TECHNICAL MEMORANDUM

Pueblo Water Resources, Inc.
4478 Market St., Suite 705 Tel: 805.644.0470
Ventura, CA 93003 Fax: 805.644.0480

To:	MPWMD	Date:	June 30, 2008
Attention:	Joe Oliver, P.G., C.Hg, Water Resources Manager	Project No:	06-0012
Copy to:	Henrietta Stern Matthew Sundt		
From:	Robert Marks, P.G., C.Hg		
Subject:	Review of Well Source and Pumping Impact Assessment for Anderson Wells #1, #2, and #3, APN 259-021-004		

Presented in this Technical Memorandum is a summary of our findings and conclusions based on our review of the above-referenced assessment report. The assessment report, dated January 25, 2008, was prepared for Anderson Properties by Bierman Hydrogeologic, P.C. (Bierman) in support of a Water Distribution System (WDS) permit application for the above-referenced property. Three existing wells, identified as Anderson Wells #1, #2, and #3, are proposed to be utilized to supply potable and irrigation water to a 60,000 square feet (ft^2) office building and outside landscaping on the subject parcel. Our review focused on evaluating the assessment for compliance with the MPWMD Procedures for Preparation of Well Source and Pumping Impact Assessments (MPWMD Procedures), dated September 2005 (revised May 2006).

Hydrogeologic Setting

The proposed WDS and subject wells are located in the Highway 68 corridor area, outside the boundaries of the Seaside Groundwater Basin and Laguna Seca Subarea. The wells are significantly more than 1,000 feet from the mapped boundary of the Carmel River Alluvial Aquifer (CVAA), and are completed with perforations in fractured Monterey Formation shale (Tm) bedrock. As such, Setting #2 of the MPWMD Procedures is considered applicable to these wells and WDS.

Water Demand Estimate

The subject wells would potentially provide both potable and non-potable irrigation supply to the proposed WDS. Presented below is a summary of the estimated demand calculations for the subject WDS:

- Average Annual[1]: 4.74 acre-feet per year (afy).
- Average Day: 4,231.6 gallons per day (gpd)
  2.94 gallons per minute (gpm)
- Dry Season: 5,077.9 gpd
  3.53 gpm
- Maximum Day: 6,347.4 gpd
  4.41 gpm
- Maximum Day 12-hour: **8.82 gpm**

Well Construction Summary

Presented below is a summary of the as-built constructions of the Anderson Wells:

Construction Feature	Well #1	Well #2	Well #3
Date Drilled	10/22/00	11/25/03	10/19/07
Total Cased Depth (ft bgs[1])	600	900	1,020
Borehole Diameter (inches)	10	8.75	10
Casing Inside Diameter (inches)	5	5	5
Perforated Intervals (ft bgs)	Various 160 to 580	Various 500 to 880	Various 170 to 990
Static Water Level[2] (ft bgs)	NA[3]	120	122
DWR Well Completion Report No.	723409	0900415	e018492
Date Signed	1/25/00	12/28/07	10/30/07
MCEHD Permit No.	99-282	03-02652	07-11134
Date Issued	11/30/99	9/19/03	8/9/07

Notes:
1 – feet below ground surface
2 – following well construction
3 – Not Available

[1] It is our understanding that this demand estimate was based on MPWMD Water Use Factors and has been reviewed and/or was recommended by MPWMD staff and was not, therefore, independently verified by Pueblo.

Well Testing Data Summary

Two separate 72-hour constant rate pumping and recovery tests were conducted by Bierman. The first test was conducted during the period June 4 through 11, 2007 with Well #1 and #2 pumping simultaneously (Well #3 had not yet been constructed). The second test was conducted during the period November 6 through 15, 2007 with Well #2 and #3 pumping simultaneously (Well #1 was utilized as monitoring well). Presented below is a summary of the well performance data developed from the testing program:

Pumping Test #1 Data Summary

Test Parameter	Well #1	Well #2
Static Water Level (feet bgs)	162.08	133.51
Total Volume Pumped (gallons)	14,107	45,027
Test Average Pumping Rate (gpm)	3.26	10.42
24-Hour Specific Capacity Calculations:		
Average Pumping Rate[1] (gpm)	3.44	11.74
Pumping Level (ft bgs)	463.77	647.62
Drawdown (ft)	301.69	514.11
Calculated Specific Capacity (gpm/ft)	0.011	0.023

Notes:
1 – During the initial 24-hrs

Pumping Test #2 Data Summary

Test Parameter	Well #2	Well #3
Static Water Level (feet bgs)	131.29	121.10
Total Volume Pumped (gallons)	42,397	44,455
Test Average Pumping Rate (gpm)	9.81	10.29
24-Hour Specific Capacity Calculations:		
Average Pumping Rate[1] (gpm)	10.13	10.28
Pumping Level (ft bgs)	496.41	178.79
Drawdown (ft)	365.12	57.69
Calculated Specific Capacity (gpm/ft)	0.028	0.178

Notes:
1 – During the initial 24-hrs

Well Yield Calculations

According to MPWMD Procedures, the yield of a well is calculated by multiplying the 24-hour specific capacity by the available drawdown. Available drawdown for Setting #2 is defined by MPWMD Procedures as:

> *One-third of the vertical distance from the static water level to the bottom of the well perforations.*

A summary of the initial well yield calculations for each of the Anderson Wells is presented below:

Well Yield Calculations Summary

Parameter	Well #1	Well #2	Well #3
Static Water Level (ft bgs)	162.08	131.29	121.10
Depth to Bottom of Perforations (ft)	580	880	990
Available Drawdown (ft)	139.31	249.57	289.63
24-Hour Specific Capacity (gpm/ft)	0.011	0.028	0.178
Calculated Well Yield (gpm)	1.53	6.98	51.55

Drawdown Curves and Transmissivity

The assessment report presents calculated transmissivity values for each of the well utilizing various analytic methods ranging between 4.7 to 176 gallons per day per foot (gpd/ft), depending on the well and portion of the drawdown curve selected for the calculations. Well #1 and #3 displayed the lowest and highest transmissivity values, respectively, which correspond to their relative well yields.

Each of the drawdown curves appear to display decreases in the apparent transmissivity between the first half and the end of the tests. We note that the early portions of the drawdown curves for Well #1 and #2 were influenced by casing storage effects, which were calculated[2] to expire after approximately 1,760, and 1,170 minutes of pumping, respectively. The shift in the slope of the drawdown curve for Well #3 is likely due to a combination of well interference from Well #2 and/or the effects of a negative boundary condition.

As required by MPWMD Procedures, adjustments to the 24-hour specific capacities were performed utilizing the ratio of the calculated late-time to early-time transmissivity estimates. These adjustments provide additional conservatism to the well yield calculations to account for the effects of casing storage, well

[2] Calculations based on an equation presented by Schafer (1978)

interference, and negative boundary conditions. A summary of the adjusted 24-hr specific capacities and corresponding adjusted well yields is presented below:

Adjusted Well Yield Calculations Summary

Parameter	Well #1	Well #2	Well #3
24-Hour Specific Capacity (gpm/ft)	0.011	0.028	0.178
Ratio of Late to Early Time Transmissivity	0.769	0.170	0.175
Adjusted 24-Hour Specific Capacity (gpm/ft)	0.008	0.005	0.031
Adjusted Calculated Well Yield[1] (gpm)	1.11	1.25	8.98

Notes:
1 – There were slight differences between our and Bierman's calculations in the last significant digits, which is likely due to differences in rounding methods.

Recovery Data

Water-level recovery data were collected from each of the wells following termination of pumping, and the water levels of all three wells recovered to more than 95 percent of the pre-test static water-levels before two times the pumping period had elapsed; therefore, further adjustments to the calculated well yields are not required by MPWMD Procedures

Confirmation of Well Capacity

As presented above, the combined final adjusted calculated well yields for the Anderson Wells totals approximately **11.34 gpm** (1.11 + 1.25 + 8.98 gpm), which is slightly greater than the Maximum Day 12-hour Demand value of 8.82 gpm. Indeed, Well #3 alone is marginally capable of meeting the proposed demand for this WDS. Therefore, based on MPWMD Procedures the combined well capacities are considered sufficient for the proposed demand.

It should be noted, however, that the well-yield calculation for each well is a theoretical maximum sustained pumping rate. The actual maximum rate achievable by any given well is limited by other factors, including: (a) the size of the selected pump and motor, (b) the pump (and intake) setting, (c) well casing diameter, and (d) discharge piping diameter.

Furthermore, the long-term sustainable capacity of wells completed in fractured-bedrock settings is dependant on a variety of factors that cannot be fully evaluated through analysis of relatively short-duration (i.e., 72 hours or less) pumping tests. The movement and long-term availability of groundwater in these materials is controlled by the occurrence, connectedness, and distribution of fractures. The distribution and connectedness of fractures to sources of recharge are essentially random, and the volume of groundwater in storage in these systems is often limited. The low volume of groundwater in storage can limit long-term

supply, particularly during periods of deficient recharge. The implications of these factors should, therefore, be taken into consideration when planning long-term use of wells that are completed in fractured-bedrock settings.

In addition, it is our understanding that an approximate 300,000 gallon capacity rooftop rainwater collection system had been proposed for the subject project[3]. Given the marginal capacity of the existing wells for the proposed WDS demands, such a system would provide an advisable augmentation to the project's supply reliability.

Water Quality

Water-quality samples were collected from each of the wells at the end of pumping, and were analyzed at a State Certified Laboratory for Title 22 general mineral, general physical and inorganic chemical parameters, as well as Coliform bacteria. The results indicate that the water met the Maximum Contaminant Level (MCL) drinking-water standards for primary inorganic constituents; however, the water exceeded several secondary MCLs. Water-quality results that exceeded the MCLs are summarized below:

Constituents	Unit	Well #1	Well #2	Well #3	MCL
Secondary Standards					
Iron	mg/l			0.337	0.3
Manganese	mg/l		0.080		0.05
					(recommended / upper)
Chloride	mg/l			306	250 / 500
Specific Conductance	umhos/cm	1,530	2,260	2,050	900 / 1,600
Total Dissolved Solids	mg/l	900	1,400	1,160	500 / 1,000

Due to the water-quality results, treatment may be required for consumptive use. Based on the water-quality results, Bierman performed additional demand calculations based on an assumed treatment system with 22 percent losses (7 percent system, 15 percent treatment), yielding a Maximum Day 12-hour demand of approximately 10.83 gpm, corresponding to an Average Annual demand of 5.82 afy. In addition, all three of the wells tested positive for Total Coliform bacteria, indicating the need for disinfection of the well and/or piping system prior to being placed into service. The Monterey County Health Department, Environmental Health Division should be consulted regarding additional sampling and/or treatment requirements for these sources and WDS.

[3] E-mail correspondence from Joe Oliver on June 30, 2008.

Analysis of Offsite Impacts

MPWMD Procedures require an evaluation of the potential well-pumping drawdown effects at existing wells or other Sensitive Environmental Receptors (SERs) within 1,000 feet of the subject well. Projected drawdown impacts were calculated by Bierman utilizing the Modified Theis Nonequilibrium Equation. The average of the recovery test-derived transmissivity values of 37.1 gpd/ft and a storage coefficient value of 0.12[4] (dimensionless) were used in the calculations. The calculations assumed continuous pumping for 183 days at the 12-hour dry-season demand rate of 6.98 gpm; however, we note that this rate is twice that required by MPWMD Procedures for this analysis (i.e. MPWMD Procedures require only the dry season demand at an equivalent rate over 183 days, in this case 3.53 gpm).

Potential Impacts on Existing Wells

Two existing wells are located within 1,000 feet of the subject well, at distances ranging between approximately 138 and 550 feet. One of these wells (Calvary Church, located at a distance of 550 feet) was monitored during the first test; however, this well was being pumped on a daily irrigation cycle during the test; therefore, response to the pumping of the Anderson Wells was difficult to discern. Anderson Well #1 was monitored during the second pumping test, and a small amount (0.69 feet) of drawdown was observed at the end of the test; however, as noted above, an offsite well was also being pumped during the testing, which may have contributed to the observed drawdown.

The analytical approach to projected drawdown impacts by Bierman similarly indicated negligible drawdown impacts at all of the offsite wells. However, our calculations utilizing a slightly different analytical approach (Theis Equation) indicated approximately 4.7 feet of drawdown impact at the nearest offsite well (Hi-Way Self Storage). Assuming this well is of similar construction as Well #1 (the closest Anderson Well), this amount of drawdown represents approximately 1 percent of the overall saturated thickness, which should not significantly affect the pumping capacity of this well. No measurable drawdown impact is projected for the farther well (Calvary Church).

It is important to note that the projected drawdown results rely on transmissivity values that were derived from pumping of wells from a fractured bedrock aquifer. As such, the transmissivity values reflect the fractures intersected by each of the pumping wells themselves, and are not necessarily representative of

[4] Derived from Warren Root, Fracture Flow/Double Porosity Method analysis of the drawdown curve.

the aquifer system as a whole. Therefore, the drawdown projections are somewhat speculative and can be misleading.

Potential Impacts on SERs

The subject wells are located more than 1,000 feet from the mapped boundary of the CVAA, and no other SERs as defined by MPWMD are within 1,000 feet of the subject well.

CONCLUSIONS

Based on our review of the subject assessment report, we offer the following conclusions:

Well Capacity

Based on MPWMD Procedures, the Maximum Day 12-hour Demand for the subject WDS was calculated to be approximately 8.82 gpm. Taking into consideration the possibility of well treatment with 22 percent losses, a corresponding Maximum Day 12-hour Demand of 10.83 gpm has been estimated. Both demand values are slightly less than the combined adjusted calculated well yields of 11.34 gpm; therefore, based on MPWMD Procedures the well capacity is considered **sufficient** for the **4.74 to 5.82 afy** annual demand for this WDS.

Analysis of Offsite Impacts

Analysis of projected drawdown as a result of pumping the subject wells to meet the demands of the subject WDS indicates that the impacts would not be significant at the two offsite wells located within 1,000 feet. There are no other SERs located within 1,000 feet of the WDS.