Evaluating Composite Hydrologic Heads in a Stacked Aquifer System Using a Multiport Well, Trinity Aquifer, Central Texas

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Abstract

Water supply wells often penetrate multiple aquifers or hydrostratigraphic units yet serve as the primary source of hydraulic head data for aquifer characterization and modeling. This study investigates the effects on head data from zones open across hydrologic units through the use of a multiport (Westbay) monitor well.

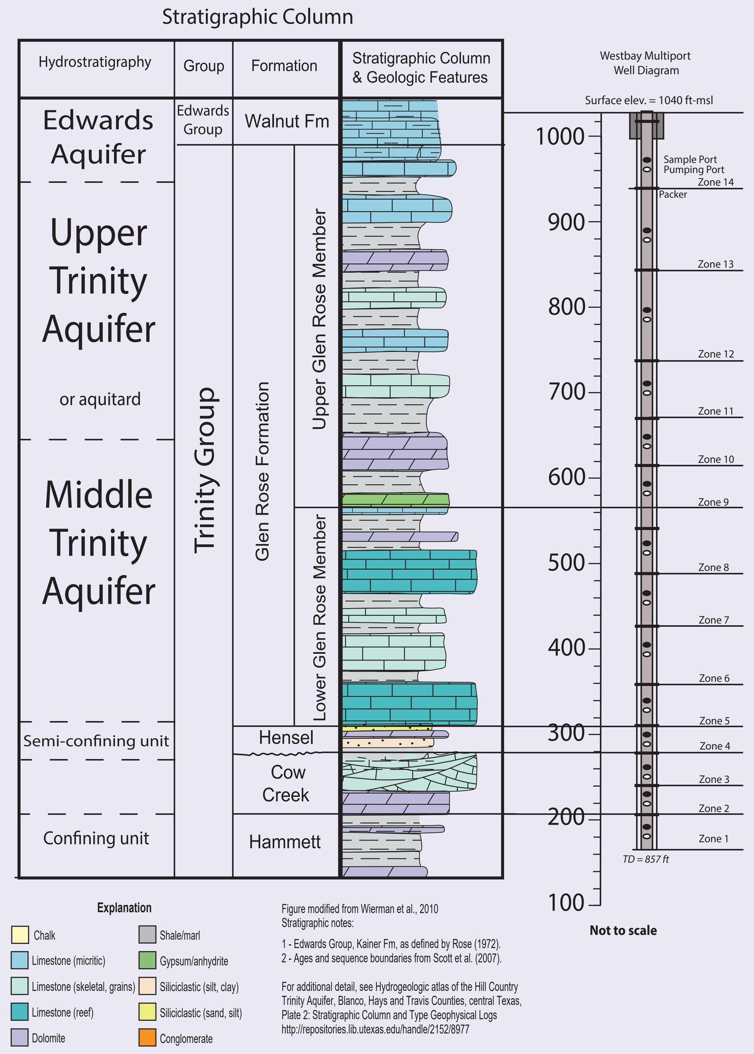
An 857-foot deep multiport monitor well (ID 57-64-613) with 14 zones was utilized to isolate and monitor specific aquifer units within (stratigraphically lowest to highest) the Cow Creek limestone (primary aquifer), Hensel (aquitard), Lower Glen Rose limestone (secondary aquifer), and Upper Glen Rose. By selectively opening and closing pumping ports, the impact of different aquifer units on the primary aquifer head was assessed over a 19-month period (starting August 2020).

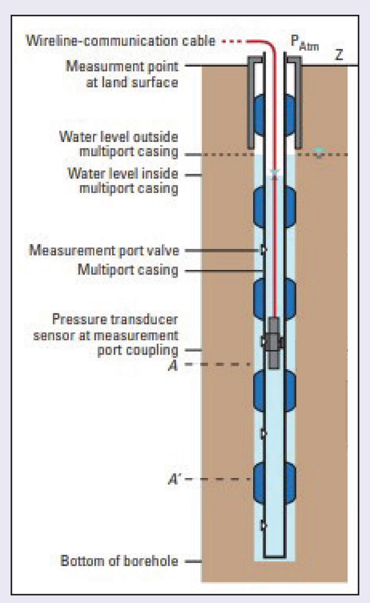
Composite head measurements in the multiport generally reflect the overall trend of the Middle Trinity Aquifer, influenced primarily by higher transmissivity units. Zone 3 (Cow Creek) dominates head elevation, with Zone 8 (transmissive upper reef interval of Lower Glen Rose) had an influence on the Cow Creek heads by shifting composite head higher by 5-7 feet. Other zones had minimal impact, even when their head values were significantly higher.

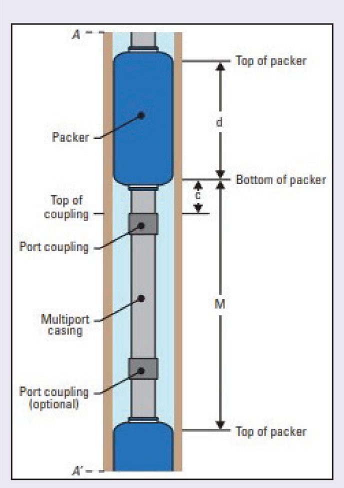
A weighted average of head values, based on transmissivity, provided a reasonable estimate of the composite head measured in the study. However, local variations in transmissivity and measurement methods of transmissivity can lead to deviations from this estimate.

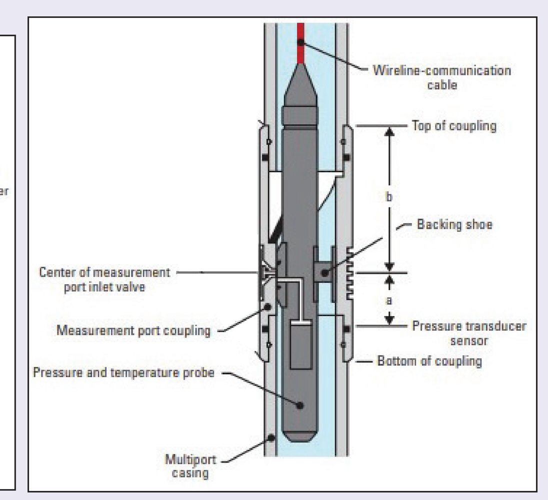
This study emphasizes the importance of understanding well completion details and the relative transmissivities of aquifer units when interpreting head data for aquifer studies. The approach of weighting heads by transmissivity offers a practical method for estimating composite heads in complex aquifer systems with good hydrogeologic data. A better understanding of these factors is crucial for accurate groundwater evaluations.

Methods

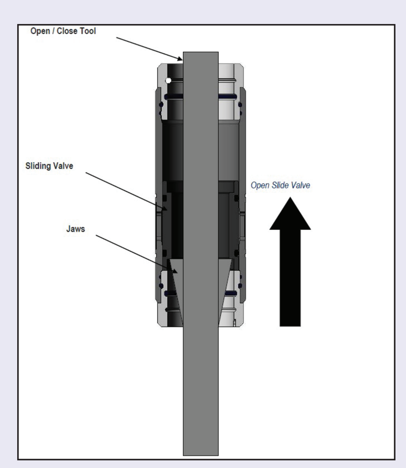


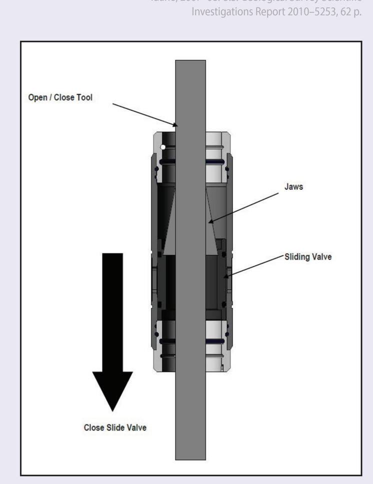

Multi-Packer Borehole Completion


Packer Isolating Zone


Westbay (WB) Pressure Transducer

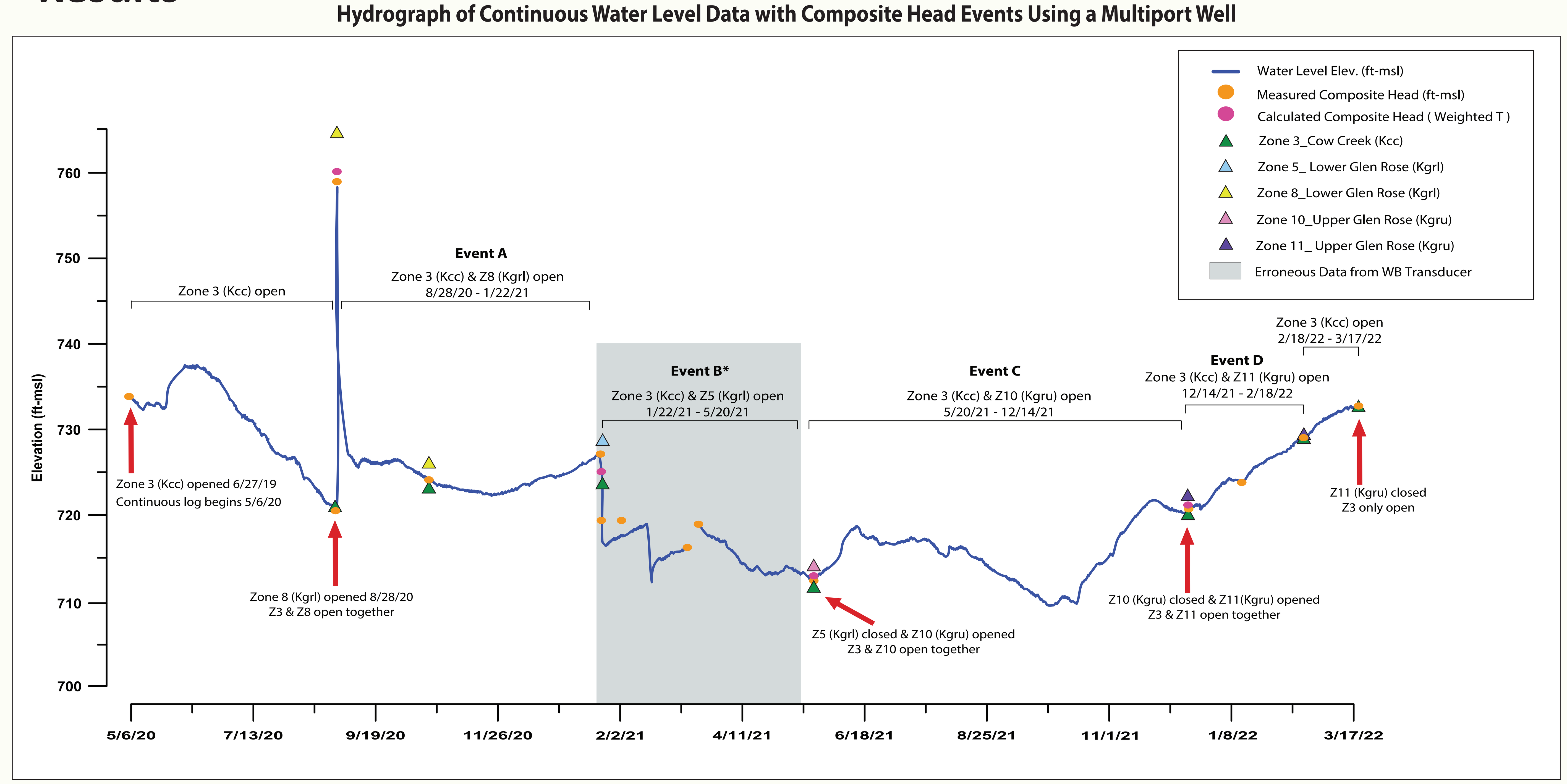

Screend Zone

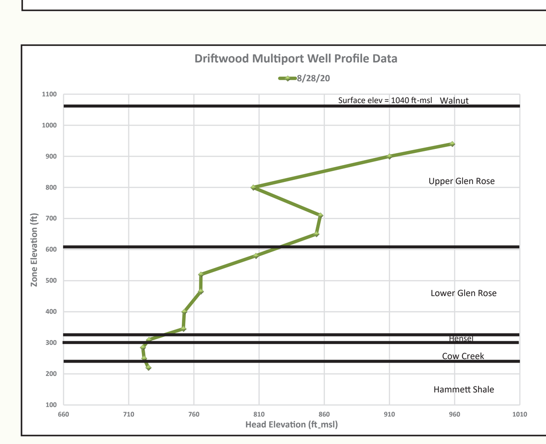

Tool Opening Screened Zone

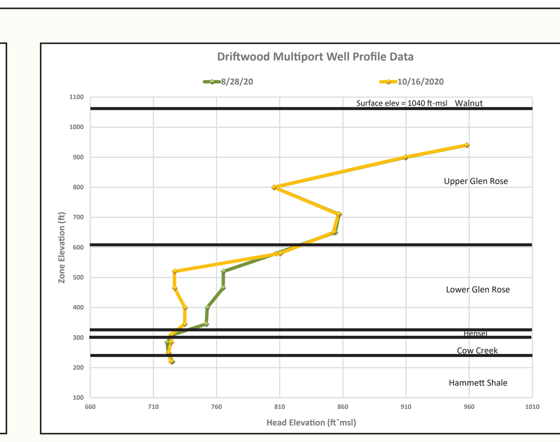

Tool Closing Screened Zone

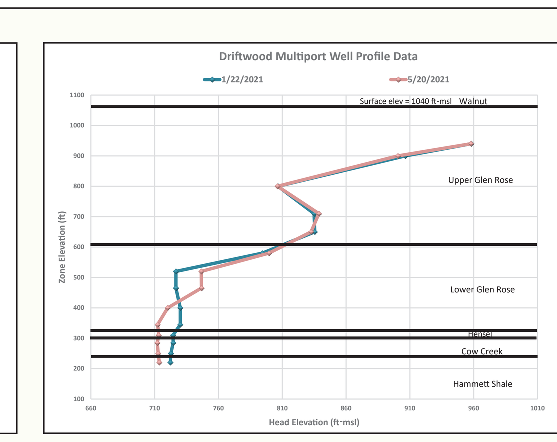
Results

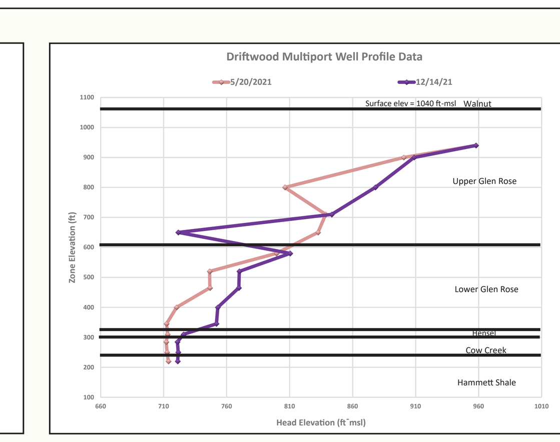
Hydrograph of Continuous Water Level Data with Composite Head Events Using a Multiport Well

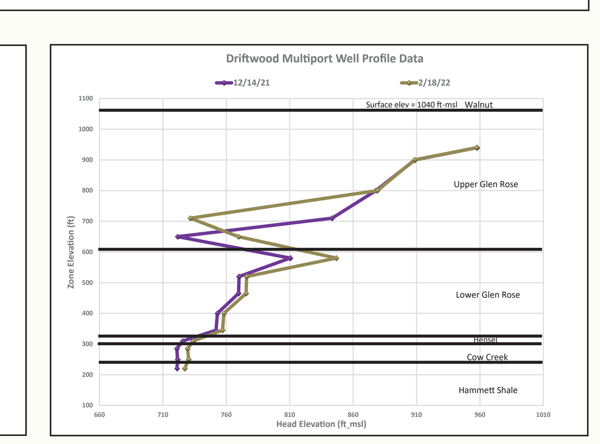



8/28/2020: Only Zone 3 (Kcc) Primary Aquifer Open


8/28/2020: Only Zone 3 (Kcc) Primary Aquifer Open (green)
10/16/2020: Zone 3 (Kcc) & Zone 8 (Kgrl) Secondary Aquifer Open (yellow)


1/22/2021: Zone 3 (Kcc) & Zone 8 (Kgrl) Secondary Aquifer Open (teal)*
5/20/2021: Zone 3 (Kcc) & Zone 5 (Kgrl) Secondary Aquifer Open (pink)
*Erroneous Data from WB Transducer


5/20/2021: Zone 3 (Kcc) & Zone 5 (Kgrl) Secondary Aquifer Open (pink)
12/14/2021: Zone 3 (Kcc) & Zone 10 (Kgru) Open (purple)


12/14/21: Zone 3 (Kcc) & Zone 10 (Kgru) Open (purple)
2/18/2022: Zone 3 (Kcc) & Zone 11 (Kgru) Open (gold)

Zone	Unit	Port Depth (ft)	Thickness (ft)	T (ft^2/d)
11	Kgru	330.0	67	0.000024
10	Kgru	390.0	47	0.01
8	Kgrl	520.0	47	266,067
5	Kgrl	695.0	37	182
4	Kh	730.0	22	0.63
3	Kcc	755.0	27	24,765

Table 1: Hydrologic Zones with Transmissivity Values = T (ft^2/d)

Table 2: Results for the Four Test Periods (A-D)
Calculated Composite Head (Weighted T): [(H1*T1)+(H2*T2)]/(T1+T2)

Date	Event	Zone	Isolated Head (ft-msl)	Measured Composite Head (ft-msl)	Calculated Composite Head (Weighted T)
8/28/2020	A	Z3	720.8		
8/28/2020	A	Z8	765.4		
8/28/2020	A	Z3+Z8		757.23	761.60
10/16/2020	A	Z3+Z8		724.4	
1/22/2021*	B	Z3	724.49		
1/22/2021*	B	Z5	730.05		
1/22/2021*	B	Z3+Z5		718.85	724.53
5/20/2021	C	Z3	712.03		
5/20/2021	C	Z10	832.49		
5/20/2021	C	Z3+Z10		710.10	712.03
12/14/2021	D	Z3	720.93		
12/14/2021	D	Z11	843.38		
12/14/2021	D	Z3+Z11		719.10	720.93

*Erroneous Data from WB Transducer

Discussion

Water supply wells are often completed across multiple aquifer units, yet are the primary source of hydraulic head data used in aquifer characterization, groundwater flow, modeling, and availability studies. The Middle Trinity is composed various stacked limestone and dolomite units with variable hydrologic properties. Units from lowest to highest lithostratigraphy: the Cow Creek limestone (Kcc; primary aquifer unit), the Hensel (Kh; aquitard unit), and the Lower Glen Rose limestone (Kgrl; secondary aquifer unit). The Upper Trinity (Kgru) overlies the Middle Trinity.

This study attempts to provide a better understanding of the effects on head data from wells completed across these hydrologic units.

Conclusions

Despite having higher heads, lower transmissivity zones (Z10 and Z11) had negligible influence on the heads of the primary aquifer unit Z3. Overall, composite heads appear to reflect more closely the heads within the higher transmissive aquifer units, as predicted by the weighting of the heads by the transmissivity. For example, the elevations rose about 35 feet closer to Z8 when the composite head was Z3+Z8. However, within a week the heads within Z3+Z8 lowered and reached an equilibrium within about 5 feet above the estimated Z3 head. This difference may be due to the local nature of the transmissivity values (based on slug tests). This data suggests that understanding the well completion and hydrogeology, including the relative transmissivities of the units is important for the interpretation or use of head data in the Trinity aquifer.