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TECHNICAL MEMORANDUM

DATE: **April 21, 2010** **Project 605.4**

TO: **Greg Ghidotti**
RESOLUTION COPPER MINING LLC

REGISTERED GEOLOGIST CERTIFICATE NO. 25063 TODD KEAY Date Signed 21 APR 10 ARIZONA U.S.A.

FROM: **Daniel Weber, Tim Bayley, and Todd Keay**
MONTGOMERY & ASSOCIATES

Expires 6/30/2012

SUBJECT: **RESULTS AND ANALYSIS OF LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION COPPER MINING PINAL COUNTY, ARIZONA**

In accordance with a request from Mr. Greg Ghidotti, Resolution Copper Mining LLC (RCM), Montgomery & Associates (M&A) has prepared this Technical Memorandum to document results and analysis of a 60-day pumping test conducted at hydrologic test well HRES-07. M&A conducted the long-term test to provide aquifer parameters for the Apache Leap Tuff (ALT) aquifer in the area of the well.

SUMMARY

A summary of the long-term pumping test operations and results is provided below:

1. The long-term pumping test was conducted at well HRES-07 for 60 days beginning October 7, 2009 and ending December 6, 2009. Recovery was monitored for 60 days after cessation of pumping.
2. Water level response was monitored at well HRES-07, at eight observation wells, and at three temporary piezometers completed in the shallow alluvium within or adjacent to the Devils Canyon stream channel.
3. Analysis of water level responses at HRES-07 provided an estimated average transmissivity of 83.5 m^2/day and an estimated average hydraulic conductivity of 7.3E-04 cm/s for the Apache Leap Tuff aquifer.

4. No discernable response to pumping was measured at any of the observation wells or Devils Canyon piezometers.
5. Analytical forward modeling based on the lack of response at observation wells yielded an estimated specific yield > 0.015. Modeling based on the lack of response at the Devils Canyon piezometers yielded an estimated specific yield > 0.07.

BACKGROUND

Hydrologic test well HRES-07 was drilled in November 2007 to evaluate lithologic and hydrogeologic conditions within the Apache Leap Tuff south from Oak Flat. Well HRES-07 is located west from Devils Canyon near its confluence with Rancho Rio Canyon, and is situated within an east-west-trending fault zone. The well terminates in the uppermost part of the Whitetail Conglomerate. The locations for pumped well HRES-07, and surrounding ALT aquifer wells used as observation wells during the test, are shown on **Figure 1**.

A schematic diagram summarizing well construction details for well HRES-07 is shown on **Figure 2**. Well HRES-07 was completed with two perforated zones adjacent to shallow and deep parts of the ALT aquifer. Annular well seals surrounding blank casing between the two perforated zones separate a moderately-transmissive shallow part of the ALT aquifer from a poorly-transmissive deep part of the aquifer. Well construction details are summarized as follows:

		BOREHOLE		CASING		
WELL IDENTIFIER	DATE COMPLETED	BORE-HOLE DEPTH (m, bls[a])	BOREHOLE DIAMETER (inches)	DIAMETER (inches)	DEPTH (m, bls)	PERFORATED INTERVAL (m, bls)
HRES-07	16-Nov-2007	325.5	14 3/4 8 3/4	10 4	0 – 6.0 0 – 317.3	--- 102.1 – 228.3[b] 247.5 – 310.6[c]

[a]m, bls = meters below land surface
[b]shallow perforated zone in ALT aquifer, HRES-07S
[c]deep perforated zone in ALT aquifer, HRES-07D

Prior to removing the packer that separated the shallow and deep zones of the ALT aquifer at well HRES-07, a falling-head slug test was conducted in July 2009. Representative hydraulic conductivity of the deep ALT aquifer screened at HRES-07 (HRES-07D) is on the order of 2.0E-05 centimeters per second (cm/s) and specific storage is approximately 1.8E-05 m^{-1}; using the deep screened interval for equivalent aquifer thickness, transmissivity is estimated to be 1.2 meters squared per day (m^2/d) and elastic storage coefficient is estimated to be 1.1E-03.

In September 2009, the packer was removed from well HRES-07, and an electric submersible pump (Grundfos Model 40S100-30) was installed to a depth of about 183 meters.

LONG-TERM PUMPING TEST

The long-term pumping test at HRES-07 was initiated on October 7, 2009. Average pumping rate during the 60-day pumping period was 2.2 liters per second (L/s) (35 gallons per minute (gpm)). Operational parameters for the HRES-07 pumping test are as follows:

PUMPED WELL IDENTIFIER	DATE / TIME PUMPING STARTED	DURATION OF PUMPING PERIOD (days)	AVERAGE PUMPING RATE (L/s)[a]	PRE-PUMPING WATER LEVEL (m, bls)[b]	MAXIMUM WATER LEVEL DRAWDOWN (m)	SPECIFIC CAPACITY (L/s/m)[c]
HRES-07	7-Oct-2009 18:30	60	2.2	116.4	8.7	0.25

[a] L/s = liters per second
[b] m, bls = meters below land surface
[c] L/s/m = Liters per second per meter of drawdown

Discharge from well HRES-07 was sampled approximately weekly throughout the pumping period. A Piper trilinear diagram showing results of these sampling events is shown on **Figure 3**. Only small variations of chemical parameters were evident during the pumping period indicating essentially no change in groundwater source. Geochemical composition of groundwater sampled during the long-term pumping test at well HRES-07 is similar to that observed in groundwater samples collected during the long-term pumping test at well HRES-04 in 2006 (**Figure 4**) (Montgomery & Associates, 2008). At the end of pumping, routine parameters for the pumped water at well HRES-07 were as follows:

PUMPED WELL	TEMPERATURE (ºC)[a]	SPECIFIC ELECTRICAL CONDUCTANCE (µS/cm)[b]	pH
HRES-07	22.63	265	7.29

[a] ºC = temperature in degrees Celsius
[b] Specific electrical conductance in microsiemens per centimeter at 25ºC

Results and analysis of the 60-day pumping period (drawdown period) and the 60-day recovery period for well HRES-07, shown on **Figure 5**, indicate transmissivity ranging from 77 to 90 m^2/d; average transmissivity is 83.5 m^2/d. Using the thickness of the shallow zone perforated interval as the representative thickness of the aquifer, hydraulic conductivity is estimated to range from 7.1E-04 to 8.3E-04 cm/s; average hydraulic conductivity is 7.7E-04 cm/s. Using the analytical modeling program AQTESOLV (hydroSOLVE, 2008), diagnostic analysis of the flow regime and analysis of the derivative of drawdown for data obtained at well HRES-07 during the long-term test indicate no discernable hydraulic boundaries and infinite-acting, radial flow conditions during the testing period.

Observation wells and piezometers monitored during the test are summarized as follows:

PUMPED WELL IDENTIFIER	OBSERVATION WELL IDENTIFIER	EASTING (UTM m)[a]	NORTHING (UTM m)	DISTANCE TO HRES-07 (METERS)	DISTANCE TO HRES-07 (FEET)
HRES-07		496851.2	3681953.0	0	0
	HRES-02s	494479.3	3683886.3	3060	9814
	HRES-02d	494479.3	3683886.3	3060	9814
	HRES-03s	496379.3	3685331.0	3411	10938
	HRES-03d	496379.3	3685331.0	3411	10938
	HRES-04[b]	495322.3	3683616.2	2259	7245
	HRES-05	495523.3	3682274.6	1366	4382
	HRES-08s	495620.0	3680752.8	1719	5514
	HRES-08d	495620.0	3680752.8	1719	5514
	Oak Flat	496371.7	3685360.3	3441	11035
	A-06	497365.7	3683231.7	1378	4420
	MJ-11	498075.8	3681789.2	1235	3962
	DCSW-01[c]	497265.0	3682379.0	594	1905
	DCSW-02[c]	497283.0	3682387.0	612	1963
	DCSW-03[d]	497207.0	3682675.0	805	2581

[a] UTM = Universal Transverse Mercator projection, NAD27, in meters
[b] Barometric pressure is recorded at this site in addition to water level
[c] Temporary piezometer completed using drive point method in stream alluvium near Devils Canyon stream channel; piezometers DCSW-1 and DCSW-2 monitored hydraulic head 1.2 and 0.91 meters below land surface, respectively.
[d] Water level in shallow perennial pool in Devils Canyon

At observation wells and piezometers, analysis of water levels monitored during the drawdown period and partial recovery period indicate no discernable water level change due to pumping at well HRES-07. Results and analysis of water level data from observation wells and piezometers are presented and described in **Appendix A**.

Using the average transmissivity derived for well HRES-07 and radial distances from well HRES-7 to the stream channel in Devils Canyon (piezometer DCSW-1) and the nearest observation wells (MJ-11 and HRES-05) to constrain forward analytical modeling, a range of potential minimum values of specific yield is derived for the ALT aquifer in the area of well HRES-07. Graphical results of modeling shown as distance to the observation wells and projected drawdown are shown on **Figure 6**. The value of specific yield greater than 0.015 is derived based on no discernable drawdown at the closest observation wells after 60 days of pumping. Discernable drawdown is defined as observed water level decline larger than 0.03 meters. Because no positive hydraulic boundary effects from Devils Canyon were observed during the drawdown period at pumped well HRES-07 and there was no discernable drawdown at piezometer DCSW-1, specific yield may be greater than 0.07. This larger value of specific yield assumes hydraulic connection between the ALT aquifer at well HRES-07, piezometers completed in shallow saturated stream alluvium near Devils Canyon, and surface water in Devils Canyon.

In summary, hydraulic parameters derived from long-term testing operations at well HRES-07 are as follows:

			COOPER-JACOB (1946) DRAWDOWN METHOD	THEIS (1935) RECOVERY METHOD	THEIS (1935) DISTANCE-DRAWDOWN METHOD
PUMPED WELL IDENTIFIER	OBSERVATION WELL IDENTIFIER	DISTANCE TO PUMPED WELL (meters)	TRANSMISSIVITY[a] (m^2/d)		SPECIFIC YIELD[b]
HRES-07	---	---	77	90	---
	DCSW-1	594	ND[c]	ND	>0.07
	MJ-11	1235	ND	ND	>0.015
	HRES-05	1366	ND	ND	>0.015

[a]rate of flow of groundwater through a square unit of aquifer under a unit hydraulic gradient, expressed as square meters per day (m^2/d)
[b]dimensionless: ratio of the volume of water sediments or rocks will yield due to gravity drainage to the total volume of the sediments or rocks.
[c]ND = not determined; computation of aquifer parameters not possible due to indiscernible water level change during pumping

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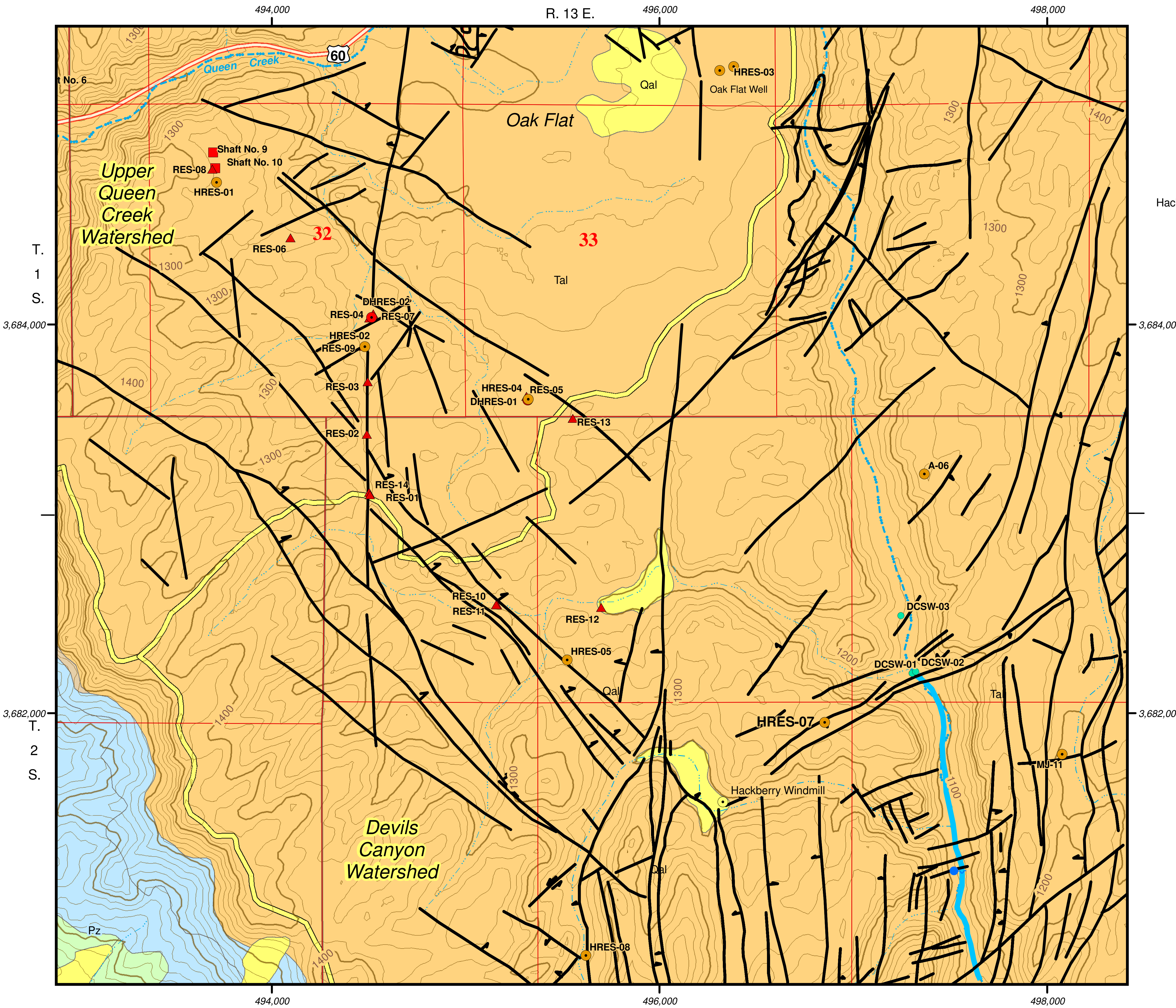

EXPLANATION

Watershed Boundary

Perennial Reach

Fault (Mapped by J. Gant/J. Wilkins)

Groundwater and Surface Water Monitoring Sites

Hackberry Windmill — Alluvial Aquifer Monitor Well and Identifier

A-06 — Apache Leap Tuff Aquifer Monitor Well and Identifier

DHRES-01 — Deep Aquifer Monitor Well and Identifier

RES-01 — Exploration Borehole and Identifier

Shaft No. 9 — Shaft and Identifier

DC 13.5 C — Spring and Identifier

DCSW-01 — Surface Water Monitoring Station During HRES-07 Pumping

Geologic Units

Qal — Quaternary Alluvial Deposits

Tal — Tertiary Apache Leap Tuff

Pz — Paleozoic Sedimentary Rocks

0 1,000 2,000 3,000 4,000
Feet
0 200 400 600 800
Meters
Topographic contour interval : 20 meters

N

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LOCATION MAP

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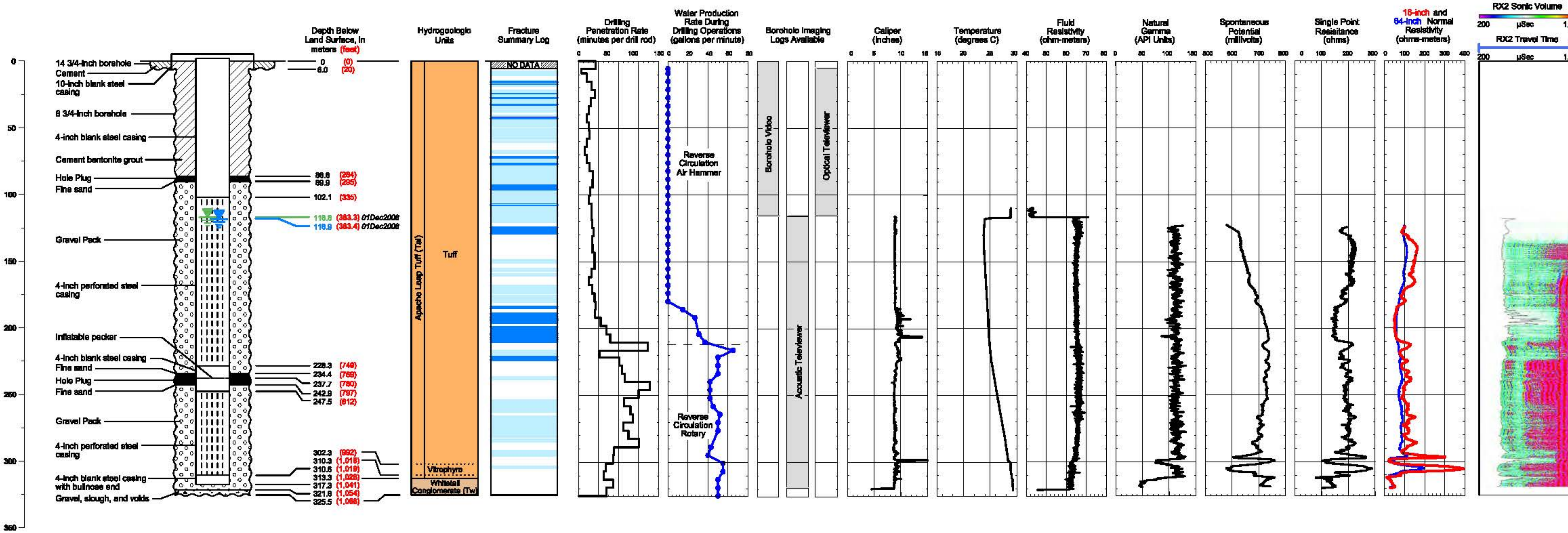
2010

FIGURE 1

GIS-Tuc\Projects\605\605.1\Locmap_HRES07_longtermPUMPTEST.mxd\31Mar2010



CADASTRAL: (D-2-13) 08aaa	ADWR NO: 55-907947
NORTHING: 3681952.962	EASTING: 496861.233
LAND SURFACE ELEVATION: 1223.31	
HORIZONTAL: UTM 12, NAD 27 VERTICAL: NGVD 29 METERS	

EXPLANATION

- No Fracturing Evident
- Minor Fracturing
- Moderate Fracturing
- Major Fracturing
- Shallow Non-pumping Water Level
- Deep Non-pumping Water Level

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HRES-07
SCHEMATIC DIAGRAM OF WELL CONSTRUCTION

Version: March 31, 2010

FIGURE 2

606\WellSchematics_2010\HRES-7-ws-PUMPTEST/31Mar2010

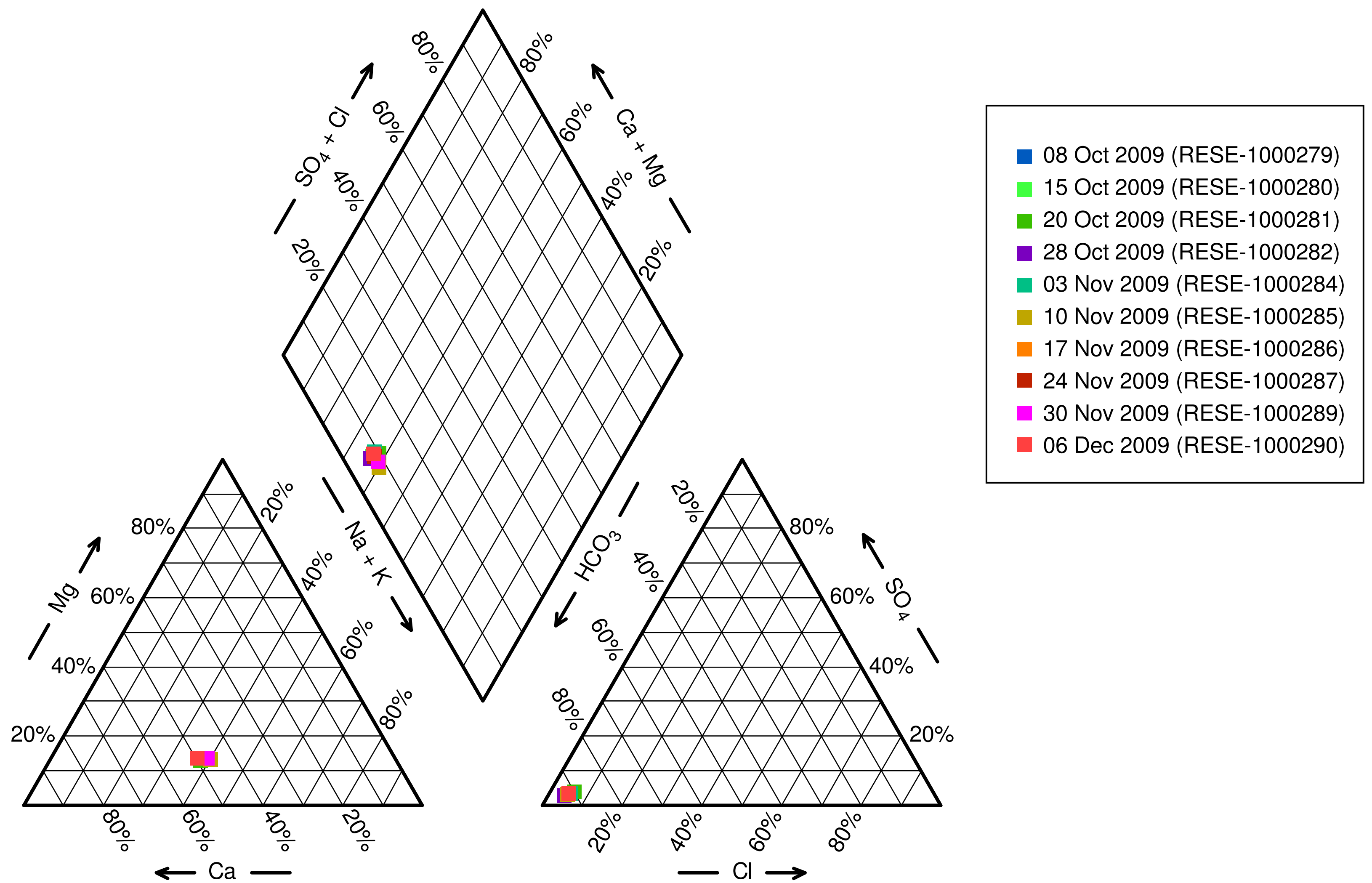

FIGURE 3. TRILINEAR DIAGRAM COMPARING GEOCHEMICAL COMPOSITION OF GROUNDWATER SAMPLES COLLECTED DURING HRES-07 LONG-TERM PUMPING TEST, RESOLUTION PROJECT

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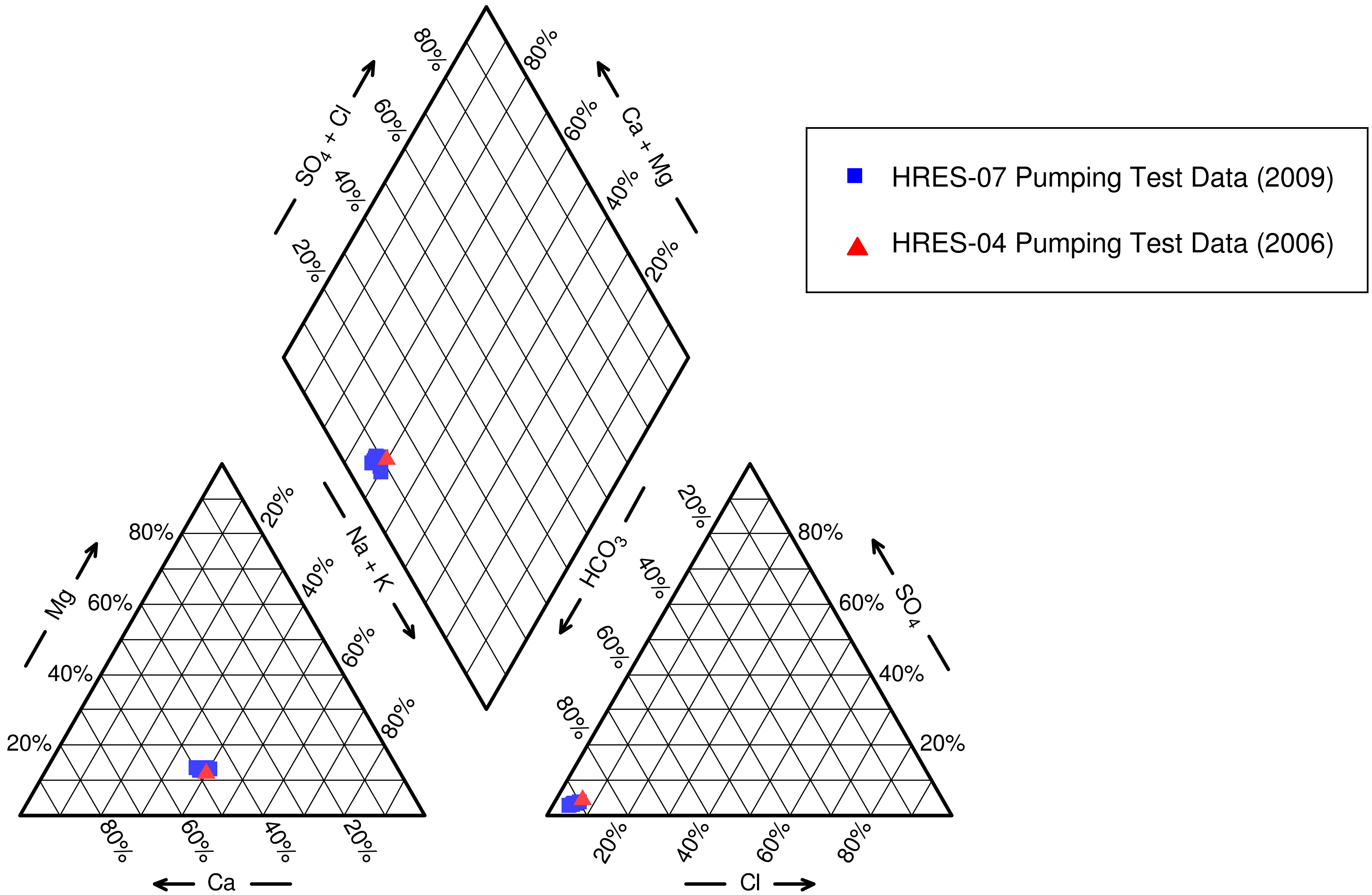

FIGURE 4. TRILINEAR DIAGRAM COMPARING GEOCHEMICAL COMPOSITION OF GROUNDWATER SAMPLES COLLECTED DURING HRES-07 AND HRES-04 LONG-TERM PUMPING TESTS, RESOLUTION PROJECT

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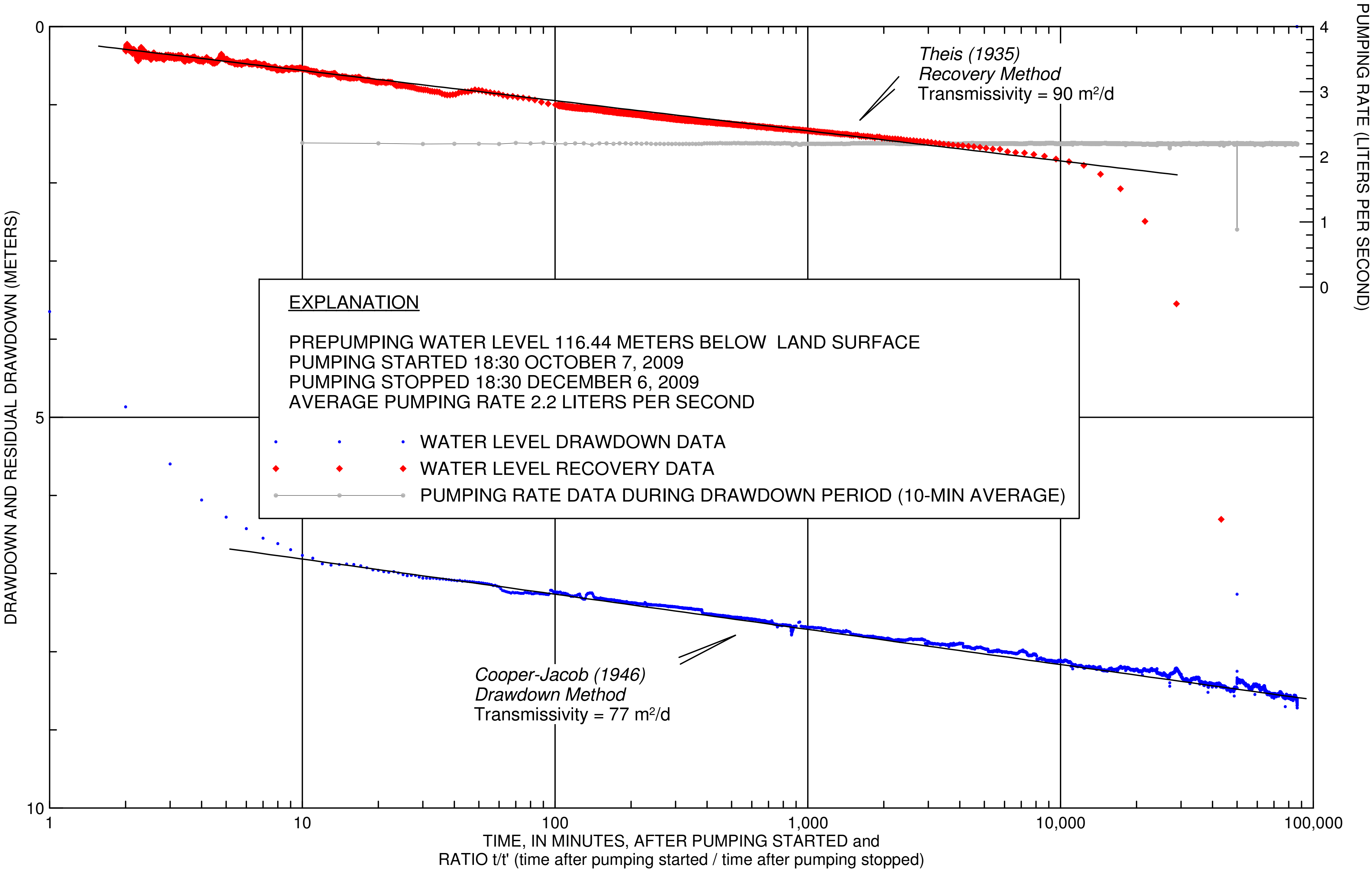

FIGURE 5. DRAWDOWN AND RECOVERY GRAPH FOR PUMPED WELL HRES-07 DURING LONG-TERM PUMPING TEST, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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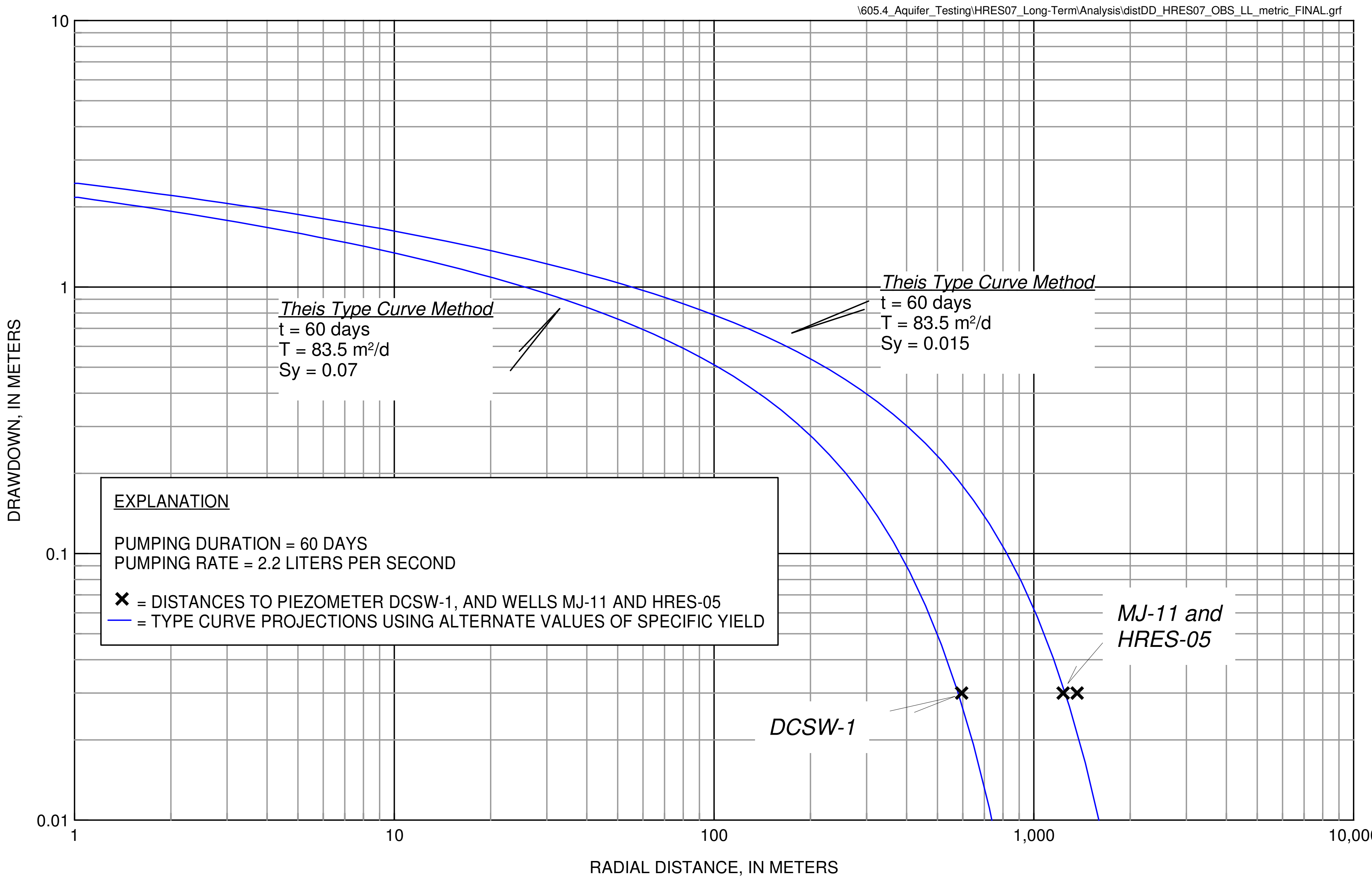

FIGURE 6. LOG-LOG DISTANCE DRAWDOWN GRAPH AFTER 60 DAYS OF PUMPING, WELL HRES-07 LONG-TERM PUMPING TEST, FORWARD ANALYTICAL MODELING ANALYSIS FOR ESTIMATING SPECIFIC YIELD, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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APPENDIX A

Water Level Monitoring and Corrections for Antecedent Trends, Barometric Efficiency, and Earth Tides

OBSERVATION WELLS

Water level measurements recorded by integrated dataloggers and pressure transducers are part of long-term monitoring operations for the ALT aquifer (Montgomery & Associates, 2010). Approximately 2 weeks prior to start of pumping, water level measurements at all of the HRES-07 long-term test observation wells were synchronized for recording at 1-hour frequency.

Water Level Correction Techniques

In order to determine aquifer hydraulic properties using analytical methods, the variation of hydraulic head with respect to time during a pumping test is commonly examined. To obtain a representative data set, external hydraulic stresses that may influence measurements of head must be considered. Barometric pressure effects, and to a lesser degree earth tidal effects, produce transients in hydraulic head conditions that must be removed from water level data when the signal to noise ratio is small (i.e., when measured water level responses at observation wells are similar in magnitude to the changes caused by external stresses). Rasmussen and Crawford (1997) provide a thorough review of barometric-aquifer response conceptual models (e.g., confined aquifer, delayed well response in unconfined aquifer, delayed well response associated with well-bore storage and skin effects) and methods to remove effects of external stresses from water level data.

Jacob (1940) states that the barometric efficiency (BE) can be defined as the change in water level in a well versus a change in atmospheric pressure, as follows:

$$BE = -\gamma_{fc} (\Delta h_w / \Delta P_a)$$

where γ_{fc} is average specific weight of the fluid column in the well, Δh_w is the change in elevation of the fluid column in the well associated with atmospheric pressure change, and ΔP_a is the change in atmospheric pressure at the top of the well and land surface. BE is dimensionless and ranges from zero to one.

Measurable water level changes in a well may also be due to a number of other factors in addition to changes induced during a pumping test. These are chiefly long-term seasonal trends and earth tides (Halford, 2006). Gontheir (2007) provides recent review of methods of determining barometric efficiency. The methods can generally be said to determine an average response with selective application of corrections depending on the overall trends.

In order to prepare water level data from observation wells for analysis the following tasks were performed:

1. Plot barometric pressure change
2. Plot water level
3. Correct water level data for barometric pressure change
4. Analyze water level data for antecedent water level trend
5. Correct water level data for antecedent trend
6. Analyze water level data for barometric efficiency and earth tide effects
7. Correct water level data for barometric efficiency and earth tide effects
8. Analyze corrected water level data

The hydrographs shown on **Figures A-1 through A-9** illustrate measurements obtained at observation wells before, during, and after the HRES-07 pumping test and results of the corrections outlined above. The barometric pressure change, in terms of feet of water, is plotted with reference to a “zero” reading about 2 weeks prior to start of the test (when observation wells and barometer were set to monitor response to pumping at well HRES-07).

There is an inverse relationship between barometric pressure and water level i.e., when barometric pressure increases water levels drop and vice versa. However, nonvented pressure transducers result in the opposite response; an increase in barometric pressure results in an increase in measured water level. Once the nonvented pressure transducer readings are corrected for barometric pressure change, the usual (inverse) relationship between barometric pressure and water level is observed. There are also smaller-order, sinusoidal variations which occur twice daily attributable to tidal cycles. Two types of water level corrections were employed as described separately below.

Graphical Barometric Efficiency Correction Method

The Graphical Barometric Efficiency Method (**A-1 through A-12**) uses linear regression techniques to graphically correct the transducer pressure reading for barometric pressure trends (Rasmussen and Crawford, 1997).

Spreadsheet methods for processing and filtering data were used to determine graphical barometric efficiency (BE) corrections throughout the background measurement period (1 month prior to the beginning of the test). The method focused on data previously corrected for antecedent trends of declining water levels throughout the monitoring period. Corrections for earth tides were employed, but because they have small amplitudes (i.e., on the order of 0.03 meters and less) they are near the noise limit of transducer accuracy. The magnitude of BE is likely a function of aquifer confinement and rigidity of the aquifer matrix. Time lagged water level response or delayed effects of barometric pressure is largely a function of well-bore storage/well skin or air permeability in cases of an unconfined aquifer regime.

BETCO Correction Method

A public domain computer application was used to analyze the barometric and background water level data collected prior to the pumping test. The computer method used is BETCO (Sandia Corporation, 2005), which is publicly available at "http://www.sandia.gov/betco/". Water level, time, and barometric pressure data are input and BETCO calculates corrected water level values. Using the publically available program, TSOFT, earth tide effects are calculated and input simultaneously to the BETCO program. **Figures A-4, A-5, A-8, and A-9** (wells HRES-04, HRES-05, A-06, and MJ-11) compare the BETCO corrected water levels with the graphical BE calculations; the two methods yield similar results.

DEVILS CANYON PIEZOMETERS

Prior to commencement of the long-term pumping test at well HRES-07, three temporary piezometers were completed in the shallow alluvium within or adjacent to the Devils Canyon stream channel. The piezometers were instrumented with vented LevelTROLL pressure transducers which were monitored throughout the test. Water level data collected from the installation of each piezometer through the pumping portion of the test and for 16 days after cessation of pumping are shown on **Figures A-10 through A-12**. Also shown on **Figures A-10 through A-12** are precipitation data for the period October 7 through December 22, 2009. Water levels at all piezometers were declining prior to the start of the test and continued to decline until a series of precipitation events beginning November 14, 2009 caused water levels in the Devils Canyon shallow alluvium to increase. There does not appear to be discernable impact to water levels in Devils Canyon due to pumping at well HRES-07.

SUMMARY

Water level data obtained from observation wells during the 60-day, long-term pumping test at well HRES-07 were corrected for antecedent trends, barometric efficiency, and earth tides using graphical and analytical methods. These methods were required because of the low signal to noise ratio of the test and difficulty discerning water level displacement due to testing operations. The two methods used for water level corrections, graphical BE and BETCO, yielded similar results. Detailed examination of hydrographs from observation wells and temporary piezometers located in the Devils Canyon shallow alluvium indicates that pumping at well HRES-07, at the tested rate and duration, did not have a discernable effect on water levels at any of these observation points.

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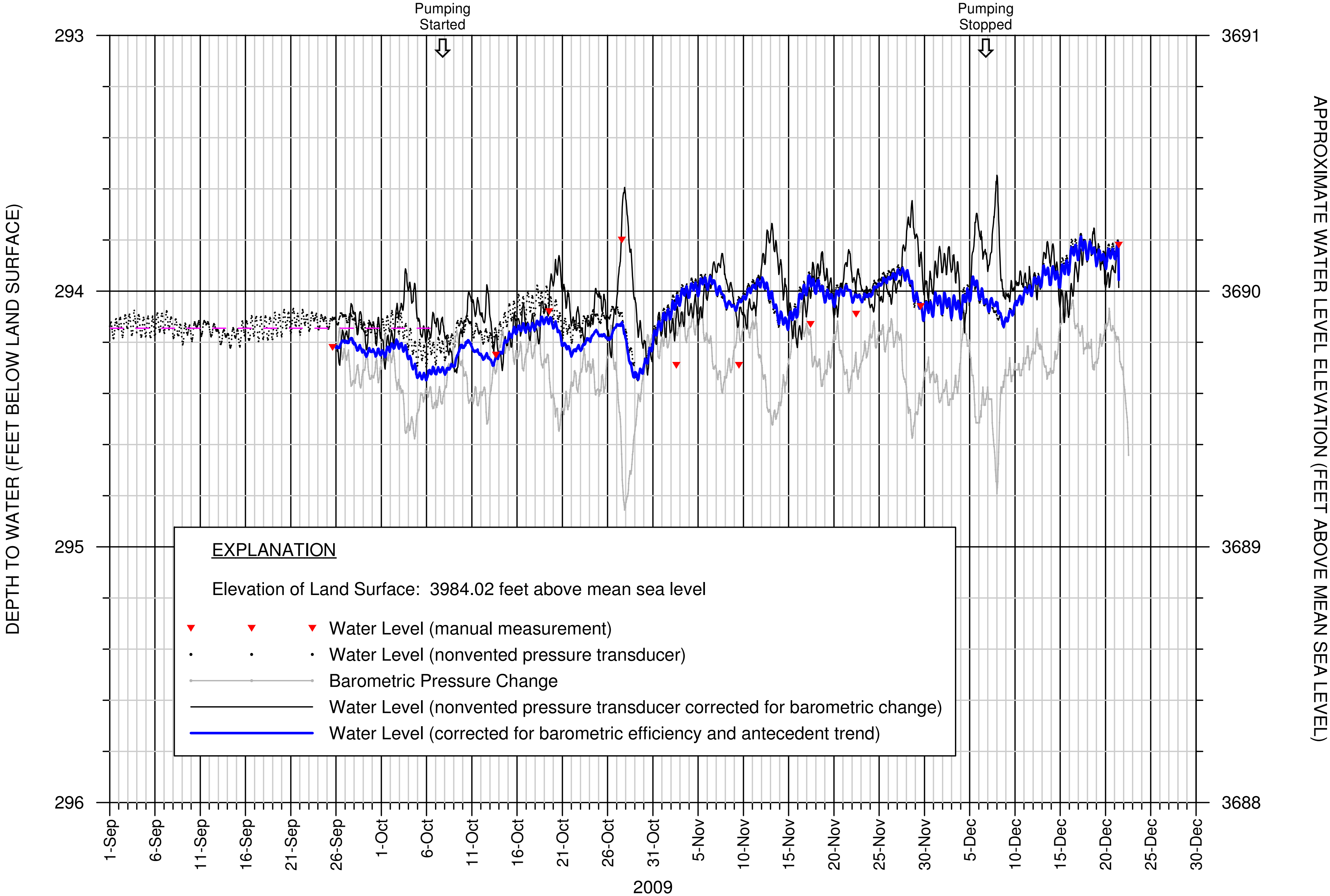

FIGURE A-1. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL HRES-02S DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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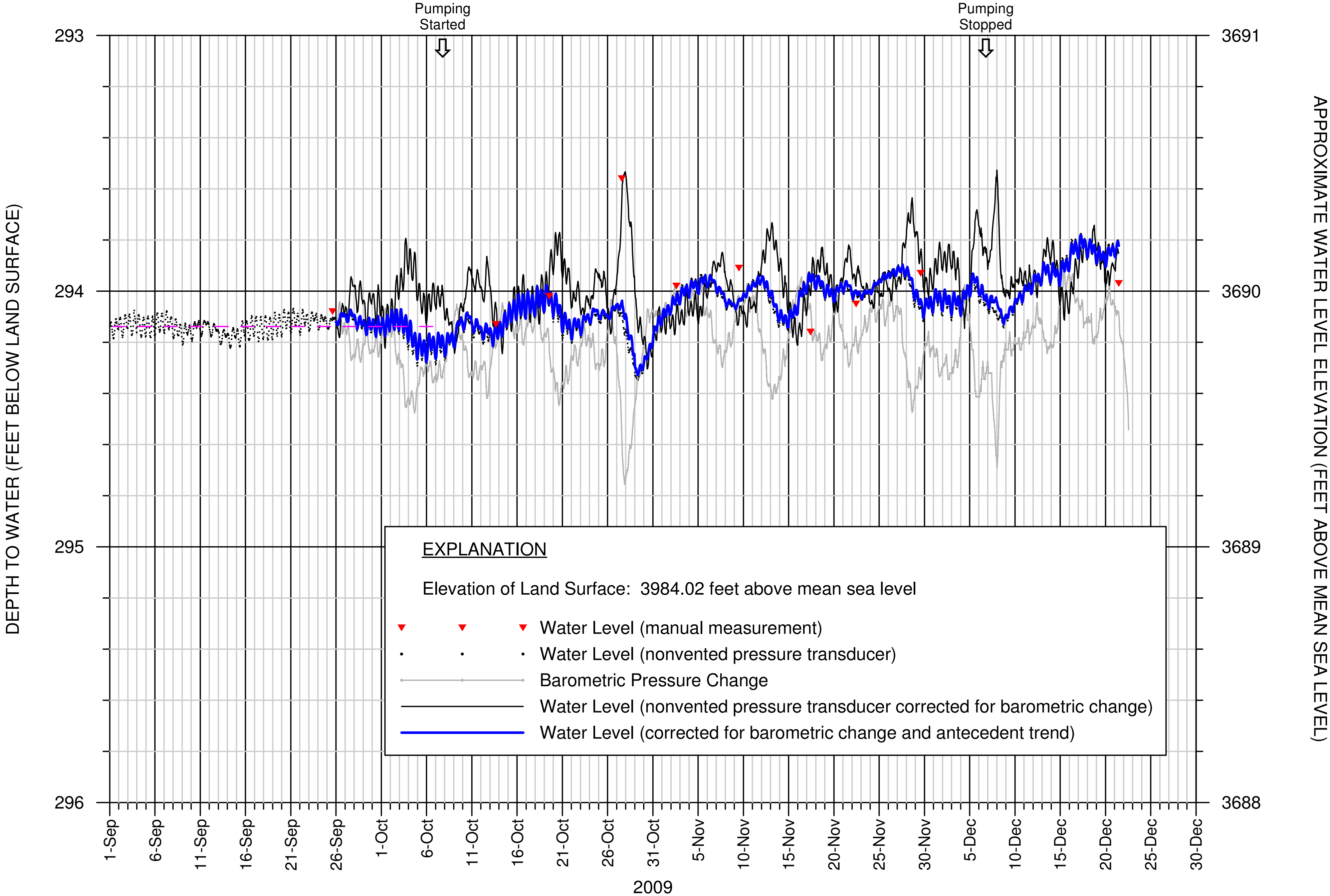

FIGURE A-2. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL HRES-02D DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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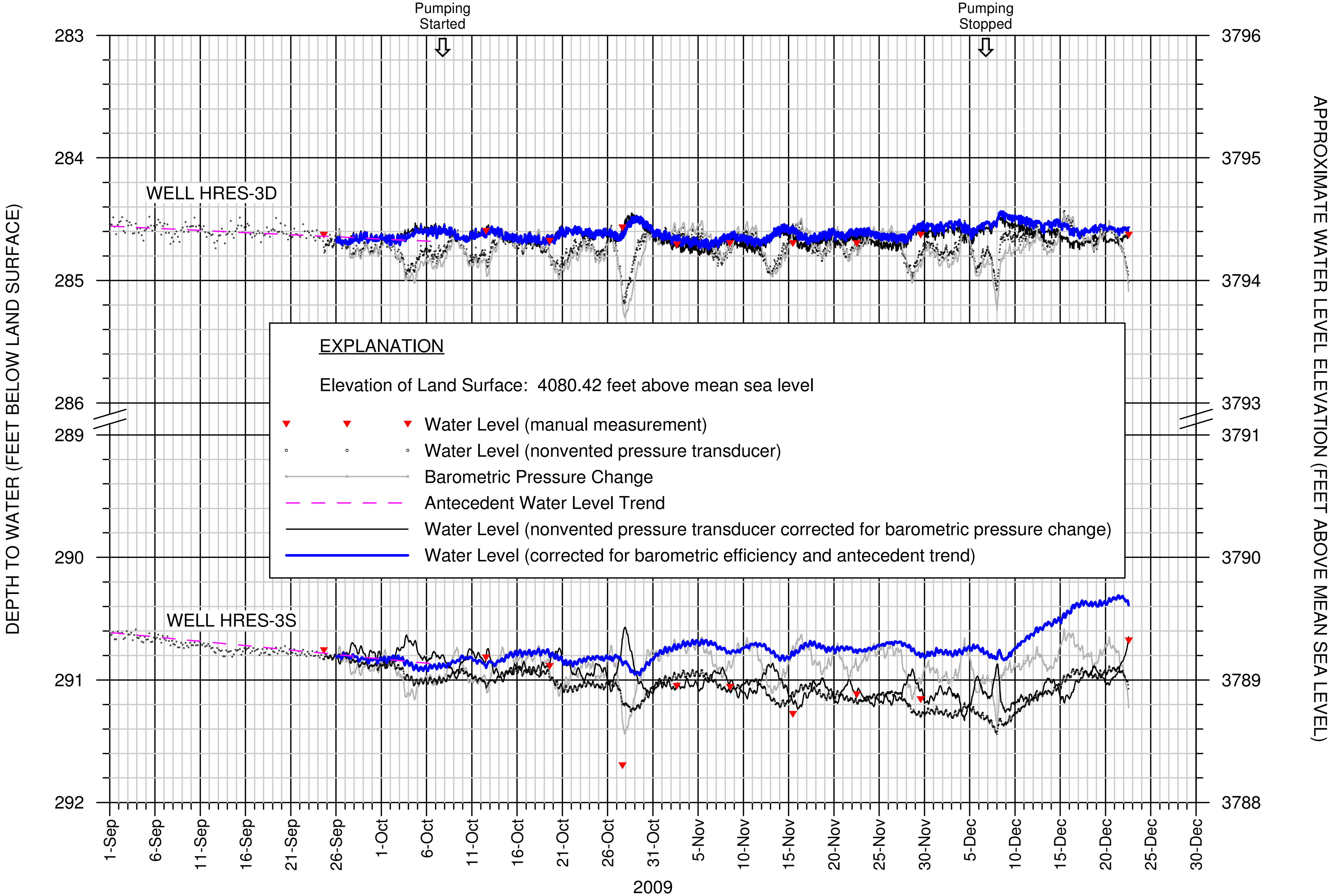

FIGURE A-3. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL HRES-03S AND HRES-03D DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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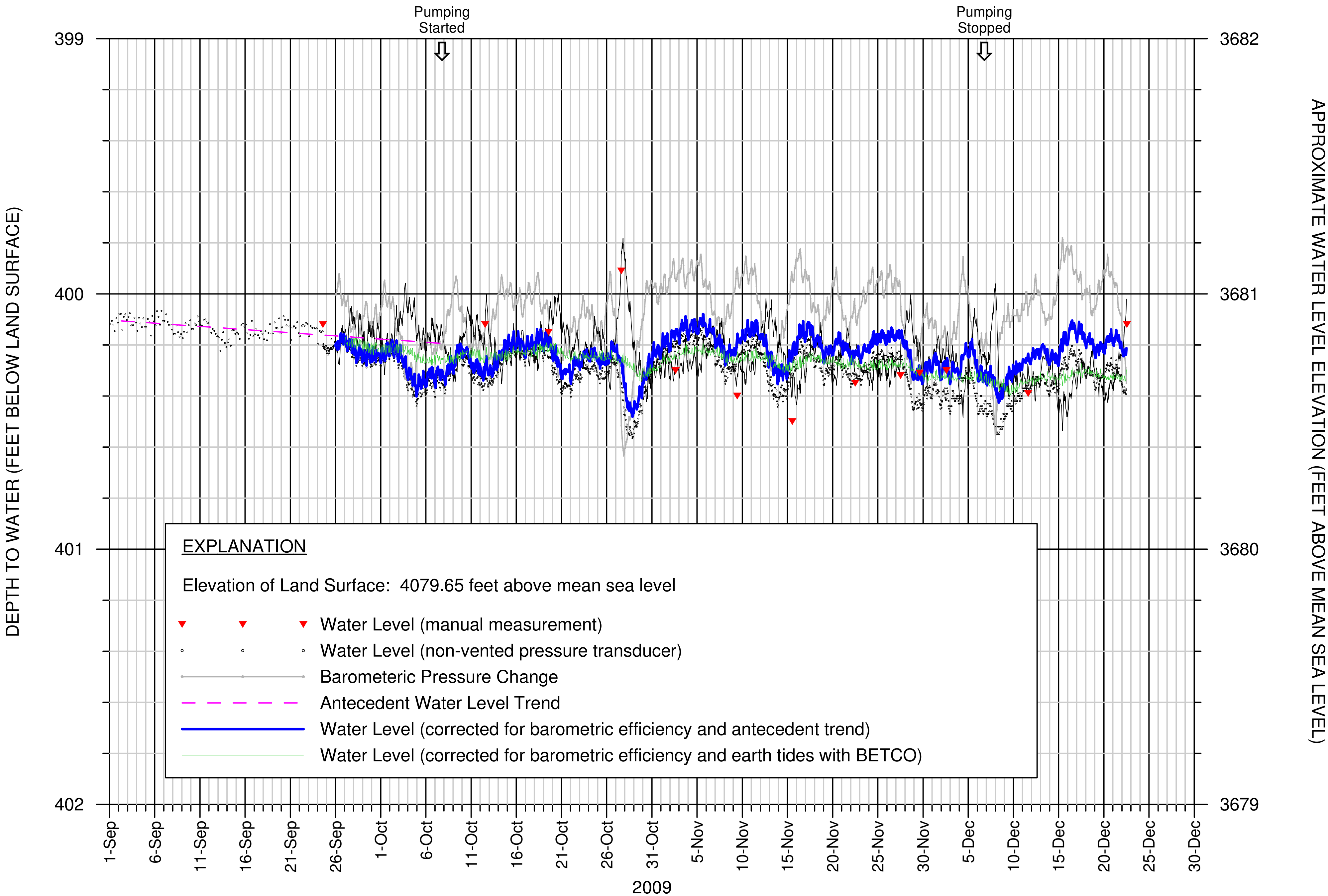

FIGURE A-4. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL HRES-04 DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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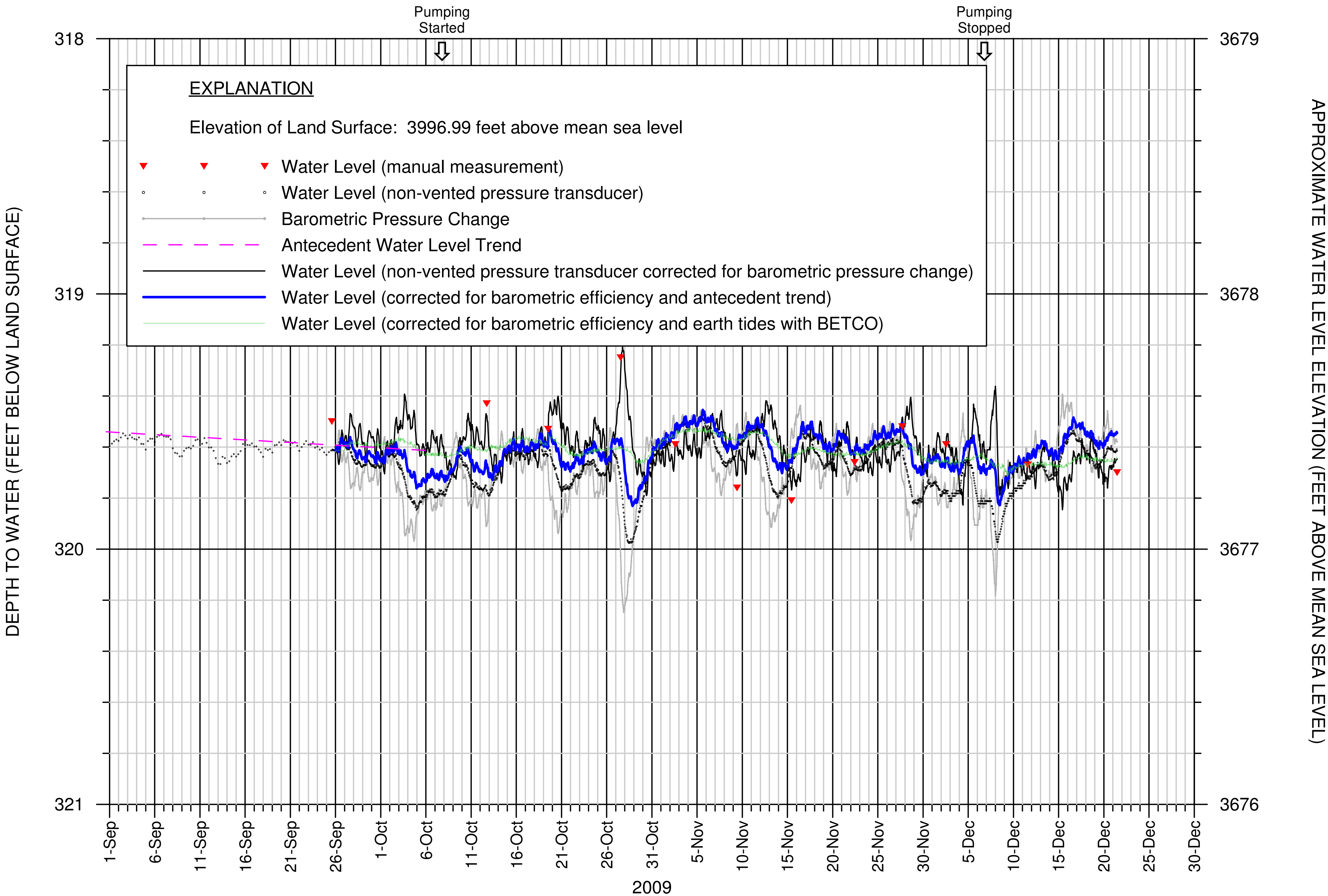

FIGURE A-5. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL HRES-05 DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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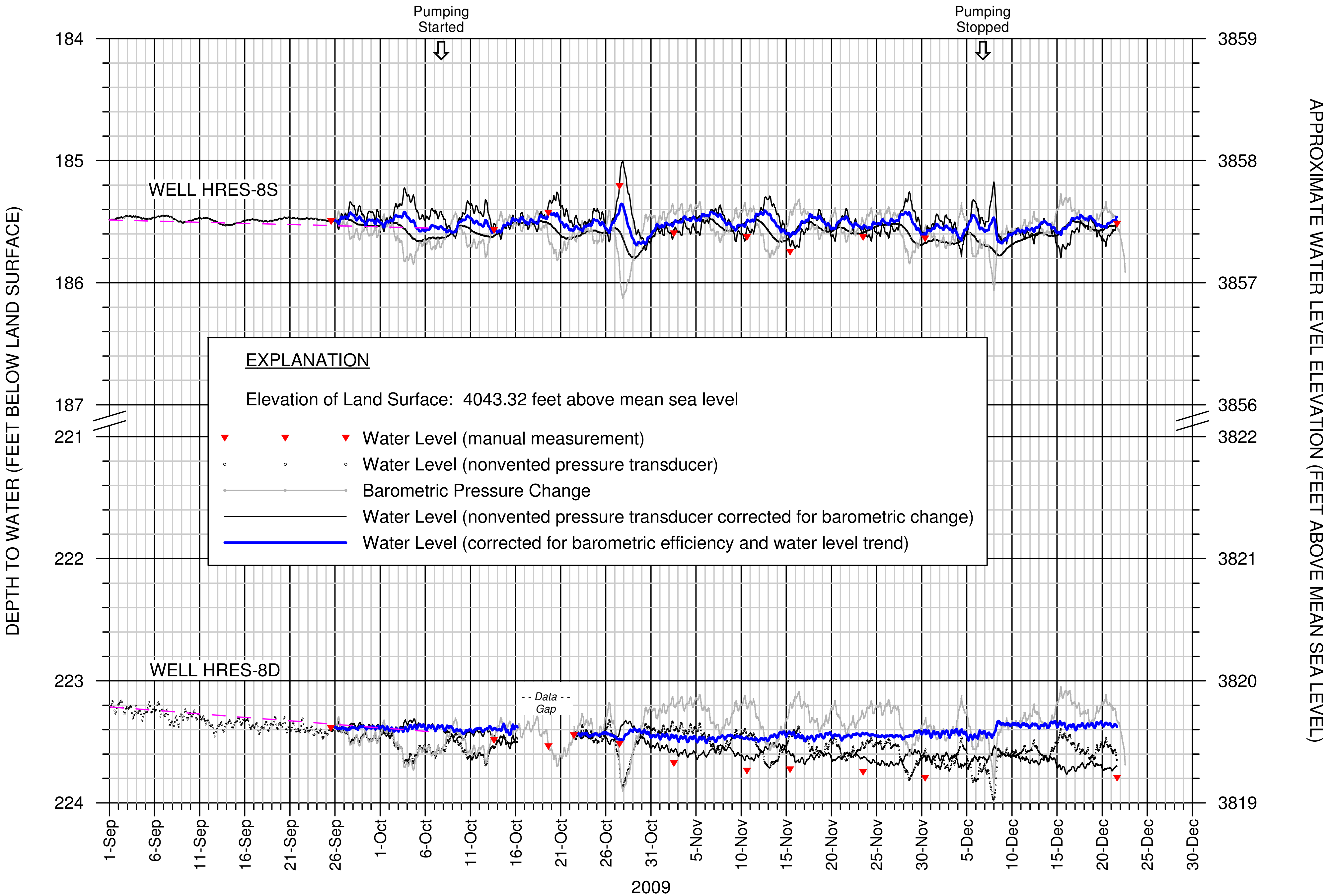

FIGURE A-6. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL HRES-08S AND HRES-08D DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

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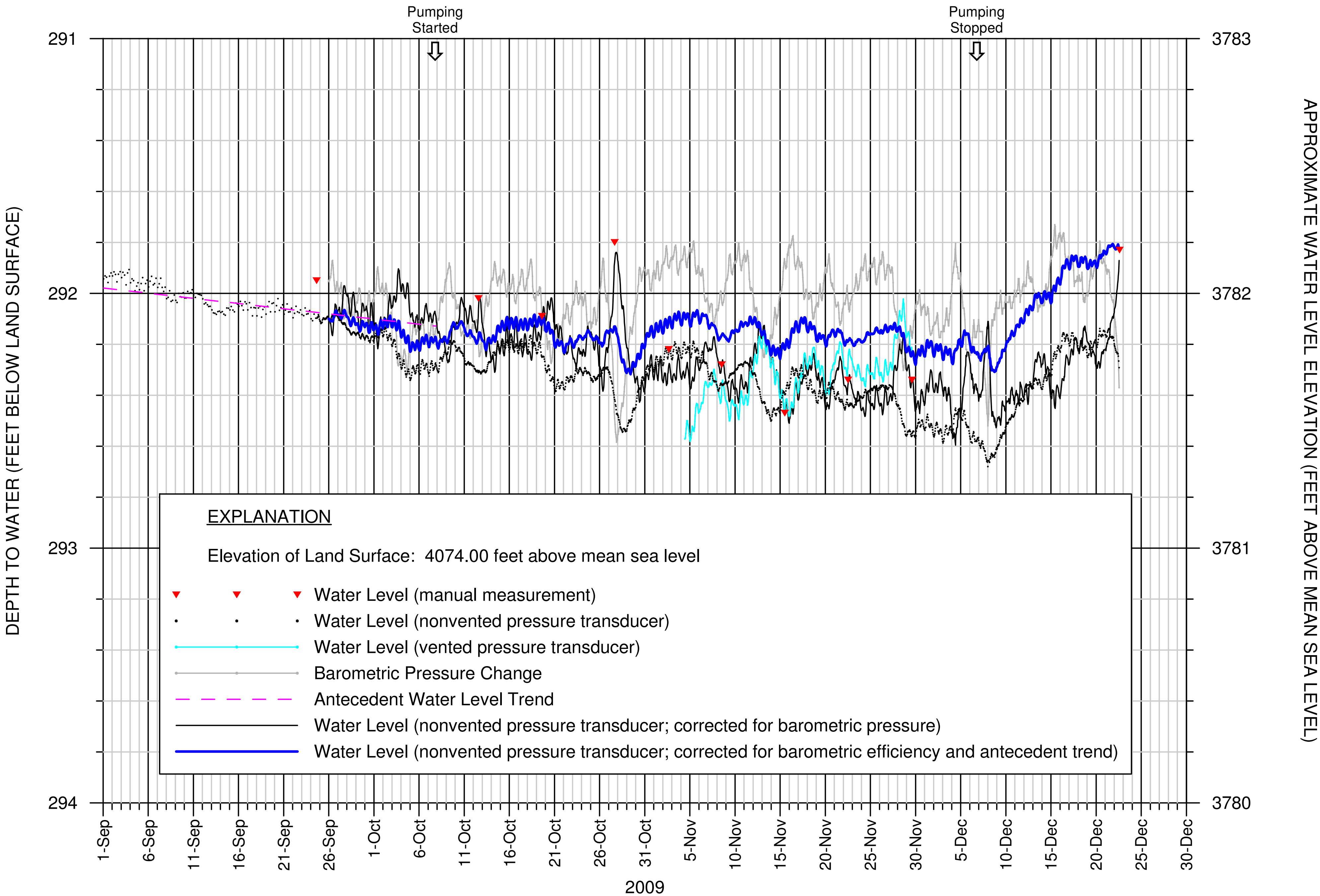

FIGURE A-7. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL OAK FLAT DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

605.4_Aquifer_Testing\HRES_07_LongTerm\Hydrographs\hydWELL_OakFlat_2009.grf

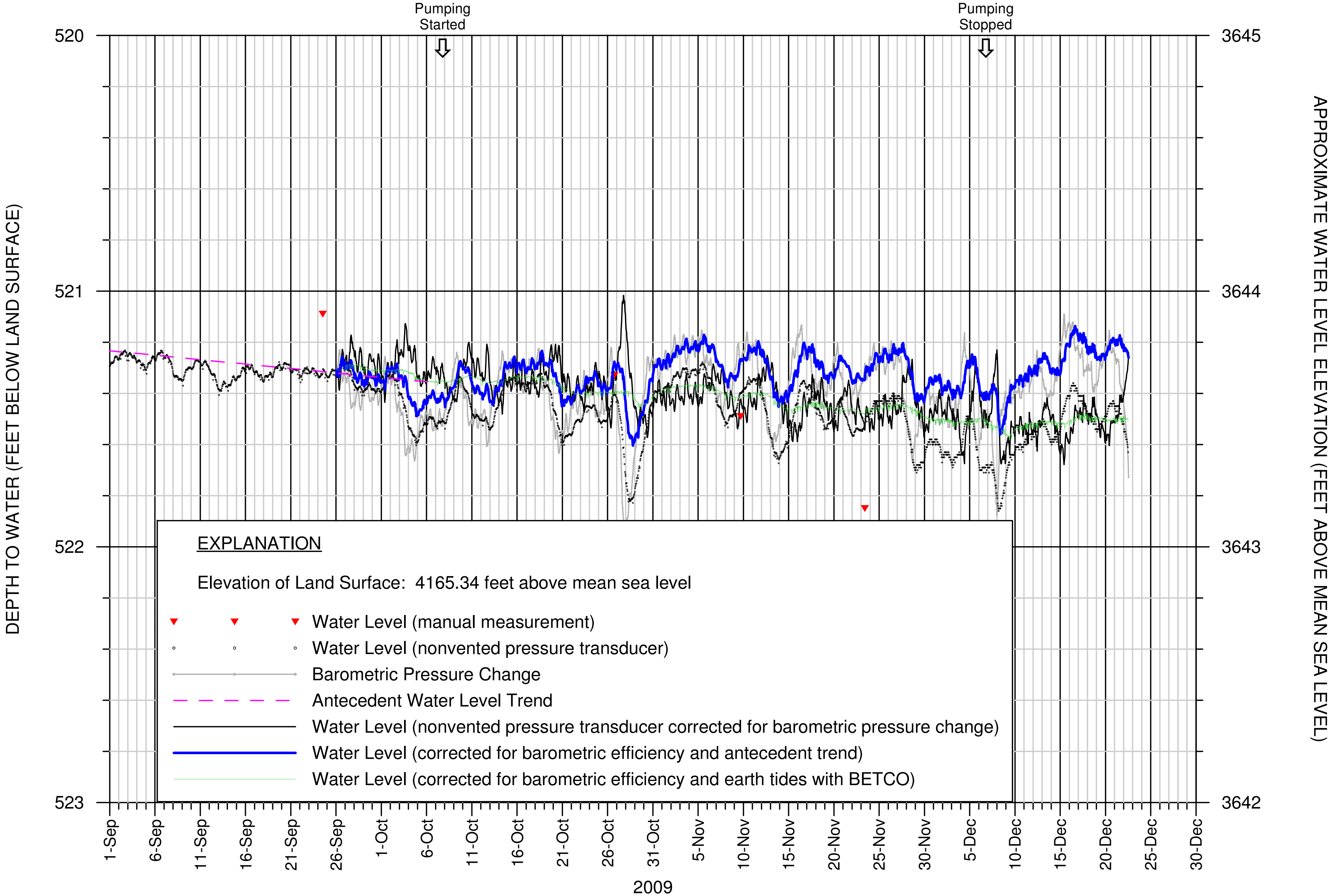

FIGURE A-8. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL A-06 DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

605.4_Aquifer_Testing\HRES_07_LongTerm\Hydrographs\hydWELL_A-06_2009.grf

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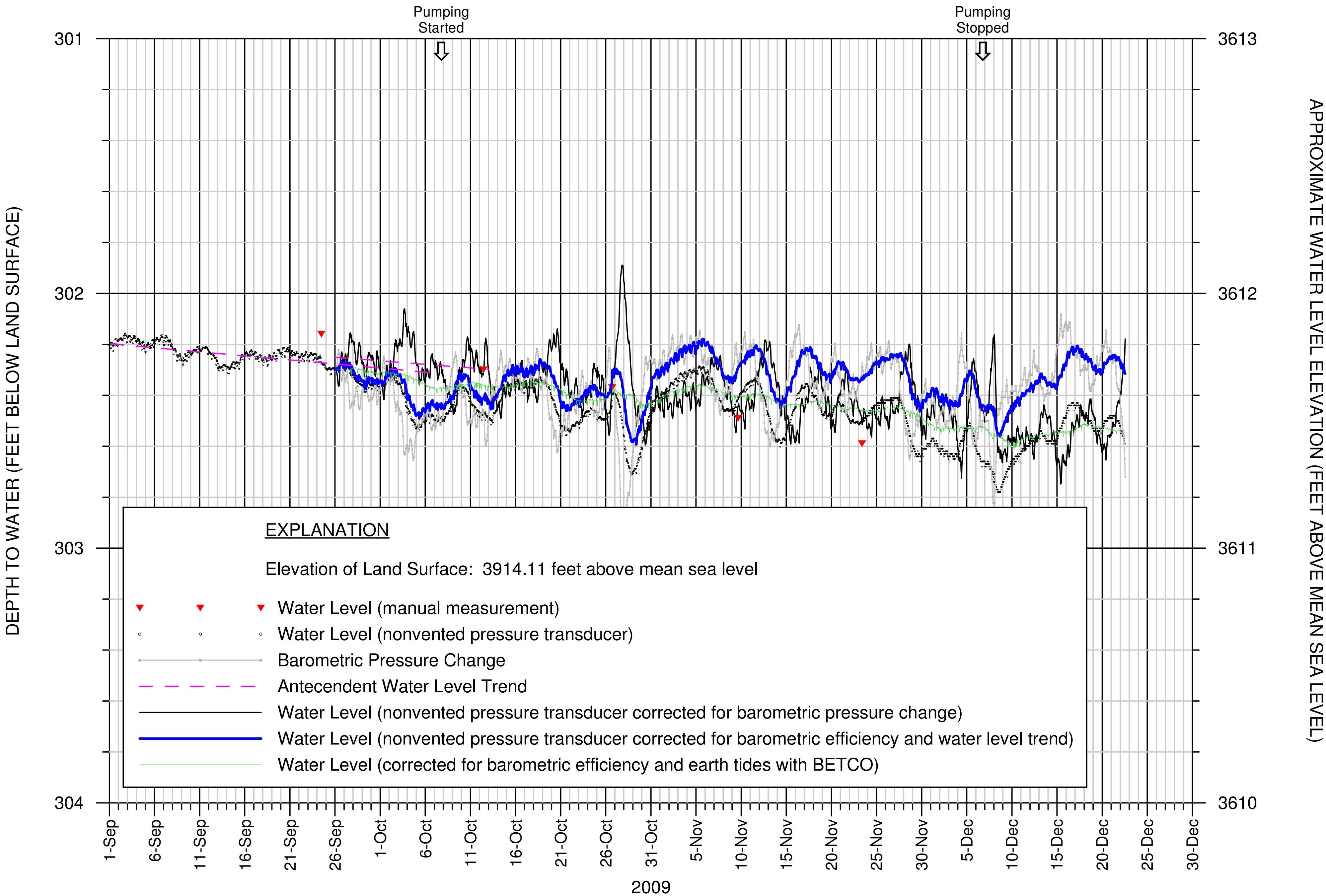

FIGURE A-9. HYDROGRAPH OF WATER LEVEL AT OBSERVATION WELL MJ-11 DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

605.4_Aquifer_Testing\HRES_07_LongTerm\Hydrographs\hydWELL_MJ-11_2009.grf

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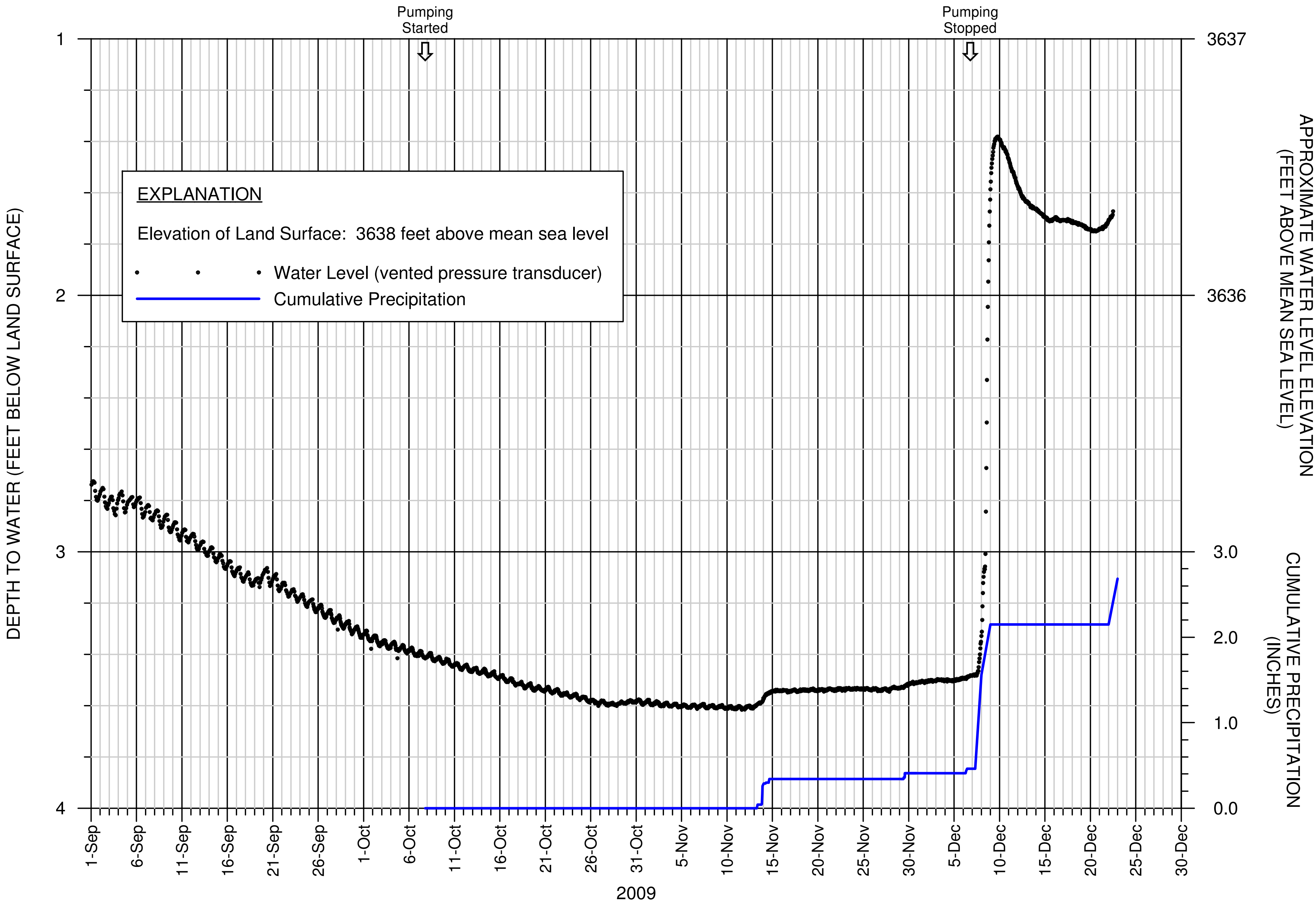

FIGURE A-10. HYDROGRAPH OF WATER LEVEL AT OBSERVATION PIEZOMETER DCSW1 DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

605.4_Aquifer_Testing\HRES_07_LongTerm\Hydrographs\hyd_DCSW1_ppt_2009.grf

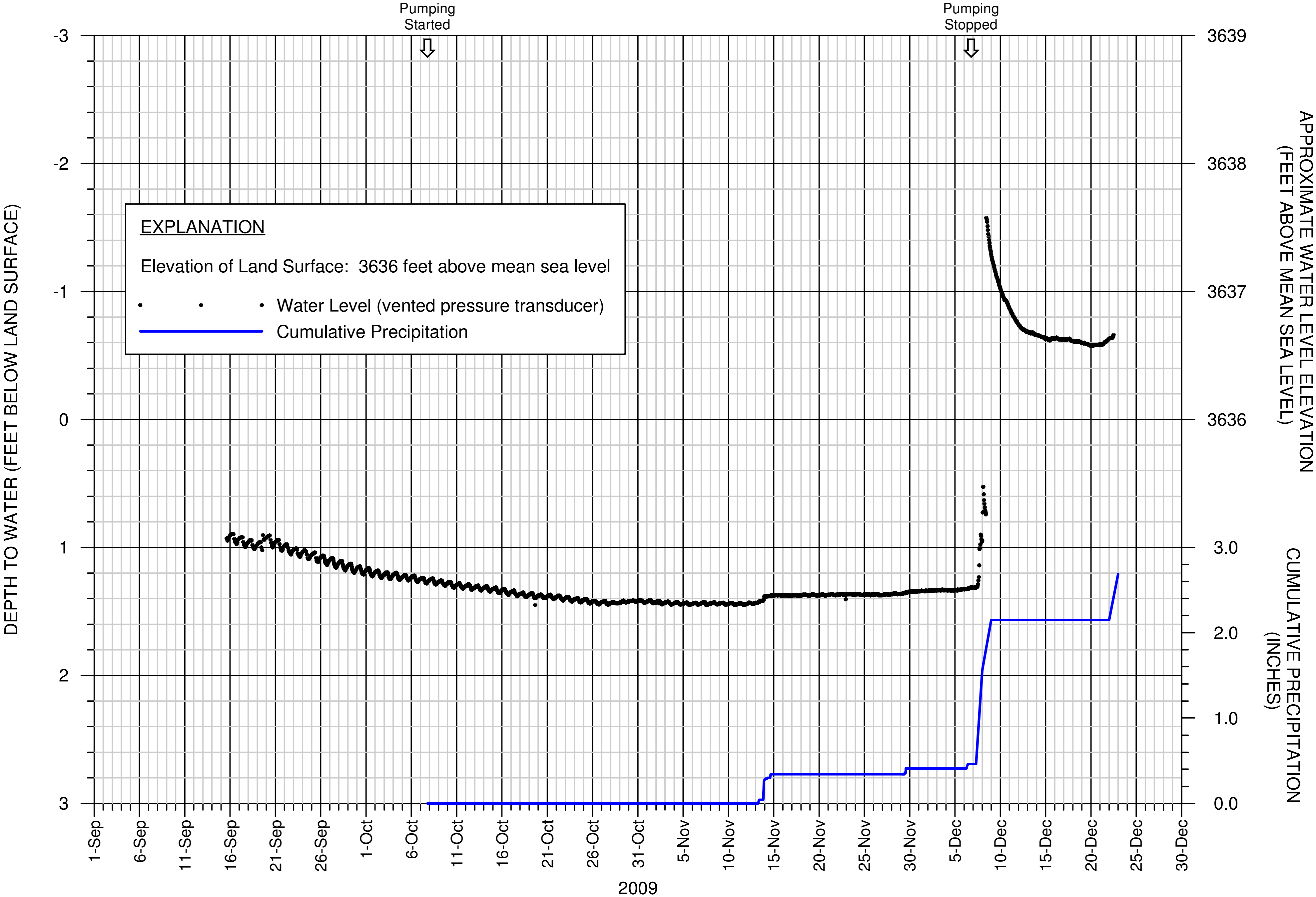

FIGURE A-11. HYDROGRAPH OF WATER LEVEL AT OBSERVATION PIEZOMETER DCSW2 DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

605.4_Aquifer_Testing\HRES_07_LongTerm\Hydrographs\hyd_DCSW2_ppt_2009.grf

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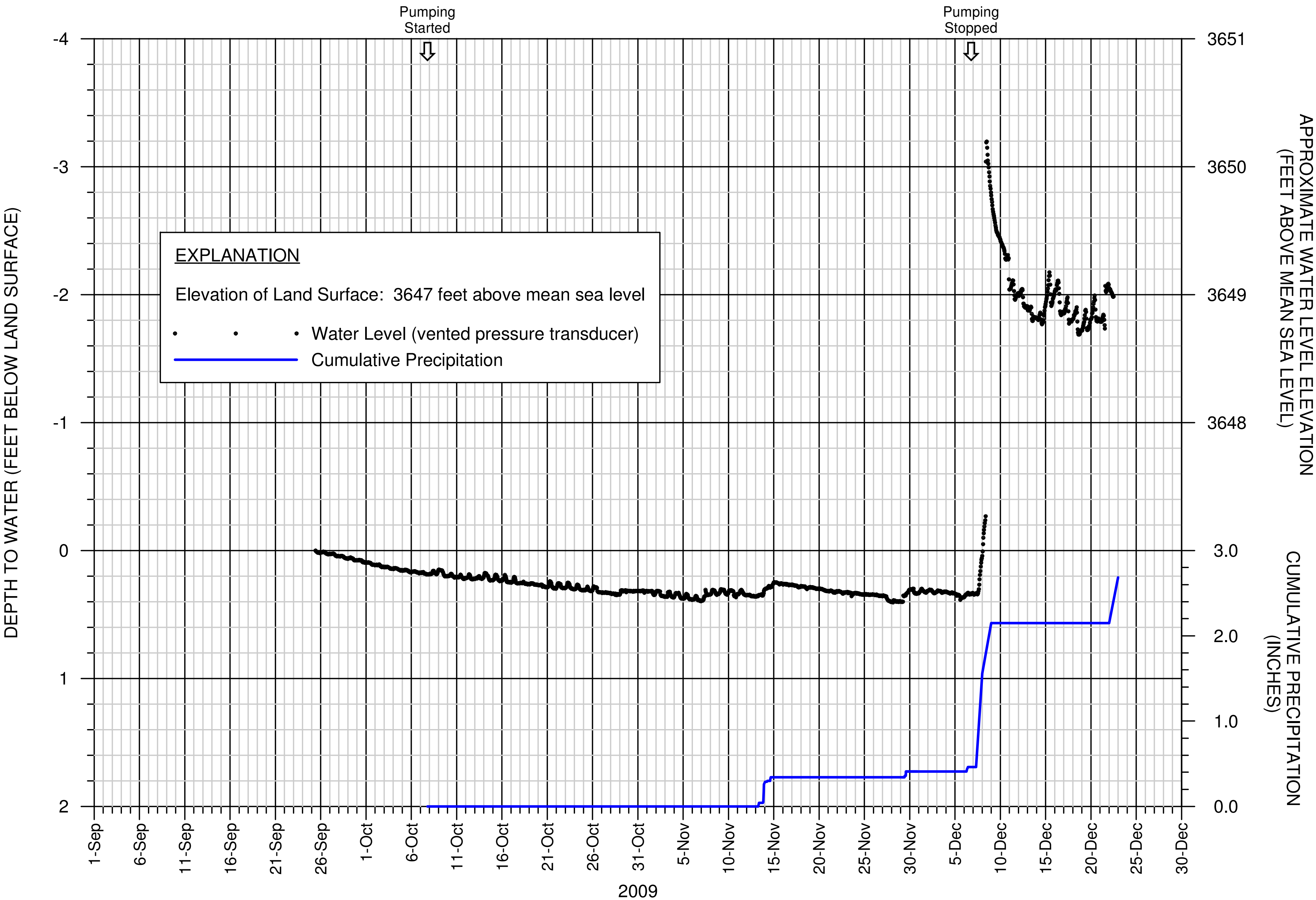

FIGURE A-12. HYDROGRAPH OF WATER LEVEL AT SURFACE WATER STATION DCSW3 DURING LONG-TERM PUMPING TEST AT WELL HRES-07, RESOLUTION PROJECT, PINAL COUNTY, ARIZONA

605.4_Aquifer_Testing\HRES_07_LongTerm\Hydrographs\hyd_DCSW3_ppt_2009.grf

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