been used by the BSEACD to study complex, multilayer, and stacked aquifers in central Texas (Smith and Hunt, 2019). The BSEACD has used multiport wells to determine vertical variations in an aquifer and the hydraulic relationships between stacked aquifers. With multiport wells, properties, such as hydraulic head, temperature, hydraulic conductivity, and water quality of discrete units within an aquifer can be determined. The use of multiport wells has shown how portions of the Upper Trinity lithologic units are hydraulically connected to the overlying Edwards lithologic units, and how the Edwards Aquifer is hydraulically isolated from the Middle and Lower Trinity Aquifers (Smith et al., 2018).

One of the two wells installed for this project is a multiport well with components provided by Westbay Instruments. This well, on Wimberley Valley Watershed Association property at Coleman's Canyon, was completed with ten monitor zones to a depth of 535 ft. Two of these zones were completed in the Lower Trinity Aquifer (Sligo and Hosston formations). Three zones were completed in the Cow Creek limestone. And three zones were completed in the Lower Glen Rose limestone. An additional two zones were completed in the confining Hammett and Hensel formations. Well construction details are shown in Appendices A and B and water-quality results are included in Appendix C.

Results and Discussion

What we have learned from the preliminary data collected from the multiport well is that the Hammett shale provides a very significant barrier (confinement) to vertical flow between the Lower Trinity and the Middle Trinity Aquifers (Figure 5). This confinement is apparent from the significant difference in head (water level) of about 35 ft between Zone 2 (Sligo) and Zone 4 (Cow Creek). These results confirm what is known about the Hammett being a significant confining unit throughout much of central Texas. As seen in the two multilevel wells (Figures 5 and 6), the Hensel formation appears to provide some amount of confinement between the underlying Cow Creek limestone and the overlying Lower Glen Rose limestone. The multiport well shows that heads in Zone 8 (Lower Glen Rose) are about 3 ft higher than in Zones 4, 5, and 6 (Cow Creek). In the dual completion well, the head difference between the Lower Glen Rose and the Cow Creek was 3.4 ft in April 2022 and increased to 7.4 ft in July 2022 (Figure 6). In the multiport well, we also see two distinct perched aquifers higher in the Lower Glen Rose limestone (Figure 5) where the head in the Zone 10 is about 55 ft higher than in Zone 9. Zone 9 has a head that is about 40 ft higher than the head in Zone 8.

As drought conditions are impacting central Texas, heads in the three Cow Creek zones have dropped by about 3 ft between March 18 and August 2, 2022 (Figure 5). The Hosston, Sligo, and lowermost Lower Glen Rose zones are showing similar, or slightly greater, decreases in head.

These are important findings as the Cow Creek, Hensel, and Lower Glen Rose are typically assumed to behave as a single, hydraulically connected aquifer system. These new data show that the Middle Trinity Aquifer is more complex than this and may behave locally as several hydraulically separated sub-aquifers. Understanding these details about an aquifer are important for planning for water supply and for groundwater management. This knowledge will be useful as numerical models are refined and as the local groundwater districts (BSEACD and HTGCD) consider promulgation of rules to protect the aquifers.

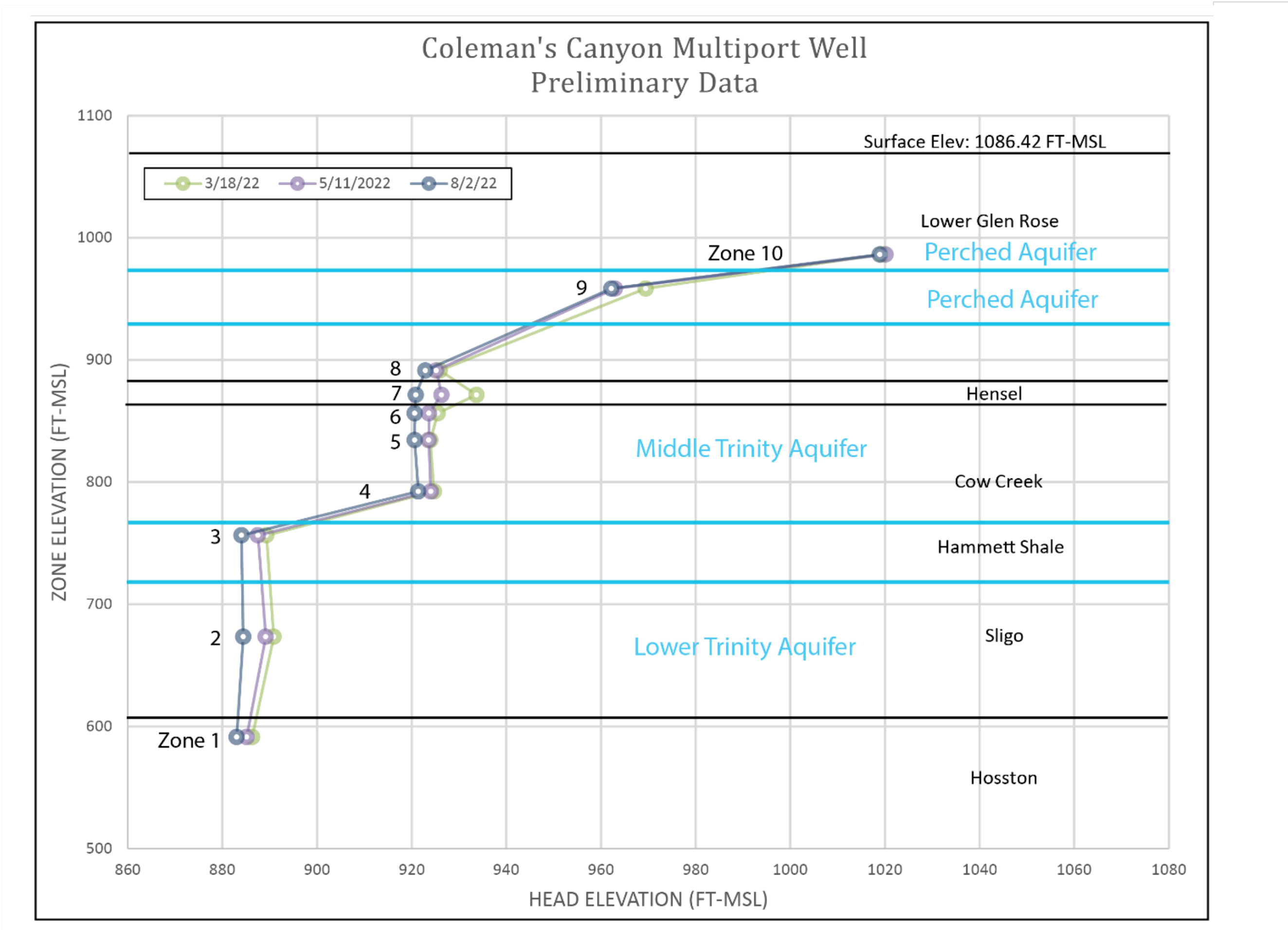


Figure 5. Hydrograph of Coleman's Canyon multiport well showing head (water-level) changes over time for each of the ten zones. Note that the colors of the symbols and lines refer to the date of measurement. Elevations of the monitoring zones are shown in the left scale. Head elevations (water levels) are shown in the bottom scale with higher heads to the right.

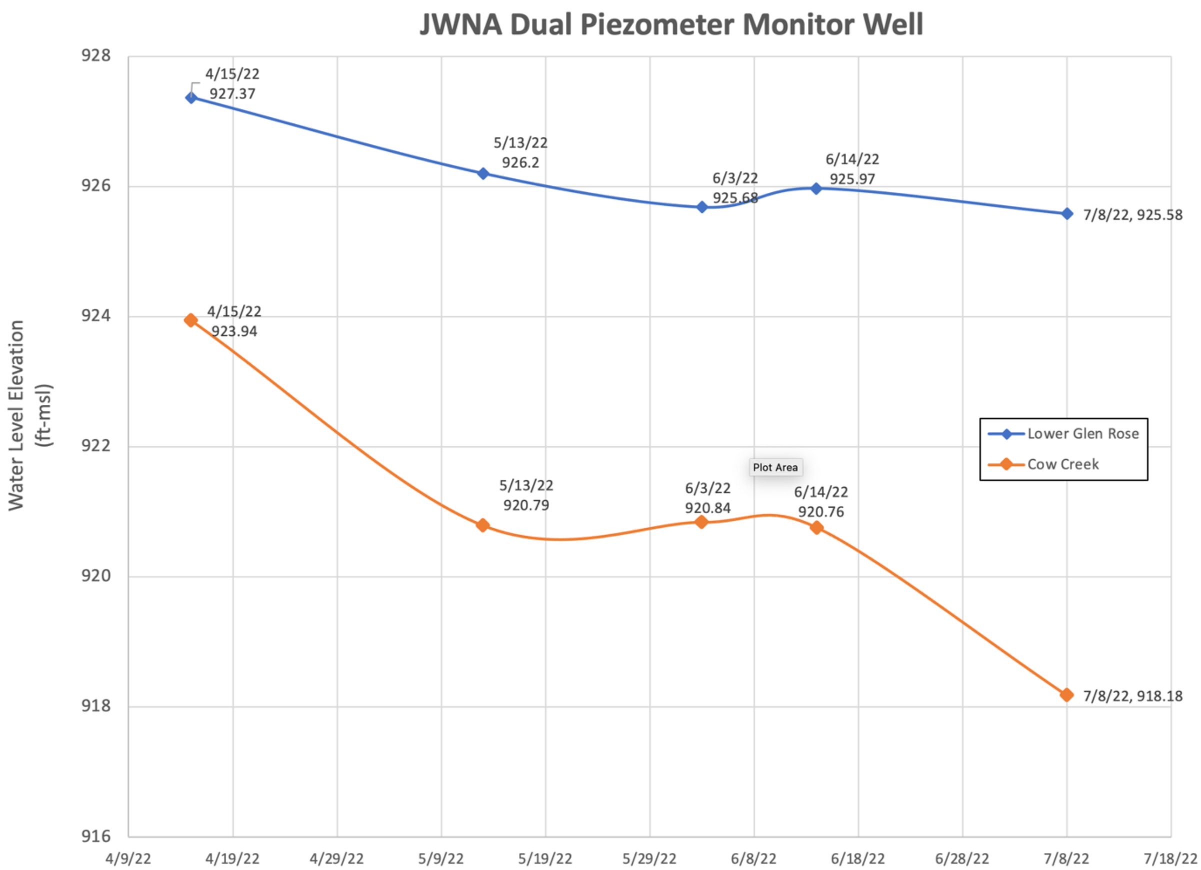


Figure 6. Hydrograph of JWNA dual completion well showing differences in heads (water levels) between the Lower Glen Rose and the Cow Creek.

Other Tasks

Hydraulic Conductivity Testing

Slug tests, which are a specific type of hydraulic conductivity (permeability) test, were conducted in each of the zones in the Coleman's Canyon multiport well. These tests are conducted by opening a pumping port in a given zone then inserting a transducer below the water level and placing a slug, or solid device, into the water inside the well. When the slug enters the water, the water level is displaced, and the transducer records this displacement over time. The amount of displacement and the time for the water level to return to equilibrium is used to calculate the hydraulic conductivity of the zone. Values of hydraulic conductivity can give an idea of how productive a zone might be or can show how impermeable a zone might be. At the time of preparation of this report, these calculations had not yet been completed. A follow-up report will be prepared in the spring of 2023 with the results of the hydraulic conductivity and water-quality analyses plus an update on changes in water levels in the two monitor wells that were installed near Jacob's Well.

Dye Tracing

The first dye trace conducted in the Jacob's Well area was conducted between March and April 2018 with the injection of dye into Raccoon Cave, about 1.2 miles upgradient of Jacob's Well (Hunt et al., 2020a) (Figure 3). Monitoring for the presence of dye was done in Jacob's Well, Cypress Creek, and several downgradient wells. Results of this trace were inconclusive. It's possible that there is no direct connection between Raccoon Cave, which is formed in the Lower Glen Rose formation, and Jacob's Well with the flow coming primarily from the Cow Creek formation.

The dye-tracing program mentioned in the ILA was initially being considered in October 2019 with funding coming in large part from Hays County and with Zara Environmental conducting most of the work. By November 2020, the amount of funding for the project had decreased so the various partners in the study, Hays County, BSEACD, HTGCD, EAA, and WVWA, decided that their staff would take on most of the work with a limited amount of budget going to a consultant. Following the signing of the ILA between Hays County and the BSEACD, the timing of the work shifted until after the monitor wells were installed since they would be an important component of the dye-trace study. However, at the time the wells had been completed and tested, flow from Jacob's Well had diminished to the level that tracing was not feasible.

Conclusions

Detailed information about these aquifers is generally not apparent in standard monitor wells or in the numerous production wells from which we typically obtain our knowledge about an aquifer. Results from the two multilevel monitor wells help us better understand how recharge enters the aquifers, how water moves horizontally and vertically through the aquifers, and how some of this water ultimately discharges from Jacob's Well.

This study suggests that rainwater entering the subsurface in the immediate vicinity of Jacob's Well is not providing significant recharge to the Cow Creek. Therefore, most of the water discharging from Jacob's Well (Figure 7) is likely from lateral flow through the Cow Creek from more distal, upgradient sources, such as further northwest in Hays County and into Blanco County. Further testing of these wells and the measurement of water-level changes over time will provide a better indication of the role of the Hensel formation as a confining unit and how water moves through the Middle Trinity Aquifer to either flow to Jacob's Well or to flow further southeast into deeper portions of the Trinity. The results of these studies will help us improve the numerical groundwater models and to determine the sustainable yield of the Middle Trinity Aquifer. In other words, how much pumping can take place during periods of extreme drought without causing undesired results such as wells going dry and springs ceasing to flow.

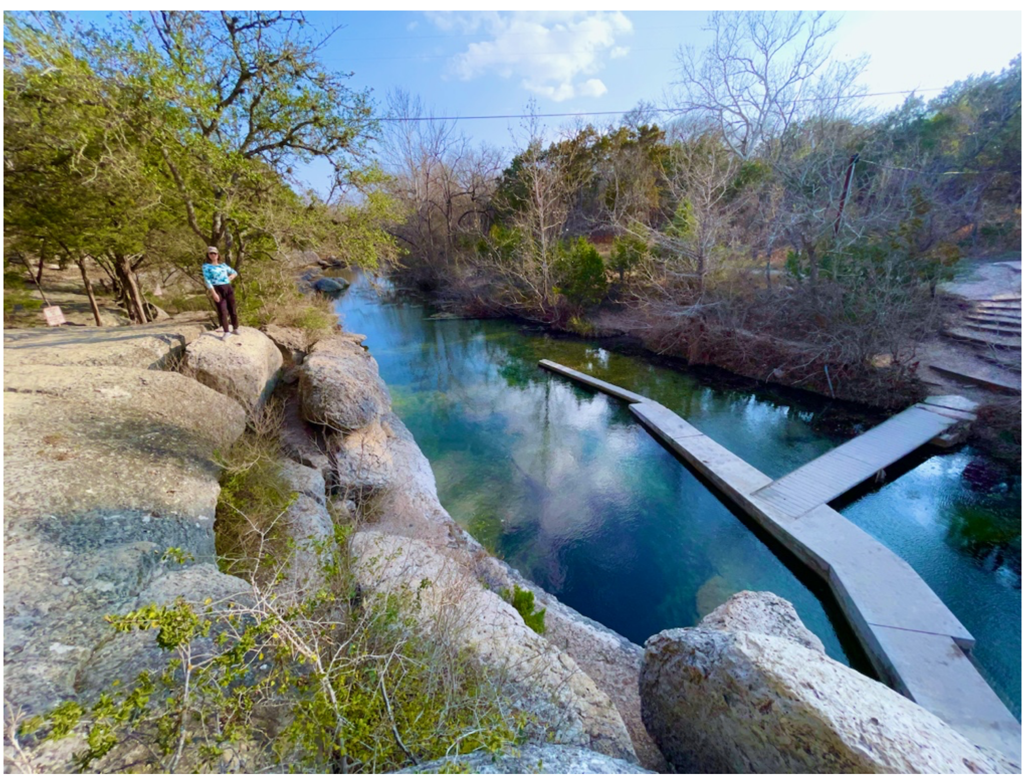


Figure 7. Jacob's Well, situated in the bed of Cypress Creek, provides water to Cypress Creek and, further downstream, the Blanco River.

References

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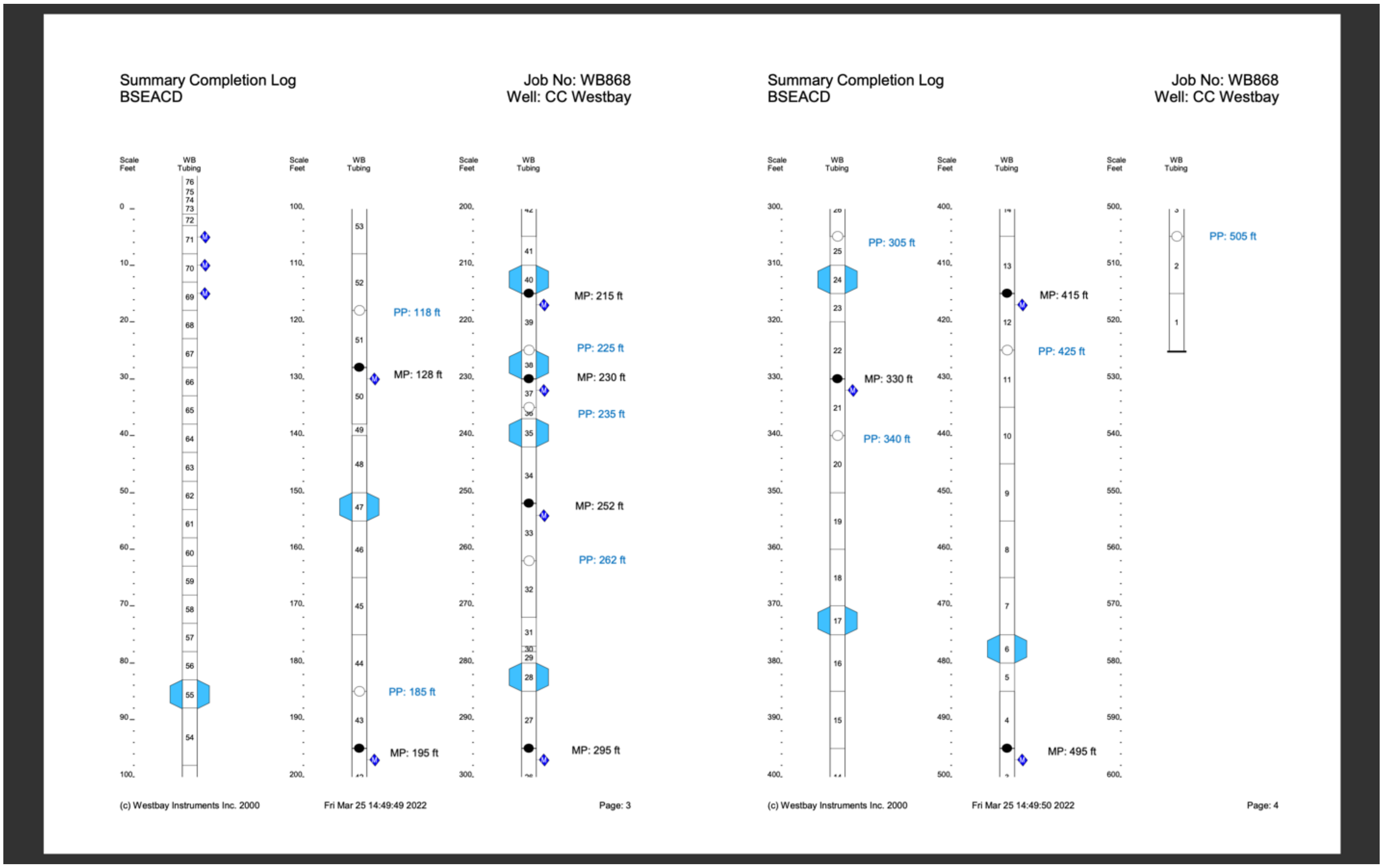
Wierman DA, Broun AS, and Hunt BB, editors. 2010. Hydrogeologic Atlas of the Hill Country Trinity Aquifer, Blanco, Hays, and Travis Counties, Central Texas. Barton Springs/Edwards Aquifer Conservation District 17 (11x17 inch) plates.

Appendix A

As-built construction diagram of the Coleman's Canyon multiport well.



Note: Blue symbols represent packers that hydraulically separate geologic and hydrologic units. Black circles represent measurement ports, and open circles represent pumping ports. The scale is in feet below ground surface.

Appendix B

Geophysical log plus summary of multiport well construction

Appendix C

Results of water-quality analyses

1. LCRA Laboratory- major cations, anions, metals, and trace elements
2. Isotopes