Hydrological and Geochemical Characteristics in the Edwards and Trinity Hydrostratigraphic Units Using Multiport Monitor Wells in the Balcones Fault Zone, Hays County, Central Texas

Barton Springs Edwards Aquifer CONSERVATION DISTRICT

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Purpose

To better understand the hydrogeological properties of and relationships between the geologic units that make up the Edwards, Upper and Middle Trinity Aquifers and to compare observed hydrologic properties of formations to generally accepted understanding of them and suggest nomenclature that best describes hydrogeologic properties of hydrostratigraphic units in the study area.

Introduction

- Permeabilities are a defining characteristic of aquifers.
- Detailed permeability data for distinct litho/hydrostratigraphic units in the Edwards and Trinity Aquifers has not been quantified in a single borehole.
- Hydrologic connection between hydrostratigraphic units in this area is not entirely understood and needs more thorough characterization to better manage water resources.
- Two Westbay multiport wells were used to measure hydrogeologic characteristics of rock units.

Location

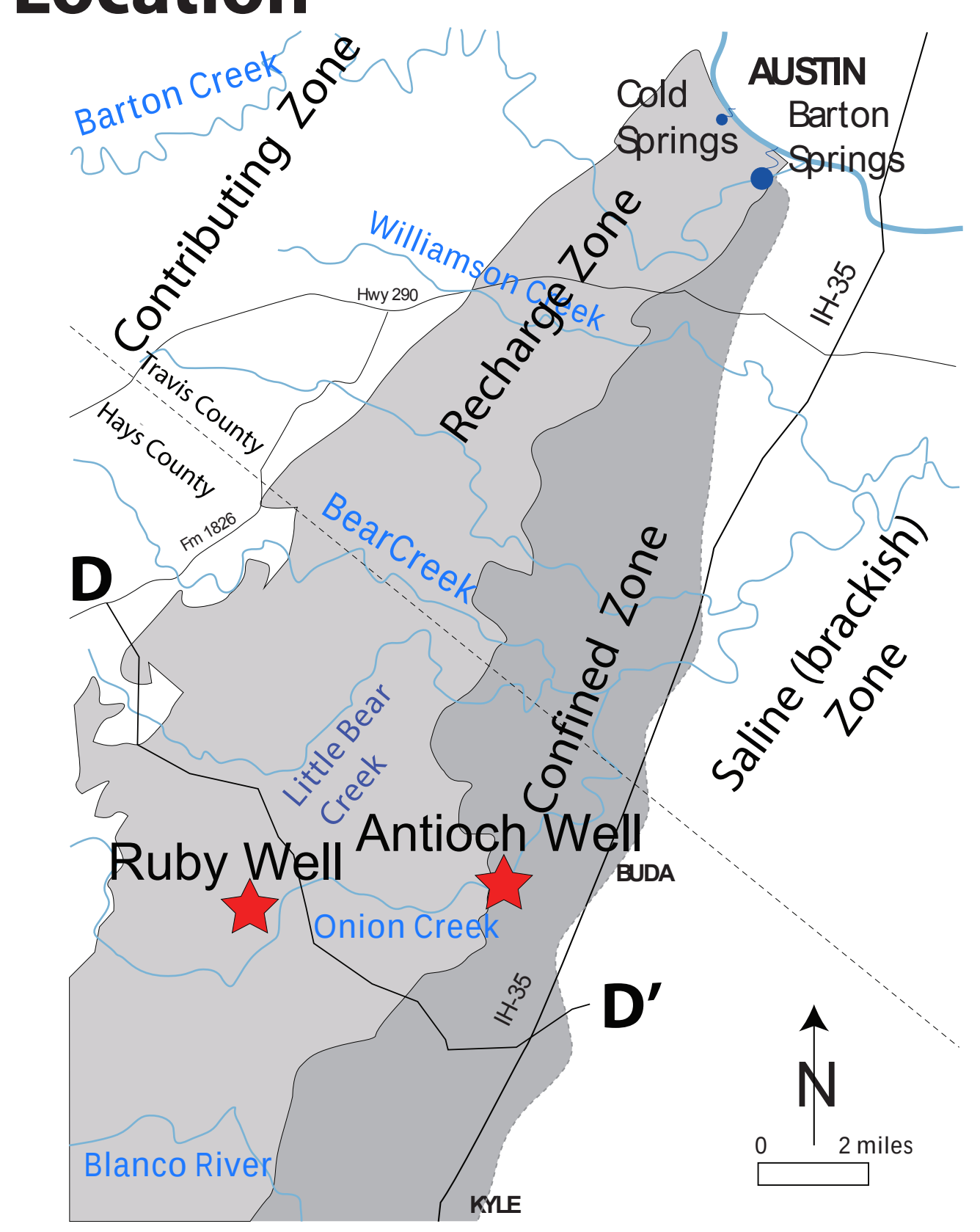


Figure 1.

Figures 1 and 2. Wells are located in the Barton Springs Segment of the Edwards Aquifer, within the Balcones Fault Zone. Both wells are about 15 miles south of Austin and 3.5 miles apart.

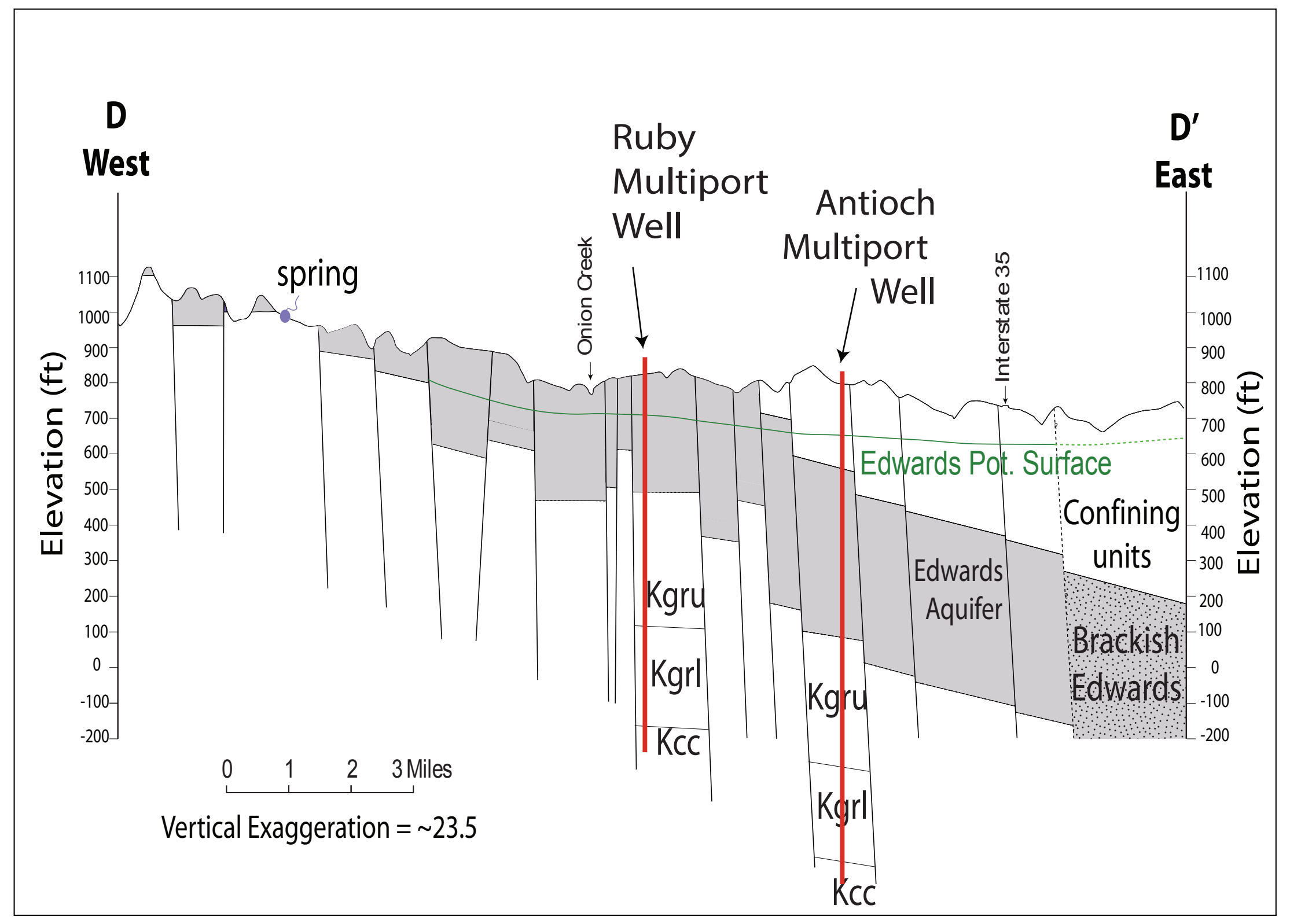
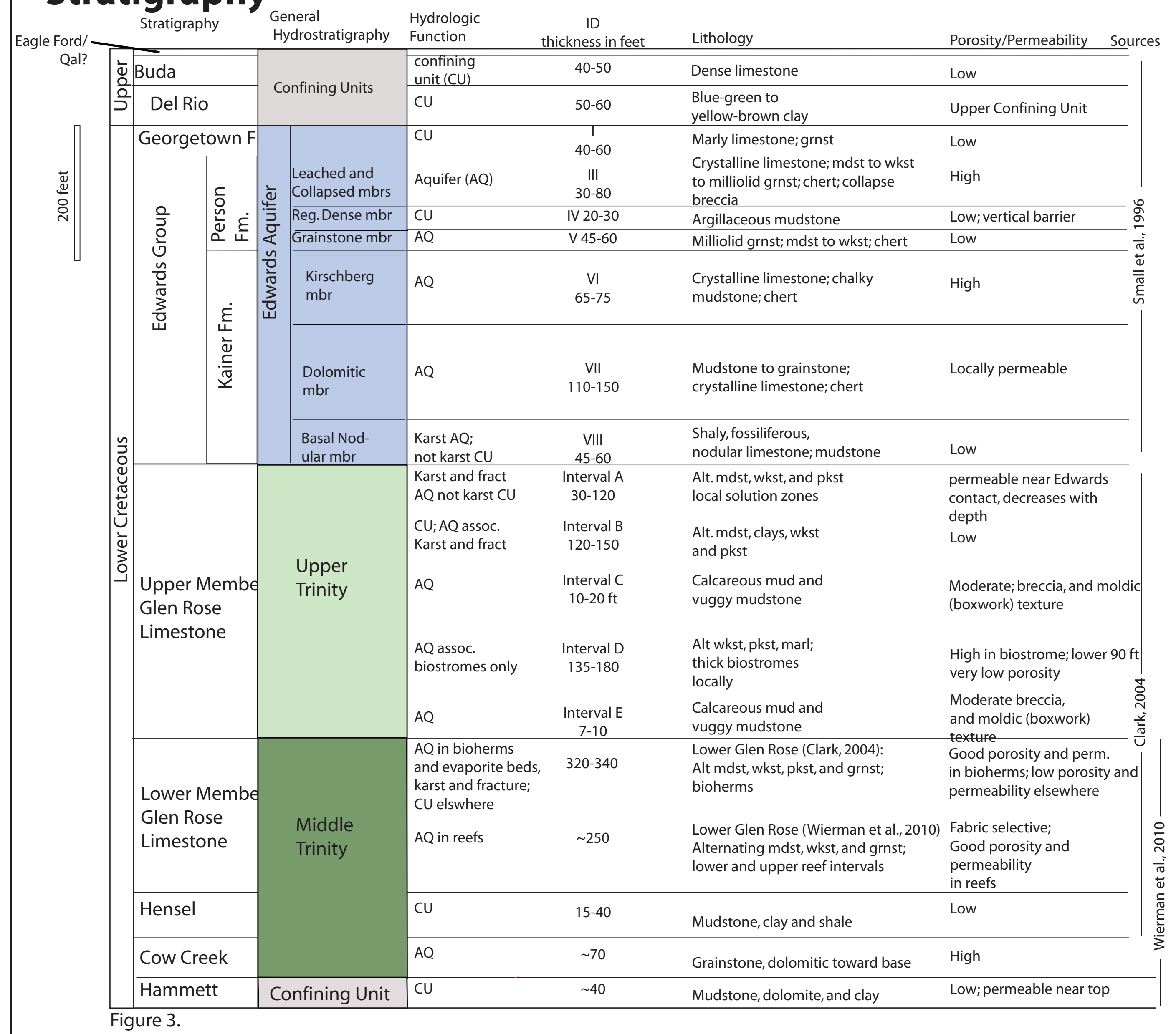


Figure 2.

Stratigraphy



Stratigraphy	General Hydrostratigraphy	Hydrologic Function	ID thickness in feet	Lithology	Porosity/Permeability	Sources
Buda	Confining Units	confining unit (CU)	40-50	Dense limestone	Low	
Del Rio		CU	50-60	Blue-green to yellow-brown clay	Upper Confining Unit	
Georgetown F		CU	I 40-60	Marly limestone; grnst	Low	Small et al., 1996
Edwards Group, Person Fm.	Edwards Aquifer: Leached and Collapsed mbrs	Aquifer (AQ)	III 30-80	Crystalline limestone; mdst to wkst to milliolid grnst; chert; collapse breccia	High	
	Reg. Dense mbr	CU	IV 20-30	Argillaceous mudstone	Low; vertical barrier	
	Grainstone mbr	AQ	V 45-60	Milliolid grnst; mdst to wkst; chert	Low	
Edwards Group, Kainer Fm.	Kirschberg mbr	AQ	VI 65-75	Crystalline limestone; chalky mudstone; chert	High	
	Dolomitic mbr	AQ	VII 110-150	Mudstone to grainstone; crystalline limestone; chert	Locally permeable	
	Basal Nodular mbr	Karst AQ; not karst CU	VIII 45-60	Shaly, fossiliferous, nodular limestone; mudstone	Low	
Upper Membe Glen Rose Limestone	Upper Trinity	Karst and fract AQ not karst CU	Interval A 30-120	Alt. mdst, wkst, and pkst local solution zones	permeable near Edwards contact, decreases with depth	Clark, 2004
		CU; AQ assoc. Karst and fract	Interval B 120-150	Alt. mdst, clays, wkst and pkst	Low	
		AQ	Interval C 10-20 ft	Calcareous mud and vuggy mudstone	Moderate; breccia, and moldic (boxwork) texture	
		AQ assoc. biostromes only	Interval D 135-180	Alt wkst, pkst, marl; thick biostromes locally	High in biostrome; lower 90 ft very low porosity	
		AQ	Interval E 7-10	Calcareous mud and vuggy mudstone	Moderate breccia, and moldic (boxwork) texture	
Lower Membe Glen Rose Limestone	Middle Trinity	AQ in bioherms and evaporite beds, karst and fracture; CU elswhere	320-340	Lower Glen Rose (Clark, 2004): Alt mdst, wkst, pkst, and grnst; bioherms	Good porosity and perm. in bioherms; low porosity and permeability elsewhere	Wierman et al., 2010
		AQ in reefs	~250	Lower Glen Rose (Wierman et al., 2010) Alternating mdst, wkst, and grnst; lower and upper reef intervals	Fabric selective; Good porosity and permeability in reefs	
Hensel		CU	15-40	Mudstone, clay and shale	Low	
Cow Creek		AQ	~70	Grainstone, dolomitic toward base	High	
Hammett	Confining Unit	CU	~40	Mudstone, dolomite, and clay	Low; permeable near top	

Figure 3.

Methods

Two Westbay multiport wells were used to measure water levels, conduct rising/falling head and slug tests, and collect water samples at ports located at different depths, and screened individually to distinct litho/hydrostratigraphic layers.

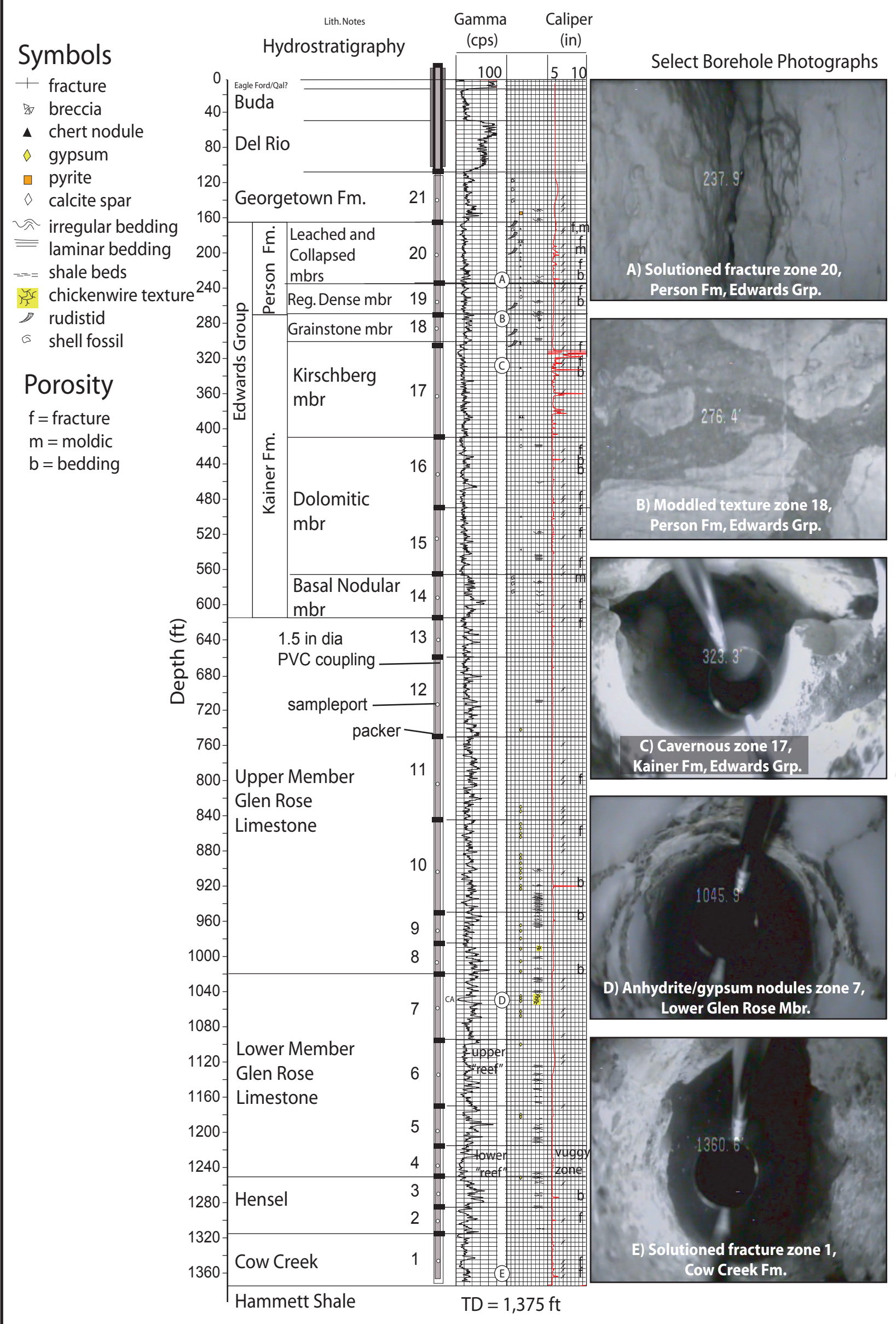
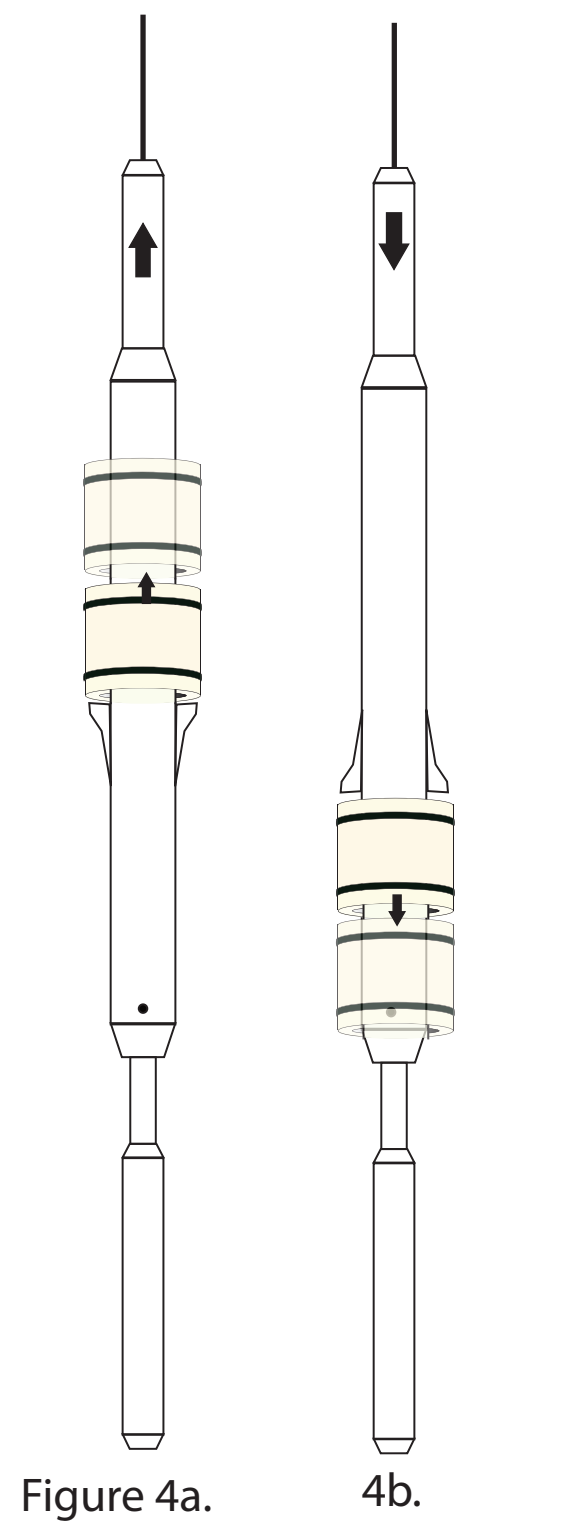
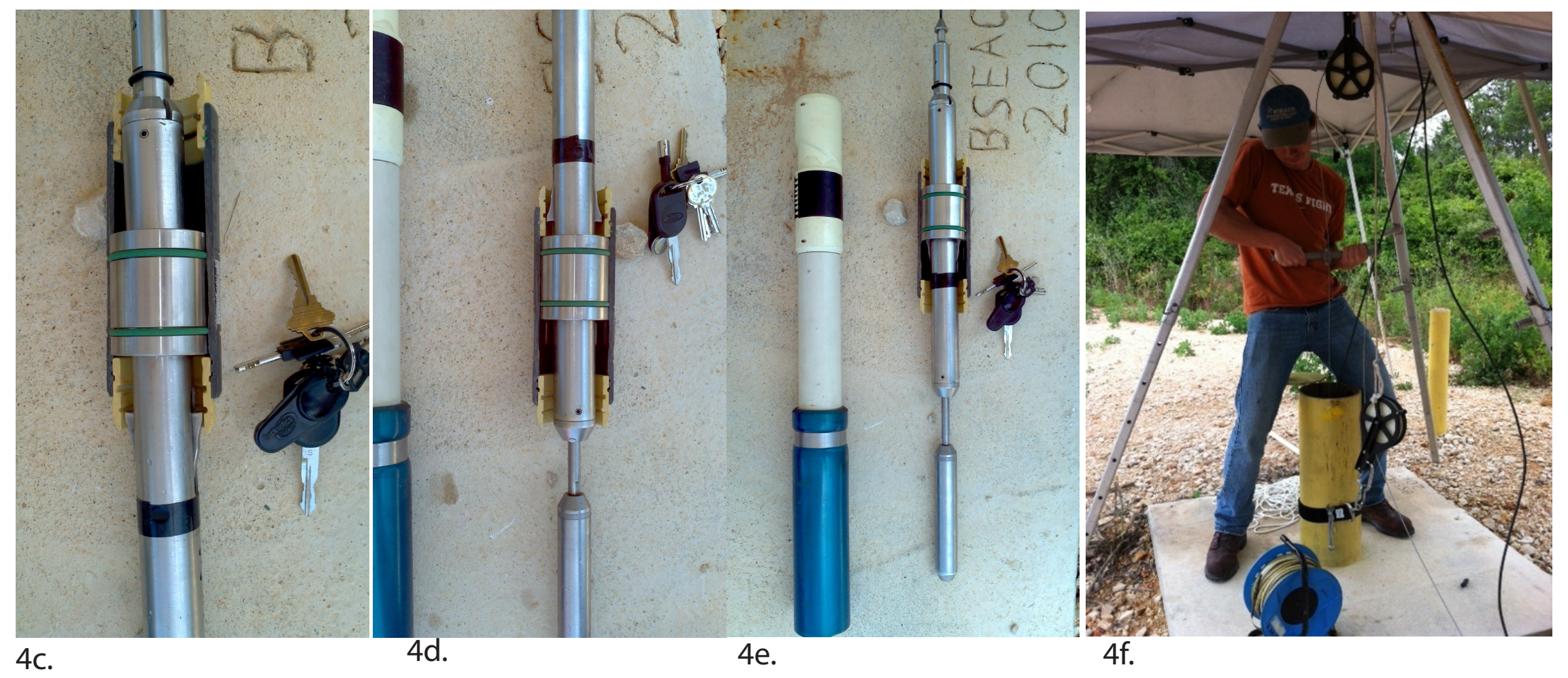


Figure 4. Multiport well layout and examples of downhole imagery, caliper log, and gamma log, which were used to establish placement of hydraulically isolated "zones" in the multiport wells during their construction.

Figure 4.





Figures 4a-f. Tool used to open and close ports inside wells. Ports consist of a screened section of PVC coupling, which when moved up or down, respectively open or close the casing to formation water.

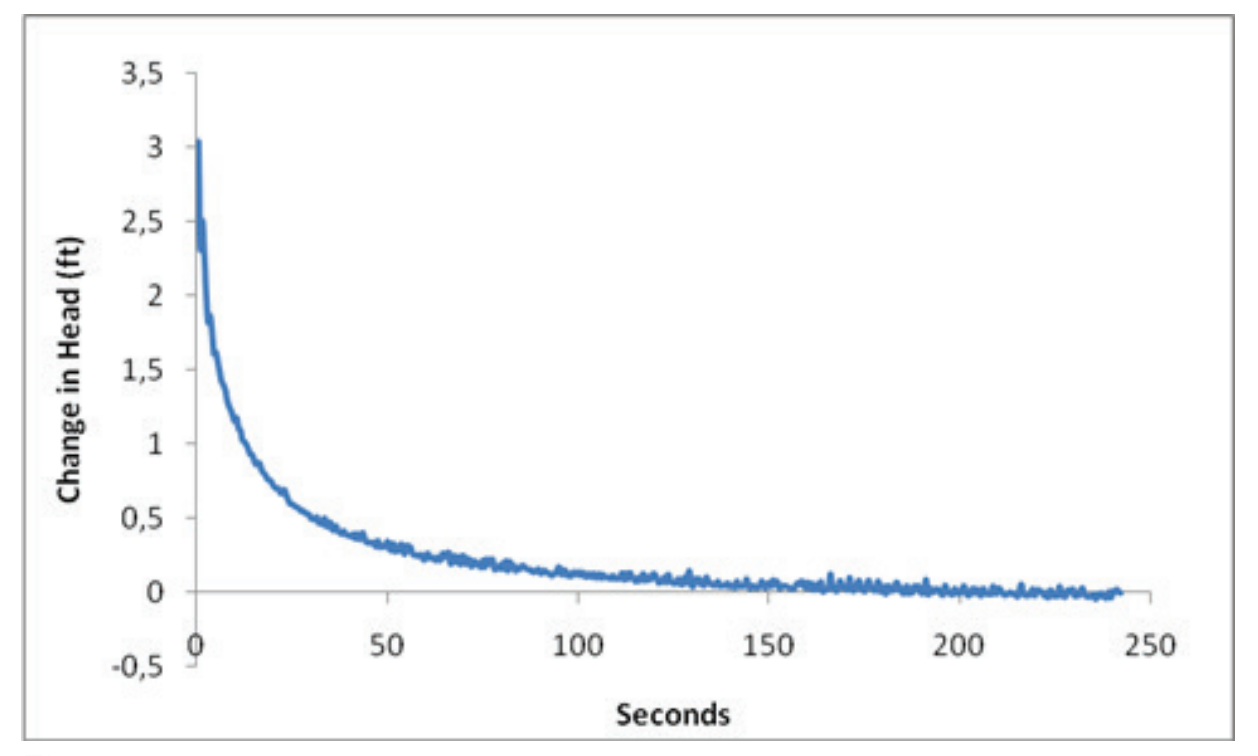


Figure 5a.

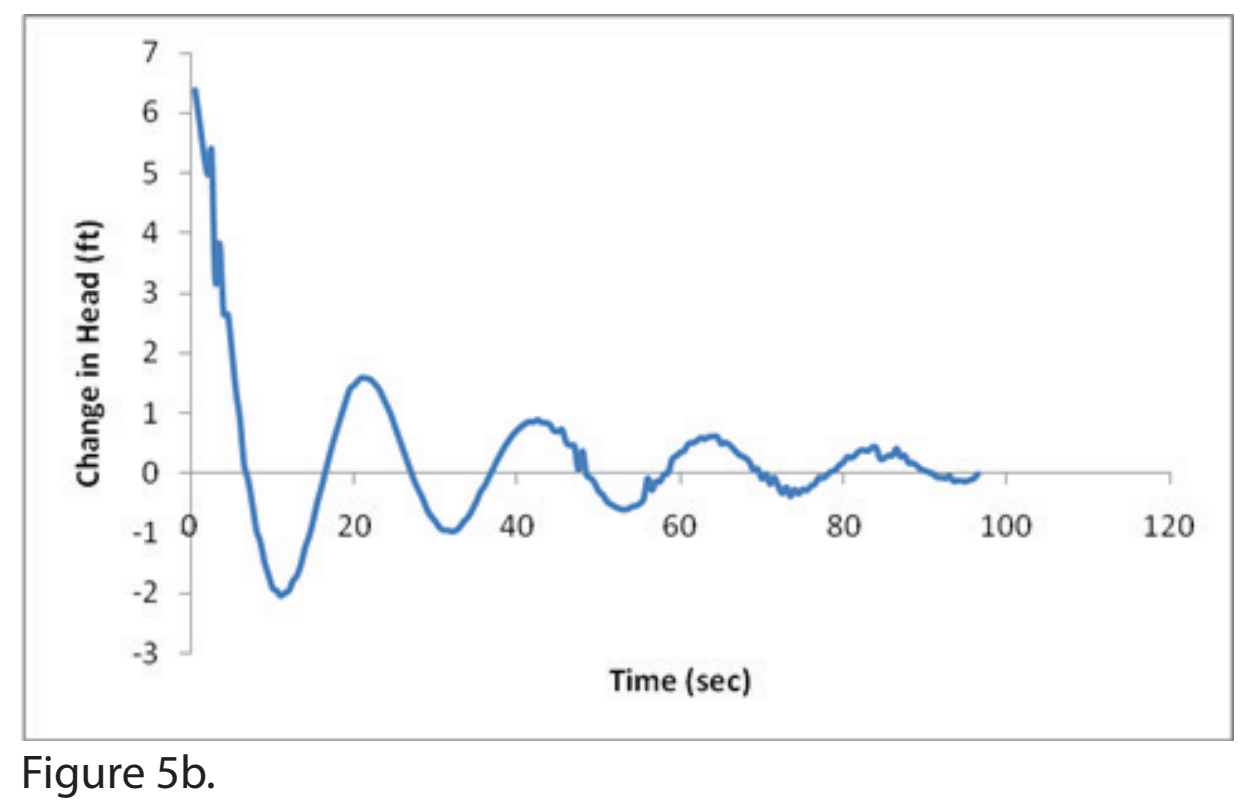


Figure 5b.

Figures 5a,b. Examples of underdamped and overdamped water level equilibration. Bouwer-Rice (Fig.5a) and Butler (5b) analytical solutions were used to calculate hydraulic conductivities at each port, based on water level response.

Results

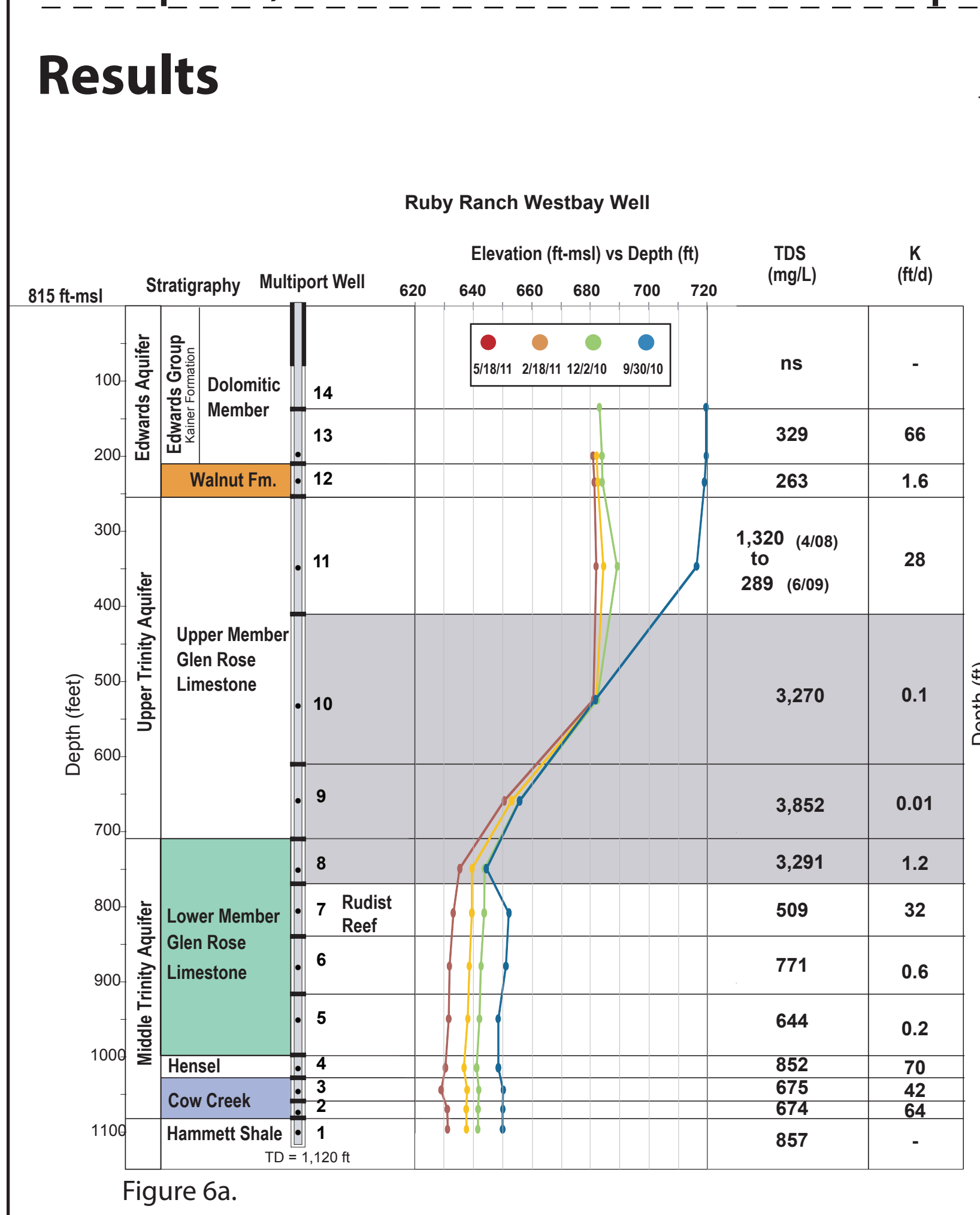


Figure 6a.

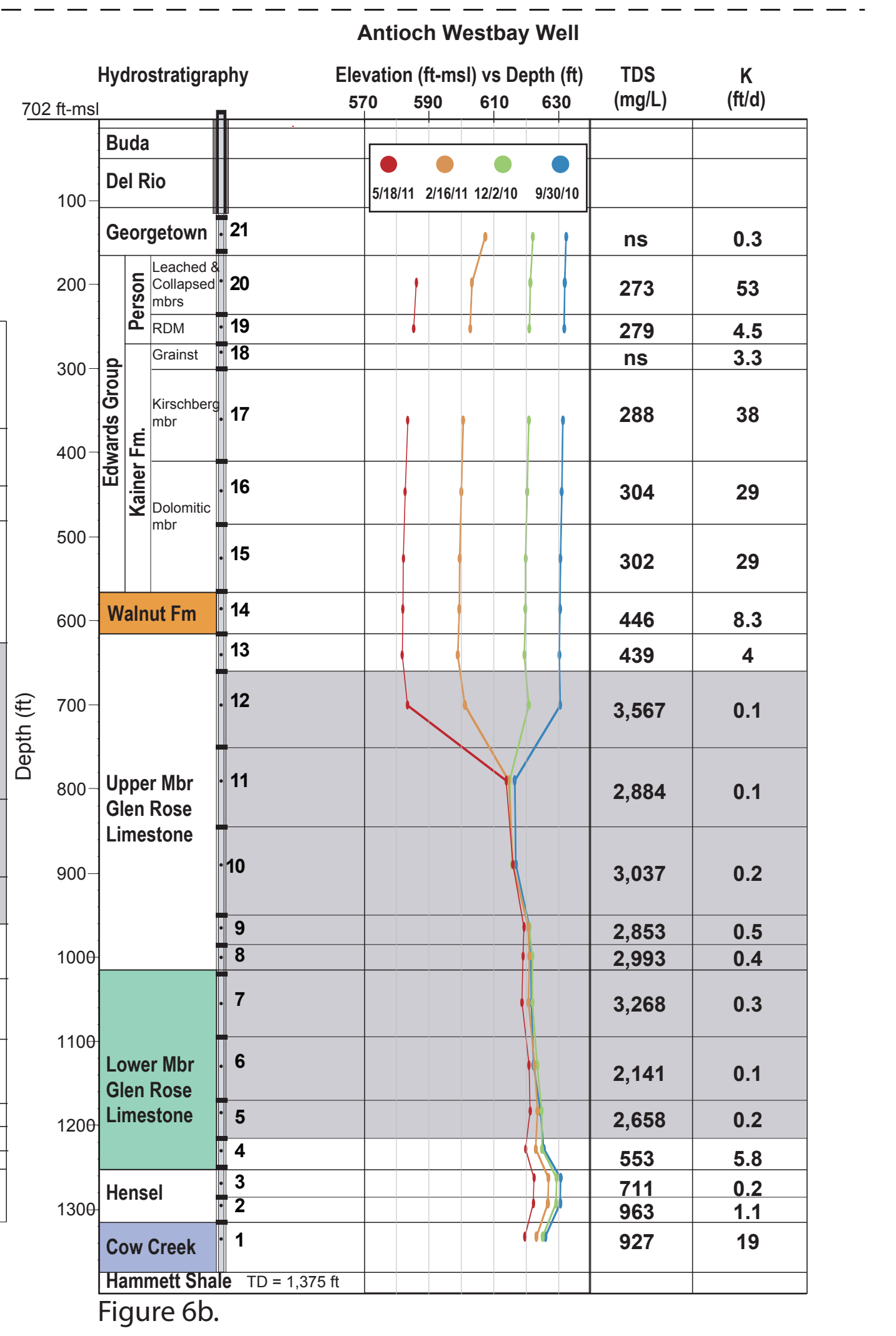


Figure 6b.

Figures 6a,b. Head distribution through time, TDS, and hydraulic conductivity in Ruby Ranch (left) and Antioch (right) multiport wells. Zones that experience little change through time indicate lower hydraulic conductivities. TDS values were measured from water samples collected from each zone.

Zone	Rising-falling K (ft/day)	Slug (ft/day) K	Zone Thickness (ft)	Transmissivity (ft2/day)
14	--	--	136	--
13	65	--	72	13000
12	2	--	34	460
11	4	--	159	8300
10	0.09	--	197	50
9	0.005	--	97	4
8	0.7	--	56	515
7	26	--	68	21000
6	0.4	0.9	72	365
5	--	0.2	77	--
4	--	37	27	38000
3	26	--	26	27000
2	34	--	20	36000
1	--	--	41	--

Table 1.

Zone	Rising-falling K (ft/day)	Slug-in (ft/day) K	Slug-out (ft/day) K	Zone Thickness (ft)	Trans ft2/day
21	0.3	--	--	35	10
20	53	--	--	70	3700
19	5	8	6	30	140
18	3	3	--	25	84
17	38	--	44	105	4000
16	29	80	19	70	2000
15	29	105	161	75	2100
14	8	10	3	45	370
13	4	2	6	40	160
12	0.2	--	--	85	--
11	0.1	--	--	90	--
10	0.2	--	--	100	24
9	0.6	0.1	--	30	16
8	0.4	--	--	30	--
7	0.3	--	--	70	--
6	0.1	0.6	--	70	6
5	0.202	--	--	40	8
4	6	7	7	30	170
3	0.2	--	--	30	5
2	1	1.5	2	25	26
1	19	60	--	55	1060

Table 2.

Tables 1 and 2. List distribution of hydraulic conductivities in Ruby Ranch (left) and Antioch (right) multiport wells, based on rising/falling head tests and slug tests.

Hydraulic conductivity values for the three hydrostratigraphic groupings observed are:

- Edwards Aquifer, values between 0.3 and 66 ft/day.
  26 ft/day avg.
- Upper Trinity Aquitard, from 0.01 to 0.7 ft/day.
  0.25 ft/day avg.
- Middle Trinity Aquifer, from 0.2 to 37 ft/day.
  13.6 ft/day avg.

Conclusions

- Observed hydraulic conductivities of the various formations that make up the Edwards Aquifer (Fig. 3) generally agree with those qualitatively assigned by previous studies.
- Upper-most units of the Upper Glen Rose exhibit high hydraulic conductivity and good quality water similar to units in the Edwards Aquifer.
- Most of the Upper Trinity "Aquifer" is best described as an aquitard and confining unit in this area, especially when comparing its hydraulic conductivities to those found in the Edwards and Middle Trinity Aquifers.
- Uppermost units of the Lower Member of the Glen Rose Limestone exhibit low hydraulic conductivity (<1 ft/d) and high TDS (2100 to 3200 mg/l), resembling values found in the Upper Trinity Aquitard.
- Differences in head, hydraulic conductivity, and geochemistry between hydrostratigraphic layers indicate that minimal vertical flow occurs between them.

References:
- Bouwer, H., 1989. The Bouwer and Rice slug test--an update, Ground Water, vol. 27, no. 3, pp. 304-309dwards-Trinity Aquifer System, West-Central Texas
- Butler, J.J., Jr., 1998. The Design, Performance, and Analysis of Slug Tests, Lewis Publishers, New York, 252p.
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- Small, T.A., Hanson J.A., Hauwert, N.M., 1996, Geologic Framework and Hydrogeologic Characteristics of the Edwards Aquifer Outcrop (Barton Springs Segment), Northeastern Hays and Soutwestern Travis Counties, Texas
- Wierman, D.A., Broun, A.S., Hunt, B.B, 2010, Hydrogeologic Atlas of the Hill Country Trinity Aquifer, Blanco, Hays, and Travis Counties, Central Texas