JLA Geosciences, Inc.

HYDROGEOLOGIC CONSULTANTS

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TECHNICAL MEMORANDUM

To: **Shannon LaRocque, P.E., Utility Director – Village of Wellington**

Cc: **Bill Reese, P.E., Kimley-Horn and Associates, Inc.**

From: **Jim Andersen, P.G., JLA Geosciences, Inc.**
Shelley Day, P.G., JLA Geosciences, Inc.

Re: **Village of Wellington Raw Water Supply and Wellfield Evaluation –Existing Wellfield System Capacity Results and Recommendations**

Date: **August 11, 2017** ***(By Electronic Mail)***

INTRODUCTION

JLA Geosciences, Inc. (JLA) was contracted by Kimley-Horn and Associates to provide hydrogeologic consulting services to the Village of Wellington (Village). The proposed scope of work included both data review and field testing components. Specifically, JLA was tasked with reviewing historical wellfield data, documents, and technical analyses related to the Village's past, present, and future water supply. JLA also reviewed the Village's existing well rehabilitation contract and the rehabilitation results obtained to date. The last task performed was field testing of the Village's 18 surficial aquifer wells to evaluate produced water quality and well performance.

JLA performed surficial aquifer wellfield testing between March 7 and March 10, 2017. Seventeen wells were tested for performance, sand, silt density index (SDI) and water quality. Well 18 was out of service for the duration of the testing period, and therefore was not evaluated. A well location map is provided as **Figure 1**.

METHODOLOGY

Wellfield testing was performed to evaluate changes in well performance and water quality since the time of construction, make observations on the physical condition of the well sites/facilities, and provide recommendations for future well improvements. Historical data were reviewed and summarized to provide a baseline for well performance and individual well water quality.

Field testing included the measurement of field water quality parameters and well performance data under normal steady-state operating conditions, and involved the following observations and measurements:

- Physical Measurements and Observations
  - Pumping Rate
  - Pumping Water Level

- Wellhead Pressure
- Observations of Wellhead and Equipment
- Static Water Level

- Field Water Quality Measurements
  - SDI
  - Sand Content Testing
  - Temperature
  - Specific Conductance
  - Chloride
  - Dissolved Oxygen
  - pH
  - Total Dissolved Solids
  - Turbidity
  - Soluble Iron
  - Total Iron
  - Hydrogen Sulfide

The suspended solids production in each well was evaluated with the use of a SDI setup and Rossum Sand Tester. SDI testing was performed per ASTM Standard Method D4189-07 after steady-state pumping was achieved. For membrane treatment, the recommended SDI value of raw water produced from a well is less than 3.0, with an ideal value less than 1.0.

The presence of sand in produced water from each well was measured using the Rossum sand test. The Rossum assembly was attached to the wellhead piping for sampling of the produced water from the well. The American Water Works Association (AWWA) standard for sand content in wells is a maximum of 5 parts per million (ppm), however recommended sand values for membrane treatment are less than 1 ppm, and ideally less than 0.1 ppm if possible.

A calibrated multi-parameter field testing unit was used to measure dissolved oxygen (DO), temperature, specific conductance and pH. DO concentrations were measured to recognize the stability of water quality parameters as well as the presence of air intrusion into the raw water system. Turbidity was measured using a calibrated field portable turbidimeter. Hydrogen sulfide and soluble and total iron were tested visually using colorimetric test kits in accordance with standard methods.

Static water levels and pumping water levels were measured using an electronic water level indicator tape.

Manual readings of wellhead pressure, pumping rate, and water levels were recorded, including SCADA system readings at the individual wells, where available. The static and pumping water level data were used, along with the pumping rate, to calculate specific capacity values for each well. The specific capacity is the ratio of the pumping rate to the drawdown at a given time and is used to calculate the productivity of the well. The higher the specific capacity, the more efficient the well, all other factors being equal.

DATA REVIEW

JLA reviewed available construction and testing reports, driller well completion reports, and water treatment plant operational data. Very little water quality data from the time of construction were available from well construction and testing reports. Well construction data (casing and screen material, completion depths and details) were available for all but two of the Village's production wells. Chloride data were summarized from water treatment plant operational data. Available data regarding well construction and water quality are summarized in **Attachment 1**.

JLA evaluated the existing wellfield rehabilitation contract with All Webbs Enterprises, Inc. (AWE) and found the pricing to be very competitive when compared to other known maintenance and rehabilitation contracts. Existing pre- and post-rehabilitation video surveys were observed and step-draw down test data are summarized in Attachment 1.

Based on the recommendations provided by AWE following the video survey, Well 20 was acidized with sulfamic acid, jetted, and air developed. The specific capacity reported by AWE post-rehabilitation increased 37%, however, half of the gain appears short-lived as capacity has decreased by 18% (based on testing conducted during the wellfield evaluation). The procedure for Well 21 was similar to Well 20, however, no pre-test data were reported.

Wells 22 and 23 were brushed, swabbed, and jetted. In addition, Well 23 was chlorinated. This approach appears to have been successful on Well 22, however, a more aggressive rehabilitation program is likely required to restore capacity in wells that have seen a dramatic decrease in yield (such as in Well 23, which when constructed had a specific capacity of 115 gpm/ft, but following rehabilitation had a specific capacity of 38 gpm/ft). A liquid acid descaler, such as that by the Cotey Chemical Corporation, along with jetting and swabbing, may be more successful. If the descaler is not successful then a stronger mineral acid (HCl) should be used.

WATER QUALITY AND PERFORMANCE TESTING RESULTS

Overall the Village's wells appear to be in good physical condition. Little rusting was present on wellheads. Most pressure gauges and valves were in good working order. Only a couple very minor leaks were noted on either air relief valves or piping to sample ports.

A detailed documentation of the results of testing is provided in tabular format in **Attachment 2** (*Surficial Aquifer Wellfield Performance Testing Results, March 2017).* A summary and discussion of the results of testing is provided below.

Water Quality

Overall, the wells produced trace amount of sand (<1.0 ppm) during a standard 60-minute Rossum sand test. Over half of the wells had SDI values less than 2.0. The remaining wells had SDI values between 2.0 and 2.4. Very little iron is present in the Village's raw water supply. Hydrogen sulfide is present in higher concentrations (up to 3 ppm) in some of the wells supplying the nanofiltration plant (north wellfield). Little dissolved oxygen was present in the water samples collected.

Based on a review of available historic water quality data, the chloride concentration does not appear to be increasing. Chloride data are relatively stable over the period of record (since 2001). Chloride concentrations in the north wellfield are higher than in the south wellfield. The chloride concentrations in the north wellfield varied from 153 to 260 mg/L during sampling associated with the wellfield testing. The chloride concentration of water samples taken from the south wellfield ranged from 58 to 81 mg/L. The eastern wellfield is freshest with chloride concentrations less than 40 mg/L.

Pumping Rates

The pumping rates for individual wells observed during wellfield testing ranged between 396 gpm to 934 gpm. Ten of the 17 wells tested had a greater than 10% difference in the observed pumping rate relative to the reported rated pump capacity.

Rated Pump Capacity Relative to Observed Pumping Rates during March 2017 Wellfield Testing

Well I.D.	Reported Pump Capacity per O&M Manual	Design Rate (gpm)	Observed Pumping Rate (gpm)	Observed Pumping Rate vs. Pump Capacity (% Difference)
Well R-1	415	417	396	-5%
Well R-2	400	417	430	8%
Well R-3	785	833	515	-34%
Well R-4	785	833	815	4%
Well R-6	940	833	843	-10%
Well R-7	940	833	835	-11%
Well R-8	940	833	934	-1%
Well R-9	940	833	843	-10%
Well R-10	940	833	864	-8%
Well-19	750[1]	750	659	-12%
Well-20	750[1]	750	717	-4%
Well-21	750[1]	750	636	-15%
Well-22	750	750	834	11%
Well-23	750	750	686	-9%
Well-24	750	750	676	-10%
Well-29	1500[1]	1500	810	-46%*
Well-30	1500[1]	1500	800	-47%*

[1]No data available from pump O&M manual; listed rate is design rate per Engineer.
*Difference in observed vs. design rate due to valving back well to match skid feed requirements

The "R" wells, which feed the nanofiltration plant, are pumped at rates that match the membrane skid feed requirements. RO Trains 1 through 5 currently require 833 gpm of raw water each, whereas Train 6 requires double that or 1,667 gpm; therefore, most of the "R" wells, when tested, had observed pumping rates in this range. Wells R-1, R-2, and R-3 were observed to be pumping at much lower rates. Wells R-1 and R-2 have smaller pumps by design, however, Well R-3 was being pumped at a much lower rate than the reported pump capacity (observed rate was 515 gpm versus a reported pump design capacity of 785 gpm).

Manual vs SCADA measurements

Manual water level measurements were compared to the SCADA measurements when possible. For 15 out of 17 wells, manual water level measurements and SCADA readings were in good agreement. Wells 21 and 29 were the only two wells where manual water level and SCADA measurement varied by more than 10%. The manual drawdown measured in Well 29 was twice that reported in the SCADA system (2.6 feet versus 1.20 feet, respectively). In addition, the SCADA readings (rate and water level) for well R-3 fluctuated constantly during testing of that well. Well 23 was the only well tested that is not yet connected to the SCADA system.

Specific Capacity

The average specific capacity calculated for the north (RO) wellfield was 24 gpm/ft, whereas the average specific capacity of the south (lime softening) wellfield was 51 gpm/ft. The east wellfield (Wells 29 and 30) have by far the highest specific capacity values of any of the Village's wells (675 gpm/ft and 381 gpm/ft, respectively). The following wells had a specific capacity of less than 20 gpm/ft.

- RO-1 (12.8 gpm/ft)
- RO-3 (13.1 gpm/ft)
- RO-4 (19.9 gpm/ft)
- LIME-24 (18.4 gpm/ft)

Historic specific capacity data (available from well completion reports and driller's testing reports) were compared to specific capacity data calculated during the wellfield testing to determine the degree of fouling (plugging) of the well. Specific capacity changes in a non-linear fashion as the pumping rate increases. It is not unusual for the specific capacity values obtained for a well to decrease as the pumping rate is increased. Therefore, in order to make meaningful comparisons with historic data, when available, historic data were plotted and a trendline was assigned so that a specific capacity value could be obtained at a value close to the current (March 2017) pumping rate.

Specific Capacity Following Well Construction vs. that Calculated during March 2017 Wellfield Testing

Well	Well Age (Year Constructed)	Original Construction		March 2017 Testing		Percent Change in Specific Capacity	Priority for Rehab – During Next 2 Years
		Pumping Rate (gpm)	Specific Capacity (gpm/ft) [1]	Pumping Rate (gpm)	Calculated Specific Capacity (gpm/ft)		
R-1	29 (1988)	NA	NA	396	12.8	NA	
R-2	28 (1989)	507	28.7	430	28.8	0	
R-3	28 (1989)	520[2]	36.1	515	13.1	-64 %	*
R-4	28 (1989)	830	54.0	815	19.9	-63 %	*
R-6	28 (1989)	885	92.8[4]	843	47.3	-49 %	
R-7	21 (1996)	958*	65.0	835	28.5	-56 %	
R-8	21 (1996)	930*	40.0	934	23.1	-42 %	
R-9	21 (1996)	840[2]	46.4	843	21.3	-54 %	*
R-10	21 (1996)	880[2]	40.1	864	20.7	-48 %	*
Well-18	37 (1980)	--	--	--	--	NA	*
Well-19	37 (1980)	NA	NA	659	43.2	NA	*
Well-20	36 (1981)	1000[3]	82.6	717	66.8	-19 %	
Well-21	18 (1999)	NA	NA	636	39.6	NA	
Well-22	28 (1989)	840[2]	148.0	834	105.8	-28 %	
Well-23	28 (1989)	611	114.6	686	32.0	-72 %	*
Well-24	28 (1989)	618	32.2	676	18.4	-43 %	*
Well-29	13 (2004)	800[2]	425.0	810	311.5	-27 %	
Well-30	13 (2004)	800[2]	500.0	800	425.3	-15 %	

*Flowmeter used during testing later determined inaccurate; Specific capacity estimated using development data

[1]Specific capacity value measured during step-drawdown testing following well construction

[2]Specific capacity at listed rate estimated based on trend of step-drawdown data

[3]Data from drillers' completion report; AWE post-rehabilitation data: at 1061 gpm, specific capacity was 59 gpm/ft, this is a -29% reduction in capacity from original values

[4]The original specific value is optimistic, the initial specific capacity value was estimated by Bill Reese to be in the 60s (Bill Reese, Kimley-Horn, personal communication).

Additional Observations

- Well R-1 and Well 30 have a wellhead pressure gauge that is either broken or has mildew inside the gauge. In addition, wells 19, 20, and 24 do not have a wellhead pressure gauge. The discharge pressure gauge at Well 19 fluctuated by 6 psi throughout well testing. Wells 22, 23, and 24 do not have a discharge pressure gauge.
- Well R-2 had a minor leak at the air relief valve connection.
- Well 29 had a very slow leak on the pipe leading to the sampling tap.

WELL REHABILITATION vs. WELL REPLACEMENT COST ANALYSIS

Based upon the current well maintenance and rehabilitation contract, the cost for a well rehabilitation including chemical treatment with liquid descaler and a sufficient amount of developmental time (budgeted at 60 hours of air development and 60 hours of contractor's pump development), is approximately $45,000 per well (not including the cost for independent oversight of the contractor).

Whether to re-construct a well in place or abandon and drill a new well will depend upon the well site constraints and the condition of the well. Reconstructing a well in-place is more challenging and thus more costly. A rough cost for new a 16-inch diameter screened well (with completion details similar to the Village's existing wells, i.e. 50 feet of screen) is approximately $220,000 (not including the wellhead).

RECOMMENDATIONS

Based on an analysis of the results of the wellfield evaluation and a review of historical data, the following recommendations are made

- Priority for well rehabilitation should be given to
    1) Those wells that are not functioning,
    2) Wells that have lost specific capacity and have pumping water levels near the pump intake, and
    3) wells that have lost the highest percentage of specific capacity but are still functioning properly at the design flow rate.
- Based on the above criteria and consultation with Water Treatment Plant staff, the wells with the highest priority for rehabilitation are Well 18 (which is currently out of service), Well R-3, Well R-10, and Well 24. Well R-3 and Well 24 both have specific capacities less than 20 gpm/ft, have a 30-40% difference in their current pumping rate relative to the reported pump capacity, and have some of the lowest pumping water levels relative to the Village's other production wells.
- Wells with significant loss in well capacity, regardless of age, are recommended for rehabilitation.
- Wells with a significant loss in capacity that do not respond to rehabilitation should be considered the highest priority for replacement.
- A more aggressive rehabilitation approach, using either Cotey Chemical Corporation liquid descaler or a dilute HCl solution should be tested.
- Water Treatment Plant staff currently produce a drawdown report, including monthly readings of static water level, pumping water level, drawdown and cavitation depth. It would be useful to include the pumping rate in the tabular data collected.

- In addition to data collection by the Water Treatment Plant staff, annual or semi-annual wellfield testing should be conducted to provide a more comprehensive analysis of well performance and water quality, and track individual well trends.
- Additional well and pump data, as it becomes available, should be added to Attachment 1.
- All records should be kept in a Wellfield Database (Including completion reports and well videos), that is accessible by GIS, if possible.
- Pressure gauges which are not functioning properly should be replaced, including:
    - Wellhead pressure gauges: Well R-1, Well 19, Well 20, Well 24, and Well 30.
    - Discharge pressure gauges: Well 19, Well 22, and Well 23, and Well 24.
- Desiccant should be added to SCADA instrumentation. Large canisters of desiccant should be replaced monthly or as needed to keep the desiccant blue (dehydrated).

Attachment 1. Well Construction and Historical Water Quality Data

WELL CONSTRUCTION AND WATER QUALITY DATA

		Well ID		R-1	R-2	R-3	R-4	R-6	R-7[a]	R-8[a]	R-9	R-10	18	19	20	21	22	23	24	25[b]	26[b]	27[b]	29	30
		Wellfield		NORTH	NORTH	NORTH	NORTH	NORTH	NORTH	NORTH	NORTH	NORTH	SOUTH	SOUTH	SOUTH	SOUTH	SOUTH	SOUTH	SOUTH	SOUTH	SOUTH	SOUTH	EAST	EAST
HISTORICAL SPECIFIC CAPACITY	AWE Specific Capacity Test Data from Rehab Work — Pre-Rehab	Static Water Level	(ft)												6.17		7.0	6.17						
		Pumping Water Level	(ft)												24		22.0	42.2						
		Drawdown	(ft)												17.8		15.0	36.0						
		Pumping Rate	(gpm)												1061		1185	752						
		Specific Capacity	(gpm/ft)												**59.5**		**79.0**	**20.9**						
	AWE Specific Capacity Test Data from Rehab Work — Post-Rehab	Static Water Level	(ft)												6.33	6.00	5.25	7.00						
		Pumping Water Level	(ft)												19.42	49.7	17.42	29.25						
		Drawdown	(ft)												13.08	43.7	12.17	22.25						
		Pumping Rate	(gpm)												1064	1200	1154	830						
		Specific Capacity	(gpm/ft)												**81.3**	**27.5**	**94.8**	**37.3**						
	Estimated Specific Capacity using WTP Drawdown Report and Reported Normal Well Yield	Static Water Level	(ft)	7.61	6.79	8.19	10.32	8.10	9.90	7.80	8.80	8.80		7.80	7.75	7.40	7.40	7.75	8.44				9.80	9.80
		Pumping Water Level	(ft)	36.10	21.80	48.10	42.00	23.70	33.20	45.70	38.50	49.10		27.60	19.45	50.90	16.30	40.22	56.20				12.80	11.90
		Drawdown	(ft)	28.49	15.01	39.91	31.68	15.60	23.30	37.90	29.70	40.30		19.80	11.70	43.50	8.90	32.47	47.76				3.00	2.10
		Pumping Rate	(gpm)	199	373	764	658	814	857	654	832	832		536	888	813	745	656	917					
		Specific Capacity	(gpm/ft)	7	25	19	21	52	37	17	28	21		27	76	19	84	20	19				0	0
	Specific Capacity at Time of Well Construction from Step Drawdown Tests	Static Water Level	(ft bls)		7.8	9.1	8.7	4.4	7.2	5.4	7.6	6.8			6.1		5.3	6.6	3.0	7.5	6.6	5.9	8.5	6.6
		Pumping Rate	(gpm)		507.0	420.0	378.0	356.0	243.0	243.0	390.0	400.0			1000.0		500.0	420.0	618.0	296.0	285.0	353.0	567.0	990.0
		Specific Capacity	(gpm/ft)		**28.7**	**35.3**	**58.4**	**103.2**	**72.1**	**49.6**	**50.2**	**41.1**			**82.6**		**173.0**	**415.0**	**32.2**	**32.3**	**21.8**	**23.0**	**460.9**	**480.6**
		Pumping Rate	(gpm)		584.0	615.0	469.0	492.0	480.0	469.0	594.0	580.0					700.0	611.0	800.0	499.0	455.0	548.0	1267.0	1206.0
		Specific Capacity	(gpm/ft)		**26.2**	**37.3**	**57.4**	**97.0**	**59.8**	**42.6**	**48.1**	**41.1**					**162.0**	**114.6**	**28.0**	**27.5**	**22.2**	**20.7**	**354.9**	**456.8**
		Pumping Rate	(gpm)		714.0	900.0	598.0	646.0	693.0	691.0	742.0	710.0					900.0	808.0	937.0	725.0	697.0	657.0	1400.0	1388.0
		Specific Capacity	(gpm/ft)		**26.9**	**35.1**	**55.8**	**94.6**	**69.7**	**49.4**	**46.7**	**40.4**					**157.1**	**102.3**	**25.7**	**24.8**	**21.8**	**19.7**	**322.6**	**465.6**
		Pumping Rate	(gpm)		946.0	1060.0	830.0	885.0	958.0	930.0	1000.0	985.0					--	1152.0	--	869.0	897.0	877.0	1533.0	1607.0
		Specific Capacity	(gpm/ft)		**25.8**	**33.9**	**54.0**	**92.8**	**78.9**	**53.9**	**45.6**	**39.7**					**--**	**94.8**	**--**	**22.0**	**21.2**	**18.7**	**323.4**	**420.7**
		Pumping Rate	(gpm)		--	--	--	--	--	--	--	--					--	--	--				--	--
		Specific Capacity	(gpm/ft)		**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**					**--**	**--**	**--**				**--**	**--**
		Specific Capacity (per Pump start up report)	(gpm/ft)														**113.8**	**98.7**	**43.0**					
		Pumping Rate	(gpm)														740	740	710					
WATER QUALITY	Historical Water Quality	Chloride (2001)[c]	(mg/L)	300	195	185	200	345	210	250	380.0	395	95	60	60	45.0	60	55	85.0				25	40
		Chloride (2016)	(mg/L)	185	112	163	184	198	170	189	209	244	58	72	41	72	71	80	83				32	36
		Change in Chloride		-115	-83	-22	-16	-147	-40	-61	-171	-151	-37	12	-19	27	11	25	-2				7	-4
		Specific Conductivity	(uS/cm)																					687
		Temperature	(°C)																					
		TDS	(mg/L)																					
		Salinity	(ppt)																					
		DO	(mg/L)																					
		pH	S.U.																					
		Turbidity	(NTU)																					
		Dissolved Iron	(mg/L)																					
		Total Iron	(mg/L)																					
		Sulfide	(mg/L)																					
		SDI	NA																					
		Sand production	(ppm)																					
WELL CONSTRUCTION INFORMATION	General Information	Vault or Above?		Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above	Above
		Existing or Proposed		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
		Year Drilled		1988	1989	1989	1989	1989	1996	1996	1996	1996	1980	1980	1981	1999	1989	1989	1989	2004	2004	2004	2004	2004
		Year of Last Major Rehab																						
		Well ID # (Table A)		23692	23689	23690	23691	23693	23921	23922	23923	23924	23682	23683	23684	23685	23686	23687	23688				118413	118414
		Original Design Hydrogeologist		Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Geraghty & Miller	Arcadis	Arcadis	Arcadis	Arcadis	Arcadis
		Original Design Engineer		PBS&J	Gee & Jensen	Gee & Jensen	RMA	RMA	RMA	RMA	RMA	RMA	Gee & Jensen	Gee & Jensen	Gee & Jensen	RMA	RMA	RMA	RMA	Arcadis	Arcadis	Arcadis	Arcadis	Arcadis
		Well Age		29	28	28	28	28	21	21	21	21	37	37	36	18	28	28	28	13	13	13	13	13
		Years since last major rehab		Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	13	13	13	Unknown	Unknown
	Pump/Motor	Pump Age																		N/A	N/A	N/A		
		Pump Type			Hayward Tyler	Hayward Tyler	Hayward Tyler	FlowServe	FlowServe	FlowServe	FlowServe	FlowServe				Goulds	Hayward Tyler	Hayward Tyler	Hayward Tyler	N/A	N/A	N/A		
		Submersible/Vertical Turbine			S	S	S	S	S	S	S	S					S	S	S	N/A	N/A	N/A		
		Motor Type			8" Sumo	8" Sumo	8" Sumo	8" Franklin	8" Franklin	8" Franklin	8" Franklin	8" Franklin				Franklin Elec.	8" Sumo	8" Sumo	8" Sumo	N/A	N/A	N/A		
		Pump Horsepower (HP)		50	30	60	60	75	75	75	75	75	50	75	75	75	60	60	60	N/A	N/A	N/A		
		Speed (rpm)			3500											3525				N/A	N/A	N/A		
		Pump Capacity (gpm)		415	415	830	830	940	940	940	940	940	1150	1150	1150	1150	1150	1150	1150	N/A	N/A	N/A	1500	1500
		Normal Pump Rate Yield (gpm)		199	373	764	658	814	857	654	832	832	0	536	888	813	745	656	917	N/A	N/A	N/A		
	Physical Characteristics	Surface Casing Diameter and Material (in)			NA	NA	NA	NA									NA	NA	NA				NA	NA
		Surface Casing Diameter Number (in)			NA	NA	NA	NA									NA	NA	NA				NA	NA
		Surface Casing Material			NA	NA	NA	NA									NA	NA	NA				NA	NA
		Outer Casing Diameter and Material (in)			20-in Steel	20-in Steel	20-in Steel	20-in Steel	20-in Steel	20-in Steel	20-in Steel	20-in Steel	18-in Steel	18-in Steel	18-in Steel		20-in Steel	20-in Steel	20-in Steel	20-in Steel	20-in Steel	20-in Steel	24-in Steel	24-in Steel
		Outer Casing Diameter Number (in)		24	20	20	20	20	21	22	23	24	18	18	18		20	20	20	20	20	20	24	24
		Outer Casing Material			Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel		Steel	Steel	Steel	Steel	Steel	Steel	Steel	Steel
		Outer Casing Depth (ft bls)			59.7	59	53	62	55	55	55	55			70	68	65	59	56.5	80	80	75	75	80
		Inner Casing Diameter and Material (in)			12-in FRP	12-in FRP	12-in FRP	12-in FRP	12-in Sch.40 PVC	12-in Sch.40 PVC	12-in Sch.40 PVC	12-in Sch.40 PVC					12-in FRP	12-in FRP	12-in FRP	12-in SDR17 PVC	12-in SDR17 PVC	12-in SDR17 PVC	16-in SDR17 PVC	16-in SDR17 PVC
		Inner Casing Diameter Number (in)		24	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	16	16
		Inner Casing Material			FRP	FRP	FRP	FRP	Sch.40 PVC	Sch.40 PVC	Sch.40 PVC	Sch.40 PVC					FRP	FRP	FRP	SDR17 PVC	SDR17 PVC	SDR17 PVC	SDR17 PVC	SDR17 PVC
		Inner Casing (Riser) Depth (ft)		70	72	75	75	70	55	55	55	55	70	72	70	70	75	75	75	80	80	75	75	80
		Total Depth (ft)		120	112	125	120	120	120	115	120	120	90	101	100	120	125	120	125	125	130	125	155	150
		Open Hole Interval From-To (ft)		N/A	N/A	N/A	N/A	N/A	NA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NA	NA	NA	NA	NA	NA	NA	NA
		Screened Interval From-To (ft)		70 - 120	75-115	75-125	75-120	70-120	55 - 120	55 - 115	55 - 120	55 - 120	70 - 90	72 - 101	70 - 100	70 - 120	75-125	75-120	75- 125	80-125	80-130	75-125	75 - 150	80 -145
		Screen Length		50	40	50	45	50	65	60	65	65	20	29	30	49	50	45	50	45	50	50	75	65
		Screen Casing Diameter and Type (in)			12-in FRP	12-in FRP	12-in FRP	12-in FRP	12-in SS	12-in SS	12-in SS	12-in SS			12-in SS		12-in FRP	12-in FRP	12-in FRP	12-in SS	12-in SS	12-in SS	16-in SS	16-in SS
		Screen Casing Diameter Number (in)			12	12	12	12	12	12	12	12			12	12	12	12	12	12	12	12	16	16
		Screen Slot Size (in)			0.07	0.07	0.07	0.07	0.05	0.05	0.05	0.04			0.1		0.07	0.07	0.07	0.045	0.06	0.09	0.06	0.09
		Pump Intake (feet bls)		60	60	60	70	70	70	70	65	65	N/A	70	70	75	70	55	75	N/A	N/A	N/A	80	80

[a]Flowmeter used during testing later determined inaccurate; Using data collected during development, previous consultant estimated specific capacity for R-7 at 65 gpm/ft and R-8 at 40 gpm/ft based on data collected during development

[b]Wells constructed but no pumps or piping connected; Wells were not included in renewal of permit in 2007 due to ommission, but are included as proposed in previous permit. During next renewal or modification request to list wells in permit

[c]Earliest chloride data availabe for Well 29 is July 2008, Earliest data for Well 30 is January 2004.

Attachment 2. Surficial Aquifer Wellfield Performance Testing Results, March 2017

				WELL DATA								MANUAL MEASUREMENT				SCADA MEASUREMENT					WATER QUALITY DATA														
Surficial Wells	Wellfield	Status	Rehabilitation is Recommended	Reported Rated Capacity (gpm)	Pumping Rate (gpm)	Reported Capacity vs. Pumping Rate (% Difference)	Well Site vs. WTP Control Room Pumping Rate (Difference ± GPM)	Well Head Pressure[1] (PSI)	Wellhead Pressure Difference (PSI)	Raw Water Main Pressure[1] (PSI)	Discharge Pressure Difference (PSI)	Static Water Level (ft BLS)	Pumping water Level (ft BLS)	Drawdown (ft)	Specific Capacity (gpm/ft)	Static Water Level[2] (ft)	Pumping water Level[2] (ft)	Drawdown (ft)	Specific Capacity (gpm/ft)	Manual vs. SCADA Specific Capacity (% Difference)	Temperature (°C)	Specific Conductance (µS/cm)	Total Dissolved Solids (mg/L) (SMCL[3]= 500 mg/L)	Salinity (ppt)	Chloride (mg/L) (SMCL[3] = 250 mg/L)	Dissolved Oxygen (mg/L)	pH (SMCL[3] = 6.5-8.5)	Total Iron (ppm) SMCL[3] = 0.3 mg/L	Soluble Iron (ppm)	Hydrogen Sulfide (ppm)	Turbidity (ntu)	Sand Content (ppm) Recommended <1 ppm	SDI (1) Recommended Value <3	SDI (2) Recommended Value <3	Field Comments:
R-1	RO	I/S		415	396	-5%	39	64	-4	63	-3	7.38	38.38	31.00	12.8	9.90	42.10	32.20	12.3	-3.7%	25.3	1,237	804	0.6	260.0	0.07	7.1	<0.1	<0.1	1.0	0.18	<0.1	2.3	2.1	SDI #1: no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable. No totalizer onsite; Flow meter digital output screen only. VOW wellhead pressure gage needle broken & gage cloudy . Broken needle reads approximately 60 psi.
R-2	RO	I/S		400	430	8%	--	69	-1	63	-1	6.42	21.37	14.95	28.8	7.90	22.90	15.00	28.7	-0.3%	25.9	1,028	668	0.6	190.0	0.03	7.0	<0.1	<0.1	0.8	0.20	<0.1	1.8	1.7	SDI #1: very light gray to yellowish gray, trace rust particles SDI #2: light gray tint, no sand Rossum: trace to unquantifiable No Totalizer/Flow meter onsite Minor leak on top T flange at ARV connectior
R-3	RO	I/S		785	515	-34%	--	78	-2	65	0	8.41	47.69	39.28	13.1	10.60	49.60	39.00	13.2	0.7%	25.7	1,130	737	0.6	152.5	0.04	7.0	<0.1	<0.1	1.5	0.33	<0.1	2.0	1.8	SDI #1: medium light orangey brown, trace rust particles SDI #2: light orange to yellow tint, no sand Rossum: trace to unquantifiable No Totalizer/Flow meter onsite, SCADA (±5 ft) and flow meter (± 20 gpm) output at WTP Control Room constantly fluctuating.
R-4	RO	I/S		785	815	4%	40	78	-10	--	0	5.88	46.90	41.02	19.9	10.40	53.00	42.60	19.1	-3.7%	25.4	1,300	845	0.7	207.5	0.03	7.0	<0.1	<0.1	1.5	0.30	<0.1	2.0	2.1	SDI #1: no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable.
R-6	RO	I/S		940	843	-10%	-3	72	-2	68	-4	6.69	24.50	17.81	47.3	8.80	25.50	16.70	50.5	6.6%	25.5	1,292	841	0.6	205.0	0.02	7.1	<0.1	<0.1	2.0	0.22	<0.1	1.6	1.6	SDI #1: very light gray to no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable.
R-7	RO	I/S		940	835	-11%	-1	70	-1	66	-2	6.64	35.91	29.27	28.5	9.80	38.60	28.80	29.0	1.6%	25.2	1,175	764	0.6	182.5	0.02	7.0	<0.1	<0.1	3.0	0.19	<0.1	1.9	1.8	SDI #1: very light gray, trace rust, no sand. SDI #2: very light gray to no color, no rust and no sand. Rossum: trace to no sand, unquantifiable.
R-8	RO	I/S		940	934	-1%	68	65	2	60	1	7.57	48.07	40.50	23.1	9.60	50.40	40.80	22.9	-0.7%	25.2	1,268	824	0.6	210.0	0.03	6.9	<0.1	<0.1	2.5	0.22	<0.1	1.4	1.6	SDI #1: no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable.
R-9	RO	I/S		940	843	-10%	-2	66	-1	59	3	6.55	46.13	39.58	21.3	9.30	47.60	38.30	22.0	3.3%	25.3	1,360	886	0.7	212.5	0.02	6.9	<0.1	<0.1	3.0	0.27	<0.1	1.8	1.7	SDI #1: no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable.
R-10	RO	I/S		940	864	-8%	4	65	3	63	-2	5.98	47.76	41.78	20.7	9.10	49.40	40.30	21.4	3.7%	25.9	1,435	930	0.7	242.5	0.03	6.9	<0.1	<0.1	2.0	0.16	<0.1	2.0	1.9	SDI #1: very light gray, trace rust, no sand. SDI #2: very light gray to no color, no rust and no sand. Rossum: trace to no sand, unquantifiable.
Well-18	LIME	O/S	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--	--	--	--	No pump istalled, unable to perform water quality and performance testing
Well-19	LIME	I/S		1150	659	-43%	-7	84	--	--	--	6.00	21.25	15.25	43.2	10.00	25.40	15.40	42.8	-1.0%	25.3	783	509	0.3	73.8	0.03	7.0	<0.1	<0.1	2.0	0.23	<0.1	2.2	2.2	SDI #1: no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable. No VOW wellhead pressure gage. VOW digital discharge pressure gage constatnly flutuating between 61-67 PSI; no additonal valve/connection for pressure gage on discharge.
Well-20	LIME	I/S		1150	717	-38%	17	75	--	--	--	6.51	17.23	10.72	66.8	8.60	19.20	10.60	67.6	1.1%	25.4	742	482	0.3	57.5	0.03	7.0	<0.1	<0.1	1.0	0.13	<0.1	2.3	2.1	SDI #1: dark gray to black, minor rust, no sand. SDI #2: medium light gray, no rust and no sand. Rossum: trace to no sand, unquantifiable. No VOW wellhead pressure gage. Valve on discharge end rusted- unable to exercise valve without breaking. Unable to obtain discharge pressure.
Well-21	LIME	I/S		1150	636	-45%	10	77 - 78	2 - 3	41	-3	6.43	22.50	16.07	39.6	10.00	24.40	14.40	44.2	11.6%	25.6	768	499	0.3	71.3	0.02	7.0	<0.1	<0.1	1.5	0.19	<0.1	1.9	1.9	SDI #1: very light gray to no color, trace rust, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable.
Well-22	LIME	I/S		1150	834	-27%	--	74	2	--	--	6.22	14.10	7.88	105.8	8.50	16.00	7.50	111.2	5.1%	25.4	749	487	0.3	70.0	0.03	7.1	<0.1	<0.1	1.0	0.28	<0.1	1.7	1.6	SDI #1: no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable. No totalizer and flow meter onsite; obtain rate from WTP Control Room No VOW discharge pressure gage, no valve/connection for pressure gage.
Well-23	LIME	I/S		1150	686	-40%	--	45	1	--	--	5.67	27.14	21.47	32.0						26.0	771	501	0.4	75.8	1.30	7.0	<0.1	<0.1	2.0	0.38	<0.1	2.4	2.2	SDI #1: very light gray to no color, trace rust, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable. No SCADA system installed. Onsite pressure gage display O/S, LEDs burned out. VOW wellhead pressure gage = 37 PSi, digital gage 45.9 PSI; no VOW dischage pressure gage and/or connection port with valve. Moderate rusting and pitting on wellhead flange, T and at ARV connection
Well-24	LIME	I/S		1150	676	-41%	-74	40	-40	--	--	5.27	41.96	36.69	18.4	6.60	43.00	36.40	18.6	0.8%	25.6	833	541	0.3	81.3	0.32	7.0	<0.1	<0.1	1.0	0.40	<0.1	2.2	2.3	SDI #1: medium light gray, moderate rust, no sand. SDI #2: light gray, trace rust and no sand. Rossum: trace to no sand, unquantifiable. No VOW wellhead and dischage pressure gage and/or connection port with valve No totalizer onsite, digital flow meter output screen onsite ranged 668-684 gpm.
Well-29	RO/LIME	I/S		1500	810	-46%	10	84	0	24	6	8.31	10.91	2.60	311.5	10.10	11.30	1.20	675.0	116.7%	25.5	696	452	0.3	34.0	0.03	7.0	<0.1	<0.1	2.0	0.32	<0.1	2.1	2.1	SDI #1: medium light gray, trace rust, no sand. SDI #2: very light gray to no color, no rust and no sand. Rossum: trace to no sand, unquantifiable.
Well-30	RO/LIME	I/S		1500	800	-47%	-6	92	0	24	2	8.35	10.23	1.88	425.3	8.60	10.70	2.10	380.7	-10%	25.6	664	431	0.3	36.3	0.03	7.0	<0.1	<0.1	2.0	0.13	<0.1	1.8	1.6	SDI #1: very light gray to no color, no sand. SDI #2: no color, no sand. Rossum: trace to no sand, unquantifiable. Discharge Pressure gage screen covered with mildew, good working condition.

[1]JLA pressure gage - VOW pressure gage = difference pressure, ± psi
[2]VOW SCADA Water level measurement system reference unknown
[3]SMCL = Secondary Maximum Contaminant Level (for Secondary Drinking Water Standard)