SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Hydrogeologic Investigation for the Kissimmee Basin Lower Floridan Aquifer Reconnaissance Project

Site B: Addendum

Polk County, Florida

Technical Publication WS-33A

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1.0 INTRODUCTION

1.1 Background

In 2010, the South Florida Water Management District (SFWMD) prepared a five-year plan for a hydrogeologic reconnaissance of the Lower Floridan aquifer within the Kissimmee Basin region to address uncertainties in LFA development. In fiscal year 2011, this plan was funded and became the Lower Floridan Aquifer Investigation, Kissimmee Basin (LFAKB) Project. A major component of the LFAKB Project is drilling and testing exploratory wells at four sites to bridge the largest data gaps within the Lower Floridan aquifer. The first of those sites was completed in 2012, and results from the drilling and testing at that site were documented in SFWMD technical publication WS-33 (SFWMD, February 2013). This report documents modifications made to wells at that site in the summer and fall of 2013.

1.2 Purpose

In 2011-2012, the South Florida Water Management District (DISTRICT) constructed three (3) Floridan Aquifer System (FAS) monitoring and test production wells at LFAKB Site B, located in east-central Polk County on the C-37 canal between lakes Hatchineha and Kissimmee (**Figures 1 & 2**). One of these wells (POF-28) was constructed as a dual-zone monitor well of the lower Floridan aquifer, and instrumented for continuous water-level readings. The annular zone of that monitor well (POF-28U) was open from 1,300 to 1,683 feet below land surface (ft. bls), encompassing the two uppermost permeable zones of the lower Floridan aquifer (LF1 & LF2) and a semi-confining unit between them.

After the well construction was complete, it became clear that LF1 & LF2 each had quite distinct water chemistry. Consequently, the initial configuration of POF-28U was not ideal for long-term monitoring, yielding water-level and water-quality data that were a blending of the two zones rather than providing a distinct representation of either. Modifications to the site were undertaken to rectify this situation and make other enhancements to the site to facilitate water quality sampling and long-term maintenance. The existing lower zone (POF-28L, 1,950 to 2,221 ft bls) was left intact. The primary objective of the project was to modify the construction of POF-28 such that the annular zone monitor (POF-28U) is discretely completed to monitor only LF1 (**Figure 3**), and leave the modified well in a ready condition for re-instrumentation. That re-construction effort and subsequent testing on the re-constructed well are documented in this addendum report.

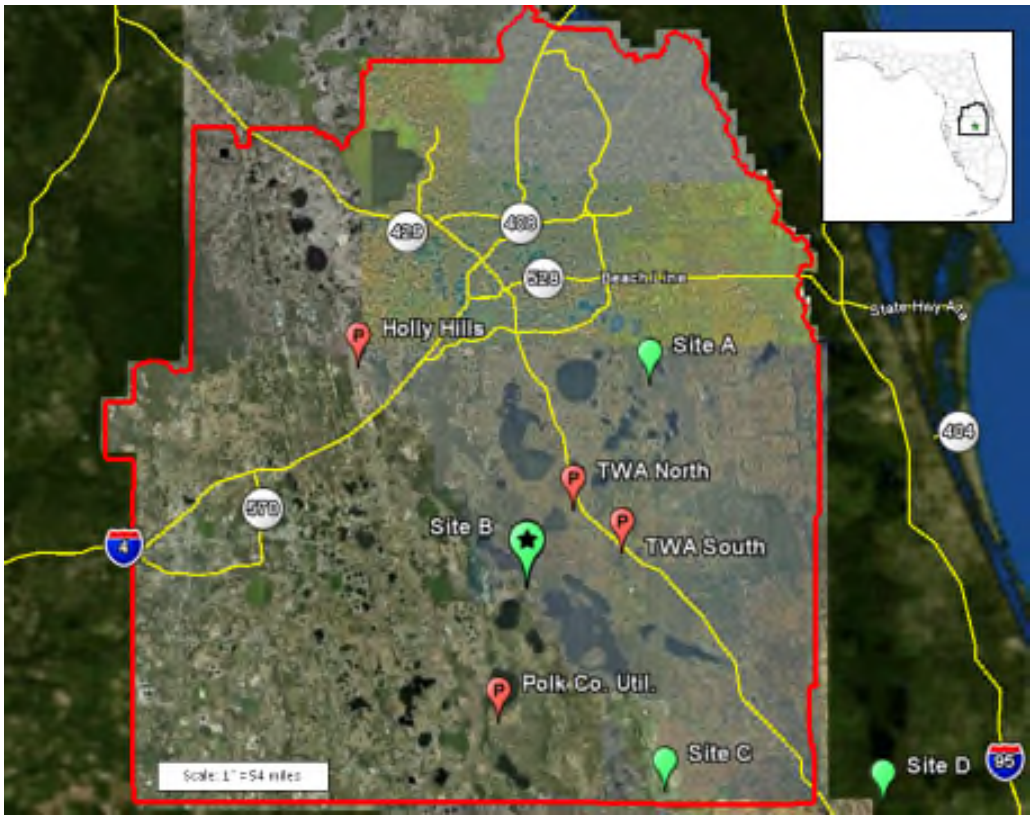

Figure 1. LFAKB project study area. Proposed exploratory drilling sites of the LFAKB Project (green markers) in relation to planned Lower Floridan aquifer production wellfields (red markers).

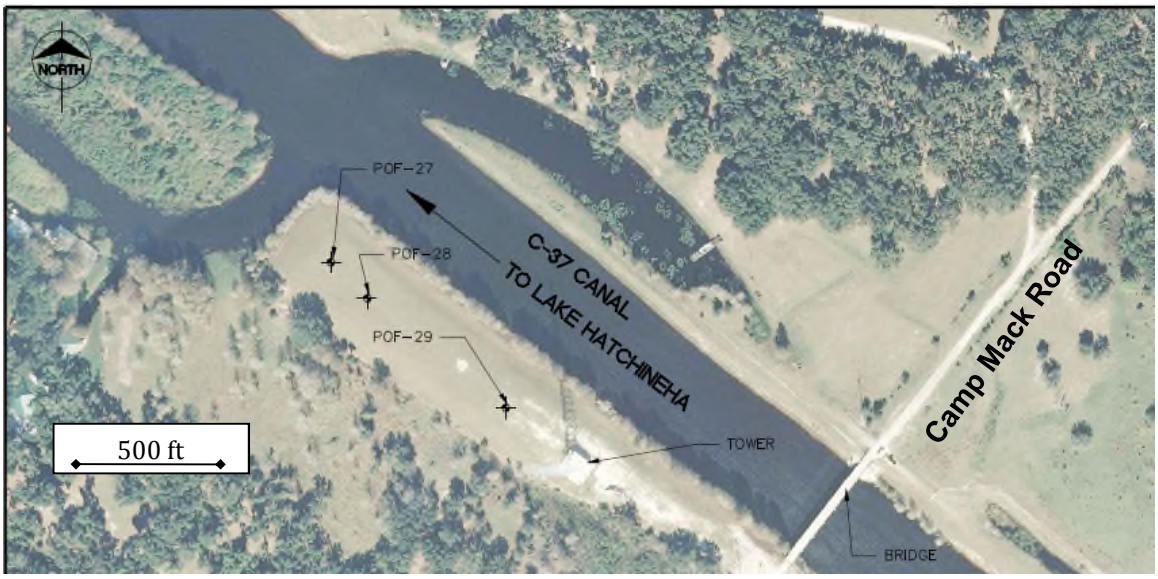

Figure 2. Site B general layout.

2.0 POF-28 Modification

The SFWMD contracted with Advanced Well Drilling Inc. (AWD) to perform the modifications to the construction of well POF-28 at Site B (PO#4500074888). On 4-Jun-2013, AWD mobilized a crane truck, tremie pipe and aggregate materials to the site, and initiated back-fill procedures. Equipment problems delayed completion of the back-fill until 22-Aug-13. Over that period, AWD installed aggregate material through 2-inch steel tremie pipe, filling the annular space from 1,680 to 1,421 ft. bls, and then sealed the aggregate with 41 feet of 4% bentonite grout (**Table 1**). Final construction of the well is illustrated in **Figure 3**.

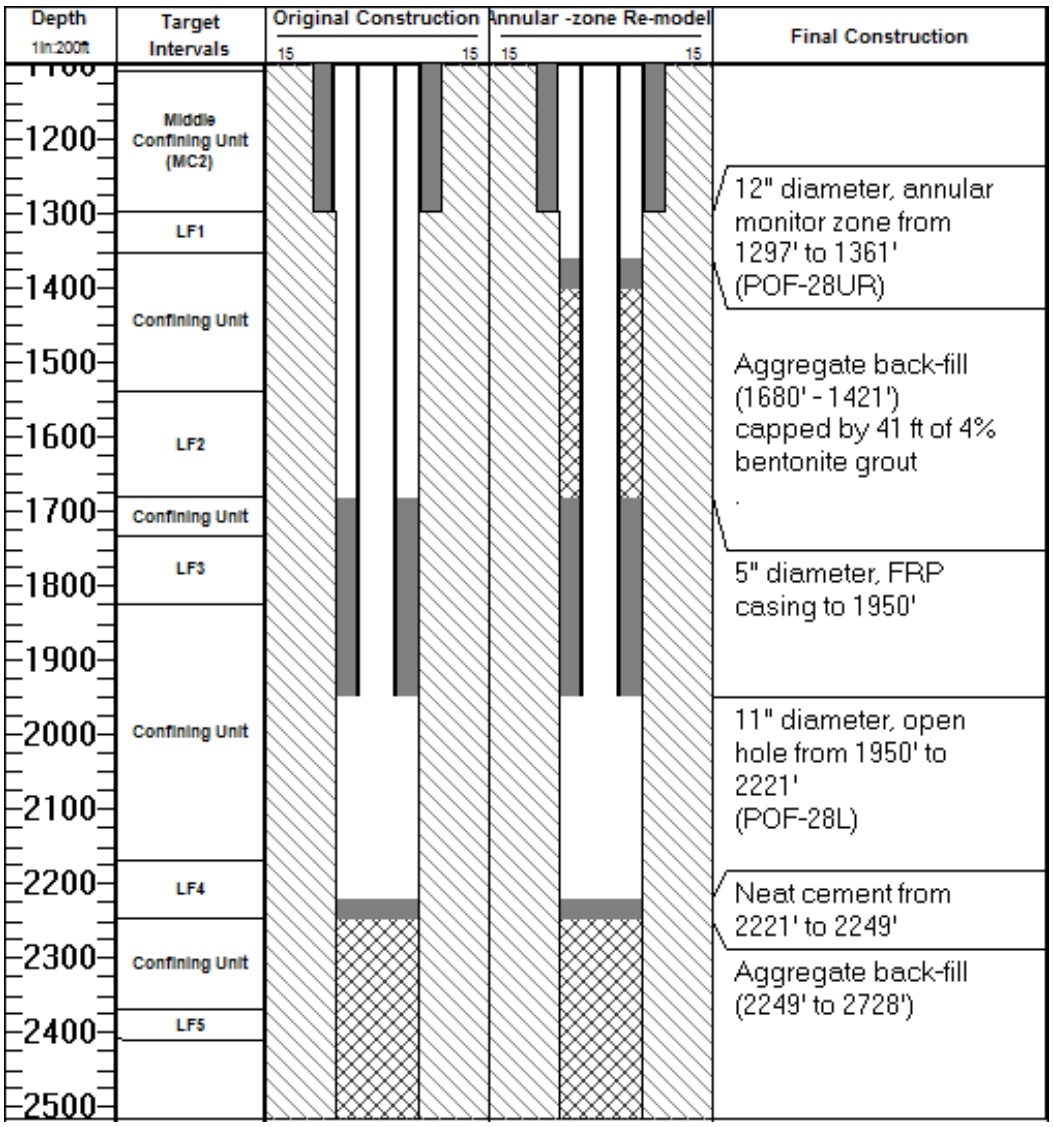

Figure 3. Well completion diagram for POF-28, showing the pre- and post-project construction of the monitored intervals.

Table 1. Annular-zone back-fill record.

Date	Initial Depth (ft. BLS)	Final Depth (ft. BLS)	Material	Volume [cu-ft]
4-Jun-13	1683	No tag	Sand	120
5-Jun-13	No tag	1602	Sand	40
Hiatus due to equipment difficulties and repairs.				
20-Aug-13	1602	1421	Gravel	162
21-Aug-13	1421	1402	Sand	6.7
22-Aug-13	1402	1361	4% Bentonite Grout	18

Upon completion of back-fill operations, the inner FRP tubing was temporarily capped to prevent contamination of POF-28L during development of the annular zone. A 2-inch tremie line was installed in the annular zone to a depth of 105 feet, and the well was developed via the direct-air method. AWD surged the well at approximately 390 gpm for four hours (**Figure 4**).

Figure 4. Direct-air development of POF-28UR.

The turbidity dropped from an initial concentration of 212 nephelometric turbidity units (ntu) to 7.8 ntu at the end of direct-air development. A submersible pump was then installed in the well, and development continued via the pumping method at a rate of 222

gpm for an additional four hours. During this time, turbidity dropped to a final value of 2.6 ntu. Water quality field parameters at the end of development are summarized below.

Temperature [deg C]	Specific Conductance [uS/cm]	pH	Turbidity [ntu]
26.7	1,359	7.71	2.6

Notes:
deg C = degrees Celsius
uS/cm = microsiemens per centimeter
ntu = nephelometric turbidity units

When the modified annular-zone was completely developed, the FRP tubing was securely attached to the outer casing (**Figure 5**), and a new well-head installed (**Figure 6**). At this point, AWD restored the protective fencing around the well, and de-mobilized from Site B.

Figure 5. 5-inch FRP tubing to the lower monitor zone (POF-28L) is securely attached to the outer casing prior to installation of the new well-head.

Figure 6. Final instrumented well-head at POF-28.

3.0 Post-Modification Testing

On November 6, 2013, the modified annular zone monitor well, POF-28UR, was purged for water-quality sample collection. To facilitate acquisition of hydraulic property information along with the sample, the purge time was extended and the well was instrumented for high-frequency water-level recording. A submersible Grundfos pump was temporarily installed in the well on 2-inch PVC drop-pipe. The discharge line was equipped with an in-line flowmeter and valved port for water-quality sampling.

Pumping was initiated at 10:40, and continued for four hours. Flowmeter readings indicated a steady discharge of approximately 77 gpm during the course of the test. A maximum drawdown of 11.13 feet was recorded in the well, yielding an estimated specific capacity of 6.9 gpm/ft. An initial transmissivity of 1,845 ft^2/d was estimated for this 64-foot interval using the following equation for confined aquifers (Driscoll 1986):

$$T = 2{,}000\left(\frac{Q}{s}\right) \qquad \textbf{Equation 1}$$

where T = transmissivity (gpd/ft)
Q = pumping or discharge rate (gpm)
s = drawdown (ft)

Further evaluation of the time-series data conducted using the Aqtesolv© software (Duffield, 2007) indicated that the actual transmissivity was slightly lower -- around 1,600 ft^2/d and the presence of a recharge boundary of some sort in the latter hours of the test. These results are summarized in **Figure 7**. As illustrated here, the test data can be separated into three broad groups. The earliest data, stage A, is strongly affected well-bore storage in this large diameter casing. It is not until stage B that the drawdown begins to represent the characteristics of the formation. During stage B of the test, the semi-log drawdown and diagnostic plots are characteristic of a confined aquifer response. The Cooper-Jacob (1946) analysis is applied solely to this stage of the test data. Although that analysis yields a storage-coefficient as well as a transmissivity estimate, that variable is unreliable in a single-well test, and will also be affected by wellbore storage. At the start of stage C, approximately 2 hours into the test, the slope-drawdown curve flattens out, indicative of a recharge boundary. The direction of leakage into the borehole can't be determined from this test, but packer testing immediately below this interval indicated low permeability materials, so it is assumed that the source of this water is from above.

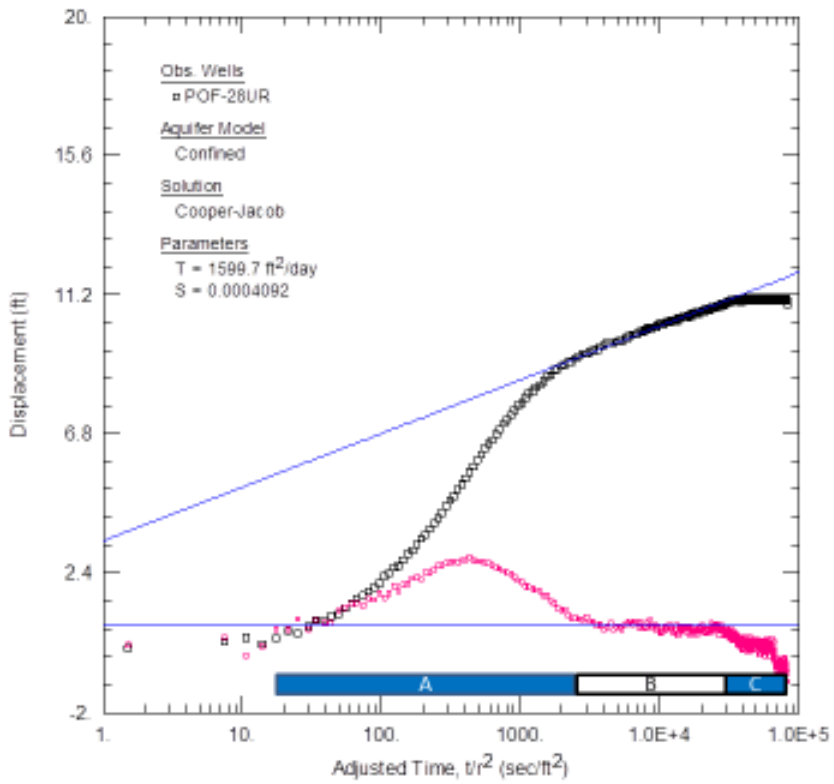

Figure 7. Aqtesolv graphic showing the drawdown (black) and diagnostic derivative (pink) plots for POF-28UR, fit to Cooper-Jacob confined aquifer solution. Three stages of drawdown response are labeled A, B, C.

4.0 Water Quality

Field parameters at the beginning of the well purge described in Section 3.0 were similar to the results from well development. Approximately two hours into the test, however, the specific conductance began to rise. Between 12:42 and 12:49, specific conductance of the water rose from 1,269 to 1,600 uS/cm. By the time the sample was collected at 14:50, values were stabilized at about 1,688 uS/cm. Given the timing of this change in water quality, coinciding with the beginning of stage C (Figure 7), it is expected that this sample is most representative of that recharge source. **Table 2** provides a comparison between this sample and results from the adjacent well, POF-29, which is withdrawing from LF2. Water from the overlying POF-28UR is significantly more brackish, but that salinity is derived almost entirely from Ca-Mg and SO_4 ions. Sulfate is still the dominant anion, but there is a strong component of NaCl also. Prior to the modification of the POF-28 annular-zone, that well was open to both of these intervals.

Table 2. Distributions of major ions in lower Floridan aquifer monitor wells POF-28UR and POF-29.

SampleID	STATIONID	SampleDate	Depth min (ft.)	Depth max (ft)	TDS (mg/l)
P63003-3	POF-29	3/19/13 13:35	1,350	1,685	828
P67340-1	POF-28UR	11/6/13 14:50	1,300	1,361	1,520
Major Anions					
SampleID	STATIONID	HCO_3 (mg/l)	Cl (mg/l)	SO_4 (mg/l)	F (mg/l)
P63003-3	POF-29	134	133	343	0.51
P67340-1	POF-28UR	102	8.6	906	1.03
Major Cations					
SampleID	STATIONID	Ca (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)
P63003-3	POF-29	117.3	3.6	42.7	75.2
P67340-1	POF-28UR	299.9	1.8	73.5	5.6

5.0 Summary

There is a hiatus in the water-level record at this site between May 2013 and January 2014 to accommodate the modifications to POF-28, and improvements to the design of the SCADA system, which allowed for instrumentation of POF-29 and Surficial aquifer system well POS-14. **Figure 8** illustrates the post-modification configuration of instrumented wells at Site B.

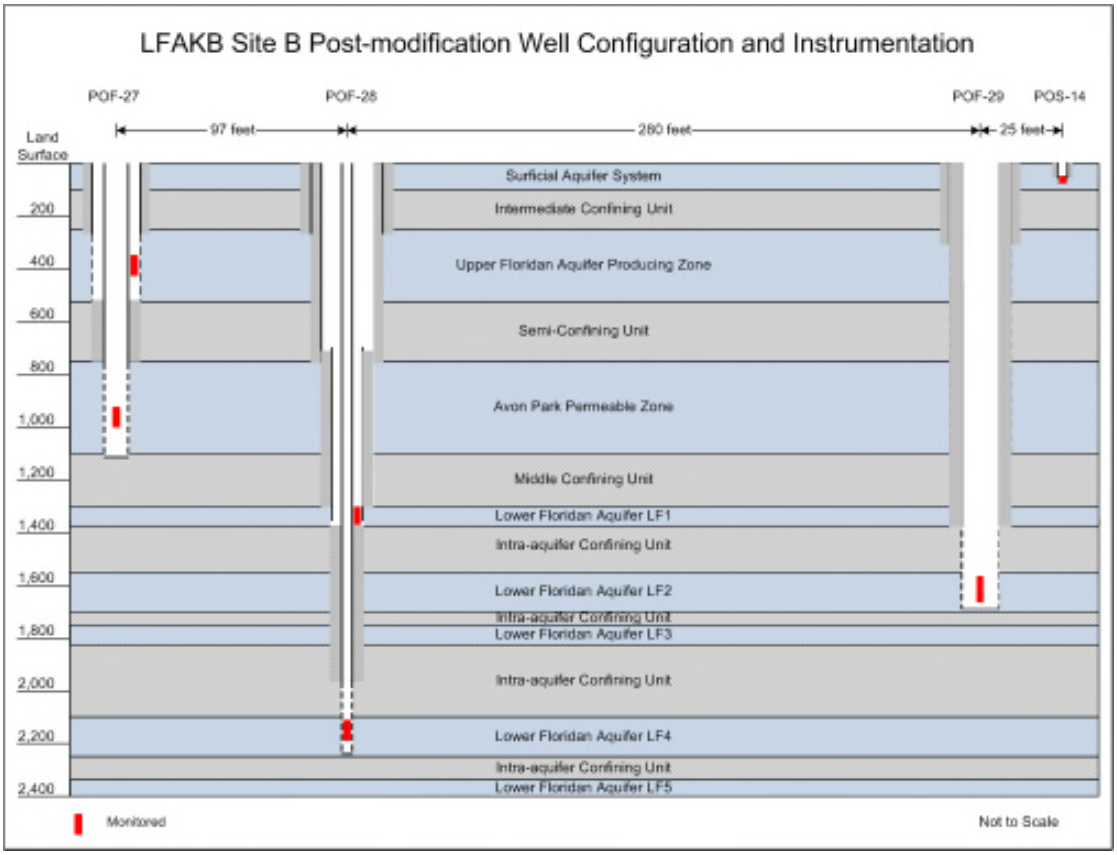

Figure 8. Site B configuration as of January 2014.

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