Multilevel Monitoring and Characterization of the Edwards and Trinity Aquifers of Central Texas

Brian A. Smith and Brian B. Hunt

Barton Springs / Edwards Aquifer Conservation District, 1124 Regal Row, Austin, Texas 78748

EXTENDED ABSTRACT

The Edwards and Trinity aquifers are significant sources of water for industrial and agricultural use, for ecological resources in Central Texas, and are the sole sources of water for many people in the area. In the Barton Springs / Edwards Aquifer Conservation District, demand for groundwater has increased considerably in recent years, to the point that usage has either reached or nearly reached the sustainable yield of these aquifers. The Trinity Aquifer has increasingly become a source of water as limits have been placed on the Edwards Aquifer. Stratigraphically, the Trinity Aquifer underlies the Edwards Aquifer. However, along the Balcones Fault Zone, normal faulting has juxtaposed the two aquifers horizontally, with units of the Trinity to the west of the Edwards in the study area (Figs. 1 and 2).

Proper management of these aquifers requires an understanding of factors affecting the hydraulic relationship between the two aquifers. Although previous hydrologic studies of groundwater resources suggest a hydraulic connection between the Trinity and Edwards aquifers, that relationship is poorly understood. The hydraulic connection is crucial to water budgets and predictions of groundwater availability and quality in the Trinity and Edwards aquifers and flow at Barton Springs. Until recently, there has been insufficient head data and water-quality data to assess the hydrologic connection and potential for flow between the Edwards and Trinity aquifers.

Methodology

Because demand for groundwater in Central Texas is rapidly increasing, groundwater scientists are now studying its aquifers in far greater detail. Most aquifer parameters are determined from wells that penetrate the entire Edwards section or wells that are completed over considerable thicknesses of the Trinity. Monitoring of more discrete intervals can provide data that reflect the true complexity of these aquifers. To address these issues, the Barton Springs / Edwards Aquifer Conservation District collects data from three well pairs and has installed a multiport well with 14 monitoring zones in the Edwards, Upper Trinity, and Middle Trinity aquifers (Fig. 1).

Geology and Hydrogeology

The Edwards Aquifer, located in south-central Texas, is one of the most prolific karst aquifers in the United States. The Edwards Aquifer is a karst aquifer developed in

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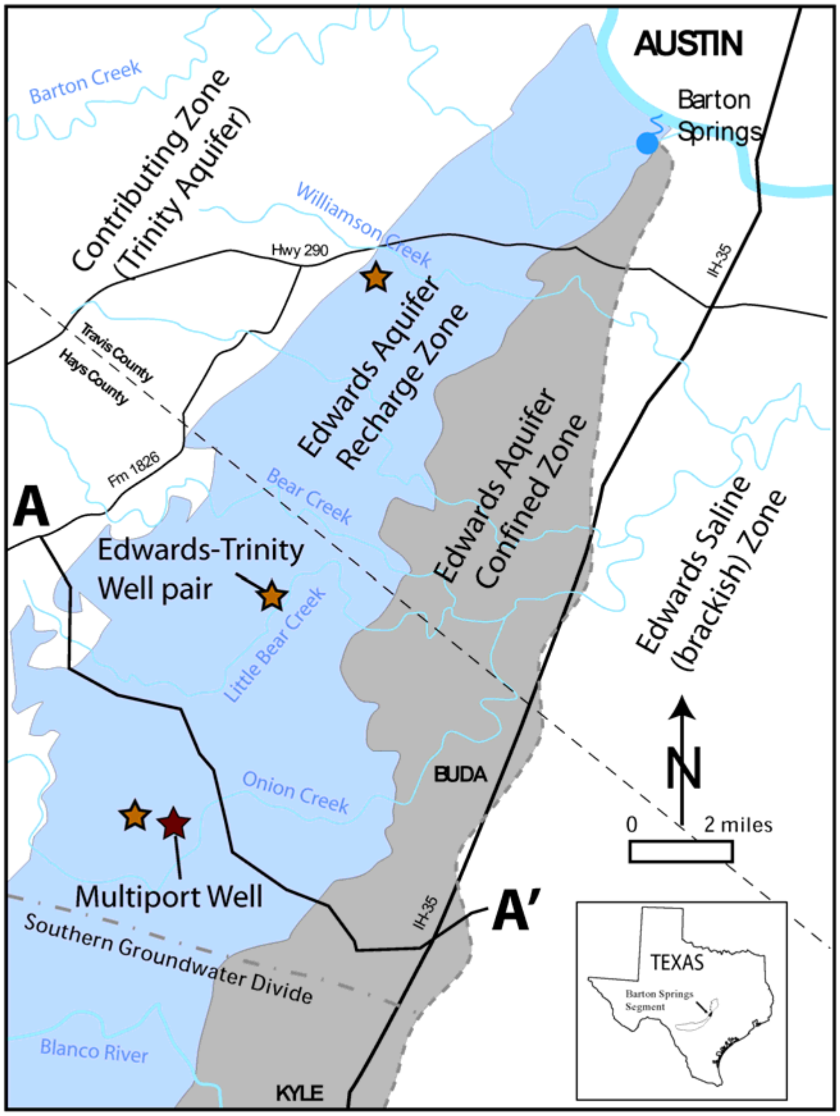

Figure 1. Map of the study area. Edwards-Trinity well pairs and multiport monitor well are indicated on the map.

faulted and fractured Cretaceous-age limestones and dolomites and lies within the Miocene-age Balcones Fault Zone. Hydrologic divides separate the Edwards Aquifer into three segments. The smallest segment, the Barton Springs segment of the Edwards Aquifer, is the subject of this paper. Studies by Smith and Hunt (2004) have shown that the groundwater resources in the Barton Springs segment of the Edwards Aquifer are susceptible to high levels of pumping and drought.

The Trinity Aquifer is composed of Cretaceous-age limestones and sandstones that are divided into the Upper, Middle, and Lower Trinity aquifers. In the Balcones Fault Zone, the Edwards Aquifer both overlies and is adjacent to the Trinity Aquifer system. Groundwater quality of the Trinity Aquifer is generally poorer than the Edwards Aquifer containing higher total dissolved solids (TDS) and undesirable constituents such as

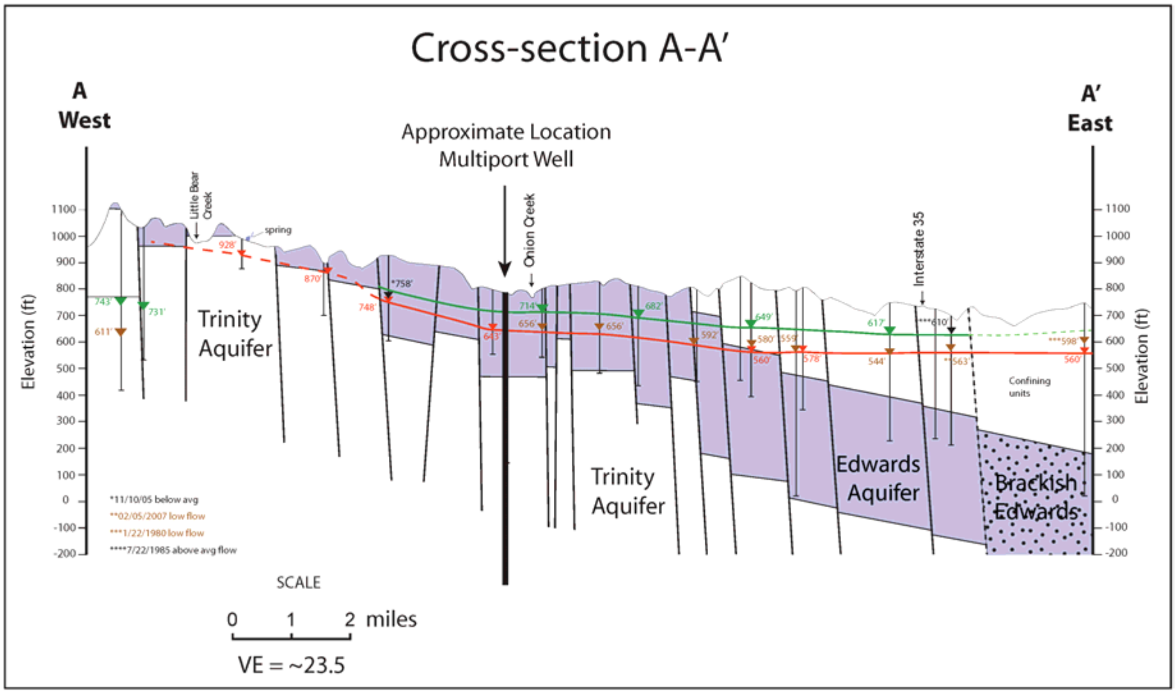

Figure 2. Cross section through the study area (modified after Smith and Hunt, 2004). Stratigraphically the Trinity Aquifer underlies the Edwards Aquifer. However, along the Balcones Fault Zone, normal faulting has juxtaposed the two aquifers horizontally, with units of the Trinity to the west of the Edwards in the study area.

sulfates. The boundary between fresh and slightly saline (1000-3000 mg/l) water is poorly defined for the Trinity Aquifer. Along the western part of the District, where the Edwards Aquifer is thin, water-supply wells commonly penetrate the lower Edwards units and are completed in the Upper and Middle Trinity aquifers. Many Trinity wells have open-hole, or multiple-zone, completions and produce water from the Upper and Middle Trinity aquifers, with exact water-bearing units difficult to determine.

Previous Studies

The hydraulic connection between the Trinity and Edwards aquifers is poorly understood. The amount of cross-formational flow is unknown, although it is thought to be relatively small on the basis of water-budget analysis for surface recharge and discharge in the Edwards Aquifer (Slade et al., 1985). Yet hydrochemical evidence near Barton Springs suggests that older, more saline water from the Trinity and lower Edwards formations flows upwards, generally along faults, into the upper Edwards. Leakage may locally impact water quality and influence water levels (Senger and Kreitler, 1984; Slade et al., 1985, 1986). A groundwater model of the Trinity Aquifer in the Hill Country includes lateral groundwater leakage into the Edwards Aquifer in the San Antonio area in order for the model to simulate observed hydrogeologic conditions (Mace et al., 2000). However, where the Trinity Aquifer is in contact with the Barton Springs segment of the Edwards Aquifer, the Trinity model indicates little or no lateral flow into the Edwards. Potentiometric maps of the Upper Trinity along the western boundary of the Edwards

Aquifer are similar in elevation, suggesting some hydrologic connection (Hunt et al., 2007).

Results

Well Pairs

Water-level data from the three well pairs show significant head differences between the Edwards and the underlying Middle Trinity, with downward head gradients from the Edwards to the Middle Trinity (Figs. 3-5). Heads differ from 30 ft (9 m) in the southwest to as much as 160 ft (49 m) in the northeast. Substantial temporal changes are seen in water levels of both aquifers, with the Middle Trinity water levels lagging behind the Edwards levels by about one to two months (Fig. 5).

Multiport Well

Installation and Operation. The Westbay® (Schlumberger) multiport system (MP38) allows pressure measurements and sample collection at discrete zones within a single borehole. A 5-in (13-cm) diameter borehole was drilled to a total depth of 1120 ft (341 m) and equipped with 14 zones isolated by permanent packers separating hydrostratigraphic units of the Edwards and Trinity aquifers (Fig. 6). The drill rig encountered circulation problems when drilling into the Hammett Shale. Despite a booster air compressor, the rig kept blowing gaskets which precluded drilling into the Lower Trinity Aquifer.

A geophysical log of the borehole, consisting of natural gamma and caliper was conducted (Fig. 6). These data are critical to the design of the well, such as the placement of packers, sample ports, and pumping ports. HX steel casing was inserted in the borehole as a guide to facilitate placement of the Westbay® system and logging of unstable portions of the borehole. District and Westbay® staff assembled and installed the system through the HX casing. Each joint was pressure tested during the installation. After installation, the HX casing was removed and the packers were inflated.

Head Data and Water Samples. Head measurements and water samples are taken using specially designed tools, which are lowered by wireline into the casing system. Head differences between zones in the multiport well range from less than 1 ft (0.3 m) to as much as 40 ft (12 m) between the lowermost zone of the Upper Trinity and the uppermost zone of the Middle Trinity. Head values generally decrease with depth, although the heads are higher in elevation within some Upper Trinity zones than the Edwards (Fig. 6).

Total dissolved solids (TDS) range from 292 mg/l in an Edwards zone to 2600 mg/l in the lowermost zone of the Upper Trinity. Two monitoring zones that were installed in the Cow Creek Limestone, near the bottom of the well, have TDS values of 433 and 674 mg/l (Fig. 6).

Conclusions

Significant differences in head and TDS values suggest that there is very little vertical flow between these zones in the vicinity of the well. Where nearby faults cut across the Edwards and Trinity units, there is greater potential for flow between zones. How-

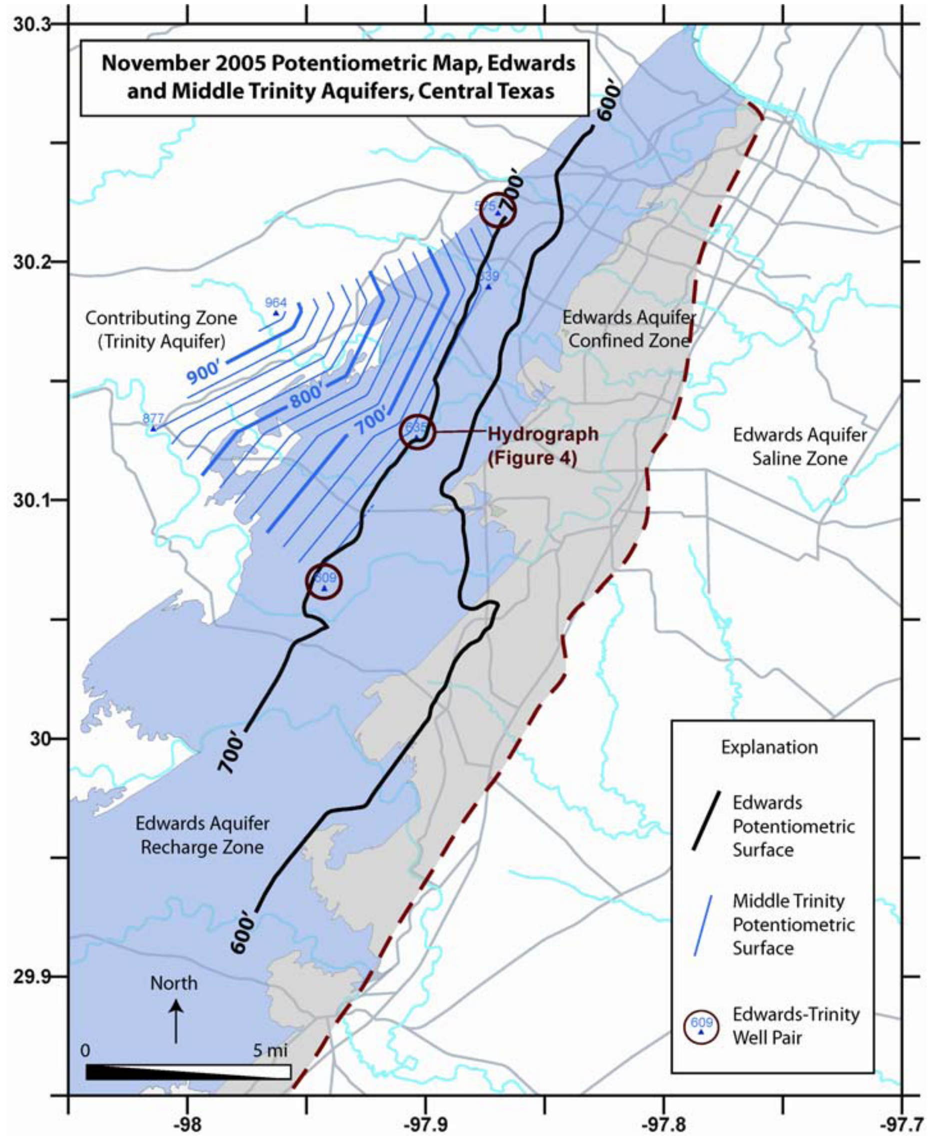

Figure 3. Potentiometric map of the Edwards and Middle Trinity aquifers for November 2005. Edwards-Trinity well pairs are indicated on the map. Heads differences increase from the southwest to the northeast.

ever, the large discrepancies in TDS values between zones suggest that flow along faults in this area is small compared to horizontal flow in each zone. Multiport well monitoring is critical to understanding the hydrologic relationships within and among the Trinity and Edwards aquifer units. Additional multiport wells should be installed on or near faults to evaluate the potential for flow along these faults and where geochemical data suggest upward flow from the Trinity into the artesian portion of the Edwards. Data from multiport wells will help to increase our understanding of these aquifers that will lead to better management of the groundwater resources of the Barton Springs / Edwards Aquifer Conservation District.

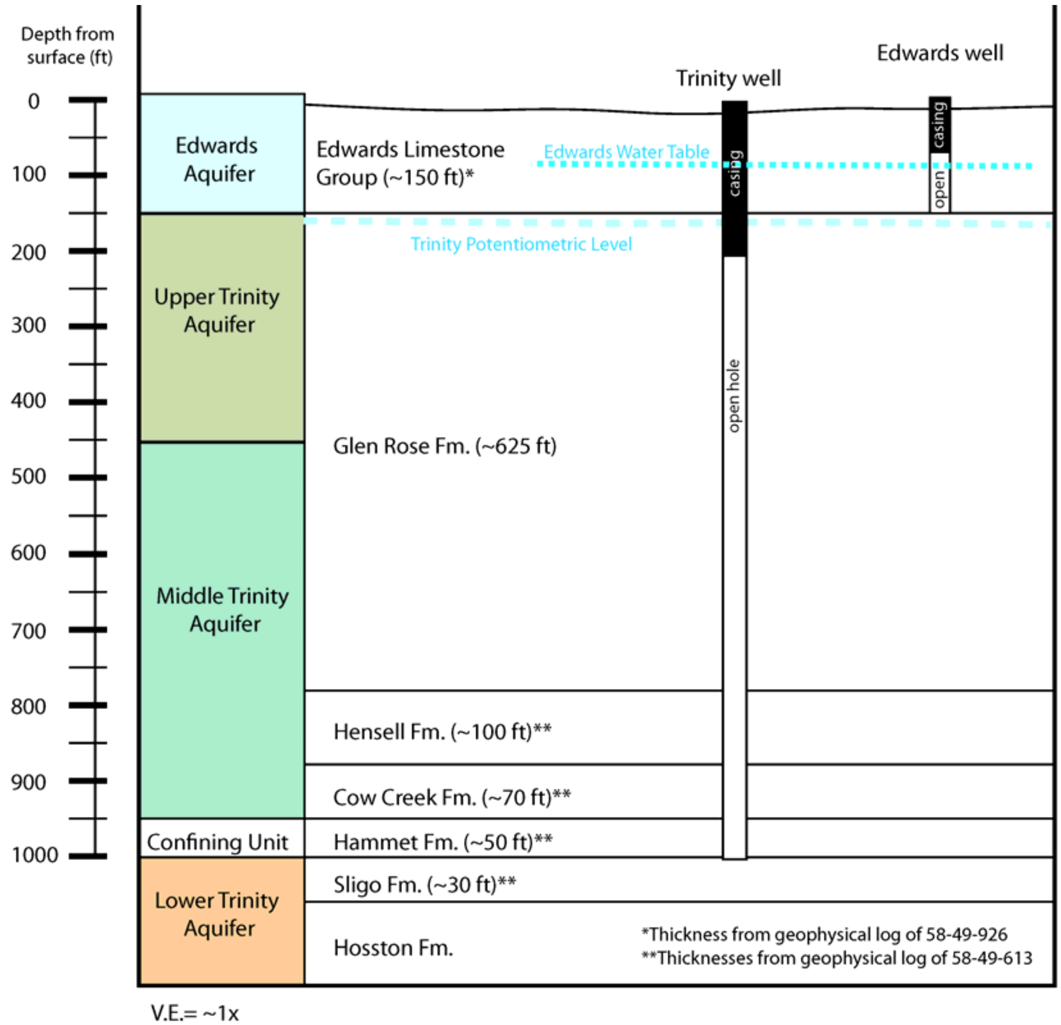

Figure 4. Hydrostratigraphy and schematic well completion of an Edwards-Trinity well pair. This well pair is located in the middle of the study area as indicated on Figure 3.

ACKNOWLEDGMENTS

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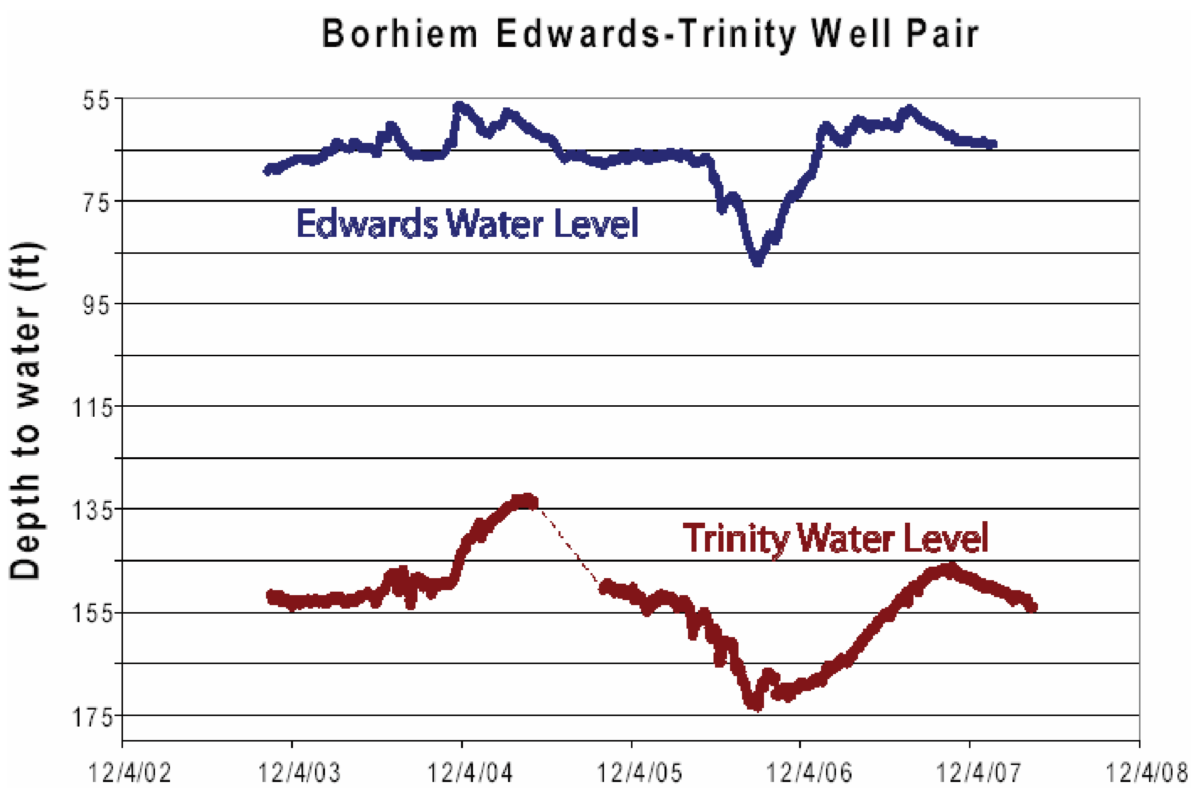

Figure 5. Hydrograph from an Edwards-Trinity well pair.

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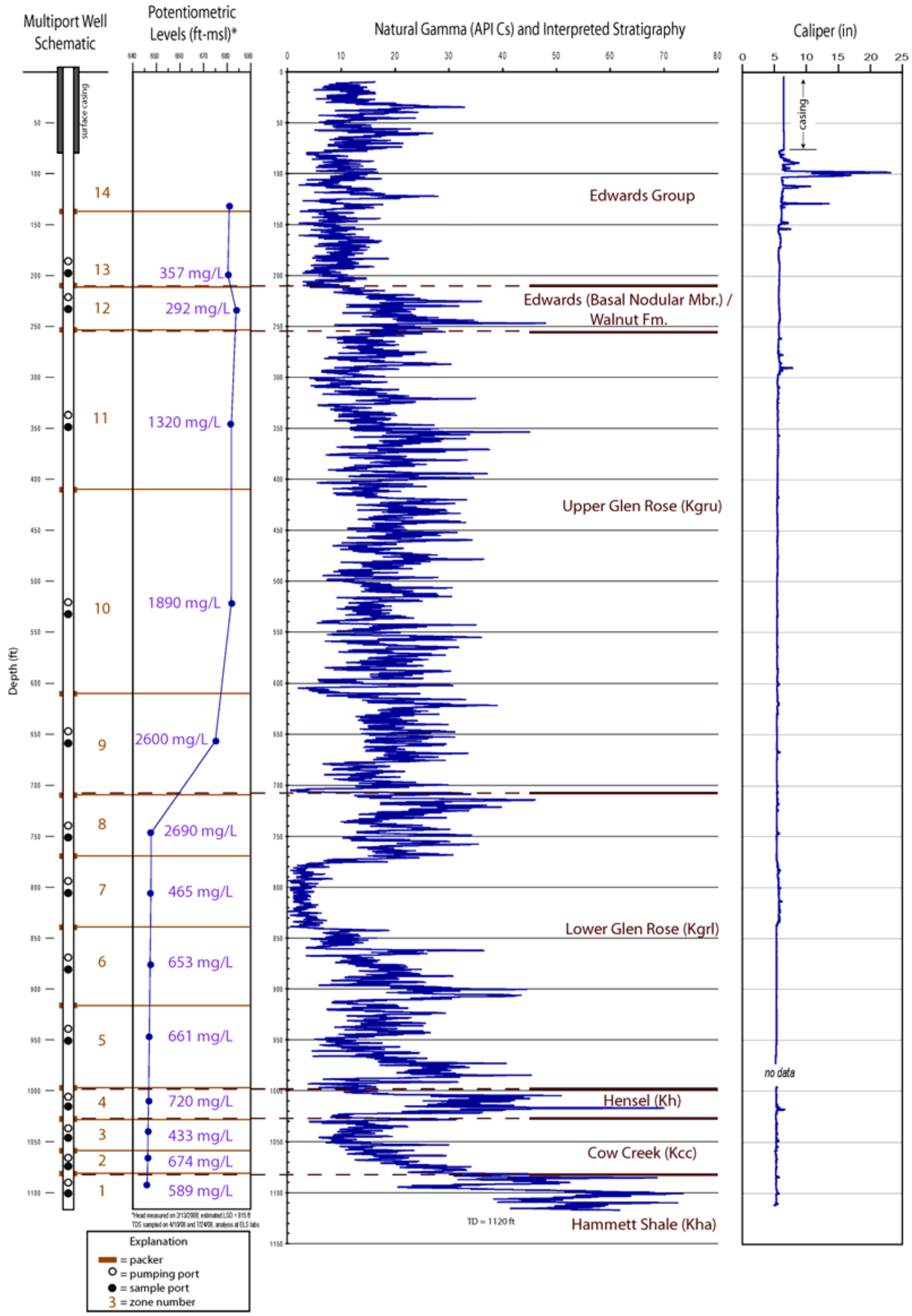

Figure 6. Composite data from the multiport monitor well. Schematic well completion with 14 zones is illustrated with potentiometric levels and total dissolved solids from sampled zones. Stratigraphy based on natural gamma is plotted.