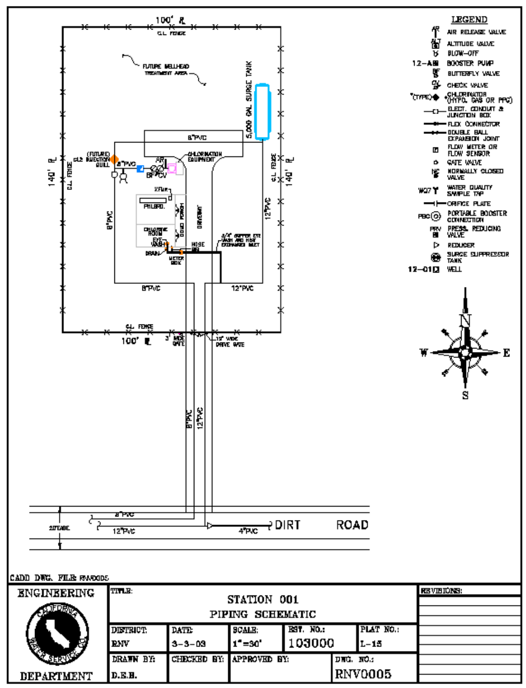
Rural North Vacaville Water District

REQUEST FOR TREATMENT VENDOR PROPOSALS

WELL NO. 2 ARSENIC REMOVAL SYSTEM



November 2, 2017

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

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1 INTRODUCTION

Rural North Vacaville Water District (RNVWD) has reached a decision to proceed with treatment of arsenic for water supply Well No. 2. Based on previous engineering evaluations, RNVWD is interested in packaged water treatment units that use either adsorption or coagulation/filtration. RNVWD has retained Luhdorff & Scalmanini Consulting Engineers (LSCE) to prepare this formal request for proposals (RFP) to obtain formal proposals from water treatment manufacturers (i.e. Vendors) for a packaged arsenic removal system for Well No. 2.

This RFP includes information for Vendors to prepare a proposal. A description of the RNVWD water system is provided in Section 2. Design basis information including Well No. 2 water quality data is discussed in Section 3. Required information to be included in the Vendor proposals is described in Section 4. The proposals received in response to this RFP will be evaluated by LSCE, RNVWD and the water system operator Solano Irrigation District (SID).

1.1 Treatment System Procurement

LSCE anticipates that the Well No. 2 arsenic treatment system will be selected, procured and installed in the following sequence of events:

1. Vendors will provide proposals for Well No. 2 arsenic treatment system in response to this RFP.
2. LSCE will evaluate Vendor proposals and make a recommendation to the RNVWD, based upon the criteria set forth in this RFP.
3. The Owner and LSCE will engage a Vendor to establish a purchase agreement based on a written Performance Guarantee and an agreed upon Purchase Cost of the system and the Vendor's services. If necessary, one or more Vendor(s) will be selected to conduct pilot testing to refine the treatment system design, purchase cost, and Performance Guarantee.
4. Once a Vendor purchase agreement is established, LSCE will prepare site designs to incorporate the selected treatment system and all necessary ancillary components, pre- or post-treatment, waste residual management, and electrical controls. LSCE will obtain all necessary regulatory approvals and permitting approvals and will coordinate with the selected Vendor for items regarding drinking water permitting and waste discharge or solids disposal requirements.
5. LSCE will solicit for bids from General Contractors for the site improvements and the installation and commissioning of the selected Vendor treatment system and site improvements.
6. The General Contractor who is awarded the work will coordinate purchase, procurement, shipping, installation, commissioning, and testing of the treatment system with the Vendor. The Vendor will oversee startup and commissioning of the installed system.
7. Vendor will train RNVWD staff and Solano Irrigation District (SID) staff on the operations of the treatment system.

1.2 Contact Information for Questions

Please direct all correspondence or inquiries to the Owner's representative:

Justin Shobe, Senior Engineer (Project Manager)
Luhdorff & Scalmanini Consulting Engineers
(530) 661-0109
(530) 661-6806 Fax
jshobe@lsce.com

1.3 Schedule for RFP Submissions

LSCE Issues RFP	November 2, 2017
Vendor Questions Due No Later Than	November 10, 2017
LSCE Responses to Questions By	November 17, 2017
Vendor Proposals Due	November 30, 2017
Selection of Vendor By	December 31, 2017

1.4 Submission Due Date and Location

LSCE will accept proposals received before 5:00 PM Friday, November 30, 2017. Proposals received after that time will not be considered.

Email electronic (PDF) proposals to jshobe@lsce.com and put the Subject heading "RNVWD Well No. 2 Arsenic Treatment System Proposal".

1.5 Evaluation Criteria

LSCE will evaluate Vendor proposals based on the key factors listed below. LSCE will consider cost and maintenance implications for ancillary components required to operate the system but are not included in the Vendor system, such as pre-treatment, post-treatment and waste residual solid management systems. If necessary during the review of Vendor proposals, LSCE may contact Vendors to obtain clarification of the proposed treatment system components, operation, cost, performance, etc.

Evaluation Criteria:

- Purchase cost of Vendor system and required ancillary components.
- O&M cost for the arsenic removal system and required ancillary components.
- Performance characteristics of the system in terms of Arsenic removal capability and effluent concentration.
- Providing a system that meets the design criteria specified in this RFP.
- Ability of Vendor to provide a Performance Guarantee.
- The need for and cost of pilot testing.
- Completeness of proposal that provides all the information requested in this RFP.

2 BACKGROUND INFORMATION

2.1 LSCE Evaluation of Well No. 2 Options

LSCE prepared a Technical Memorandum dated March 14, 2017 that evaluated options to lower arsenic levels in Well No. 2. The options consisted of:

1. Blending Well No. 2 water with Well 1 to achieve an arsenic level that meets the 10 ppb standard;
2. Construction of a new, low arsenic well to replace Well No. 2;
3. Modifications to the existing Well No. 2 structure to limit arsenic entry into the well casing; or,
4. Treatment to remove arsenic from Well No. 2 discharge.

LSCE recommended Option 4 to provide an alternate source of water that reliably meets the arsenic drinking water standard MCL. The complete Technical Memorandum by LSCE is in **Appendix B**. Key information from that report is discussed below.

2.2 Water System Description

The Rural North Vacaville Water District (RNVWD) is a community water system that serves a population of approximately 900, through 372 metered service connections across 6,500 acres of land in Rural North Vacaville. RNVWD owns and maintains two water supply wells, along with one booster pump station (two booster pumps that pump 250 gallons per minute each), two 300,000-gallon storage tanks, two chlorine injection systems, and a Supervisory Control and Data Acquisition (SCADA) System.

The RNVWD water system is operated by Solano Irrigation District (SID) under contract to RNVWD. SID will be involved in discussions regarding the treatment system and its operations.

RNVWD maintains a water distribution infrastructure that includes 43 miles of PVC and cast-iron pipelines that deliver water over variable terrain to different pressure zones and 67 fire hydrants. All potable water distributed by RNVWD contains chlorine residual for disinfection purposes.

The water supply consists of two wells drilled to a depth of approximately 1,400 feet, each having a capacity of 450 gallons per minute (gpm). Well No. 2 has been placed on emergency standby since the average arsenic concentration has consistently exceeded the 10 ppb MCL. Well No. 1 remains the only source for reliable production, with arsenic levels consistently found at 6 ppb or less.

The RNVWD water system has a Maximum Day Demand (MDD) 0.494 million gallons (MG) or 350 gpm, as reported in the CDPH 2013 Sanitary Survey Report. The capacity of active Well No. 1 is 0.648 million gallons per day (MGD), or 450 gpm. Well No. 2 is an additional emergency source that is approximately equal to Well No. 1.

2.3 Well No. 2 Construction Information

Well No. 2 was drilled and constructed in 2001. Since the well's construction, samples from Well No. 2 have had arsenic concentrations ranging from about 5 to 25 parts per billion (ppb). In 2001, the Well No. 2 water quality samples met the Department of Drinking Water (DDW) maximum contaminant level

(MCL) standard of 50 ppb for arsenic; in 2008 the arsenic MCL standard was lowered to 10 ppb. The Well No. 2 water quality exceeds the current arsenic MCL standard. Water quality data is discussed further below, and laboratory reports from samples collected by SID in 2016 and 2017 are in **Appendix A**.

Due to the water quality of Well No. 2, the California Division of Drinking Water classifies Well No. 2 as an emergency standby source, which restricts the use of the well for short-term emergencies only. For this reason, Well No. 2 requires treatment to remove the "emergency standby" status and to provide a reliable source water to meet demands when Well No. 1 is offline. A treatment unit of 350 gpm is envisioned so that the production can supply enough for the MDD of the system.

The well is cased to 1,284 feet below ground surface, with 16-inch steel casing. The cement grout annular seal extends to 901 feet below ground surface. The well casing is perforated in two intervals, from 1,071 to 1,099 feet below ground surface and from 1,210 to 1,240 feet below ground surface. The well is equipped with a 75-horsepower vertical turbine pump and has a capacity of 450 gpm. Well testing performed in October of 2001 produced a specific capacity of 5 gpm/foot. The Well No. 2 profile is presented in **Appendix E**.

2.4 Well No. 2 Water Quality

2.4.1 Arsenic Data

Results of arsenic testing in Well No. 2 available from State Water Resources Control Board Division of Drinking Water records from 2013 to current are provided below. Those results indicate arsenic concentrations vary from around 5 ppb to over 17 ppb, with an average of 12.2 ppb (**Figure 1**).

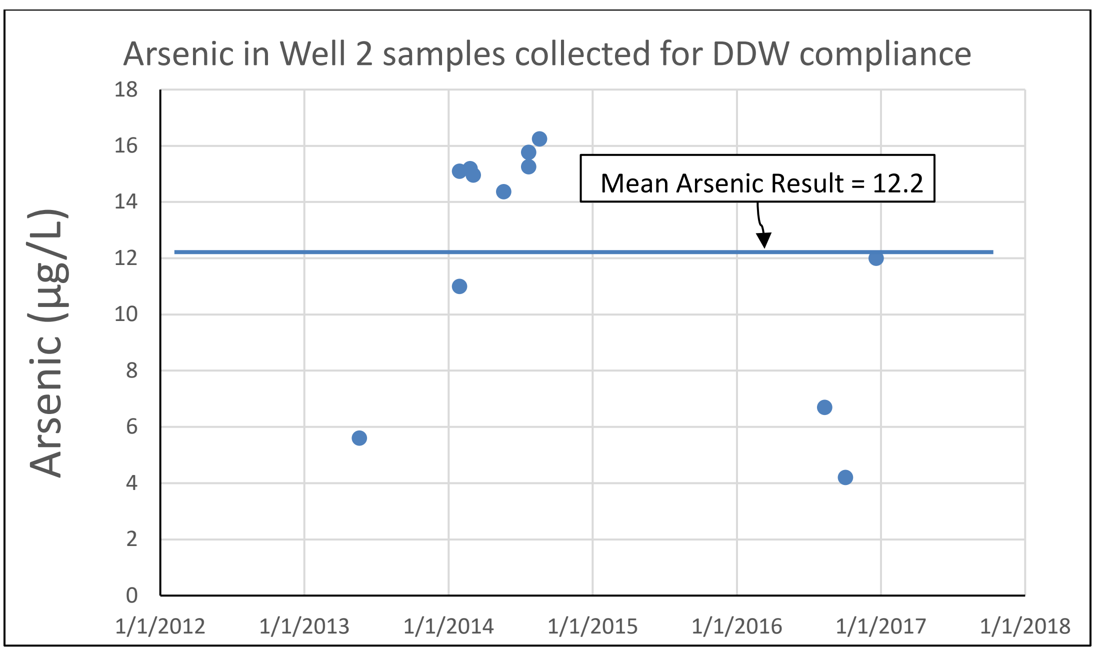


Figure 1: Arsenic data for Well 2 as time series.

2.4.2 Other Water Quality Data

Other water quality parameters that may be important factors for selection and operation of an arsenic treatment system, are provided in the 2016 and 2017 water quality laboratory reports from BSK from Well No. 2 (**Appendix A**).

Of possible concern is the presence of iron and manganese at levels less than half of the secondary MCLS for those contaminants, respectively. It is not RNVWD's objective to remove the iron and manganese unless it is required as part of the operation of the arsenic treatment plant.

Other parameters present in the water quality laboratory results that LSCE is aware could impact selection and operation of an arsenic treatment system are: silica, orthophosphate, vanadium, alkalinity, TDS and pH. If other parameters are required for the design and selection of a treatment system but are not included in the water quality laboratory reports, the Vendors should clarify this in the formal questions prior to the proposal.

Available laboratory reports from Owner-collected water quality sampling are provided in **Appendix A**.

3 DESIGN BASIS INFORMATION

This section provides Design Basis information for the sizing of the treatment units and the operation and maintenance costs associated with the unit. Treatment systems meeting two treatment targets and two annual usage rates, for a total of four different scenarios, should be described in the Vendor proposal.

3.1 Arsenic Treatment Design Requirements

Table 1: Treatment System Design Parameters

PARAMETERS	VALUE
Treatment Design Capacity [1]	350 GPM
Raw Water - Arsenic	17 ppb
Raw Water - other parameters	As provided in **Appendix A**
Effluent Treated Water - Arsenic Target	5 ppb
Operating Pressure of Treatment System	150 psi
Certification/Approval [2]	NSF 61 for components NSF 60 for chemicals ASME for pressure vessels

Notes:

1. Design flow is for total flow from Well 2, whether it is full flow treatment (Sizing Scenario 1), or combined blended flow (Sizing Scenario 2).
2. Other applicable Certifications/Approvals of the proposed treatment system shall also be included. Any exceptions to the Certifications/Approvals listed in Table 1 shall be disclosed by the Vendor.

3.2 Operation of Treatment System

The treatment system will be located at Well No. 1 where there is a connection for Well No. 2. SID will operate the treatment system. The treatment system will "ride online" sending treated water directly to the distribution system. There is no storage tank or clearwell onsite. Operating pressures of the system are 90 to 110 psi. The design operating pressure is 150 psi for the treatment system.

The treatment system shall be capable of removing the maximum amount of arsenic presented in Figure 1. Any pre-treatment or post-treatment required for adequate removal or pH control shall be considered and presented as required components.

Other improvements to the treatment system that are required but not included shall be noted by the Vendor, such as backwash systems, chemical treatment systems, etc.

Existing site plans of Well 1 and Well 2 are provided in **Exhibits D** and **E**, respectively.

3.3 Treatment System Sizing and Use Scenarios

A. Blending (Sizing Scenario): The vendors shall propose a treatment system and purchase cost for the blending scenarios below so that LSCE can assess a cost-effective sizing of the treatment system. If the same size treatment unit will be required with or without blending, the Vendors shall state so.

Sizing Scenario 1 – No Blending: Full flow treatment from Well 2 to achieve the lowest arsenic concentration possible. Vendors to specify the expected effluent arsenic concentration with full flow treatment of 350 gpm.

Sizing Scenario 2 – Blending for Half the MCL: Blending of treated and untreated flow from Well 2 to achieve the water quality effluent target of 5 ppb, equal to half the MCL. This scenario requires the Vendor to determine the size of the unit and flow proportionality of treated/untreated based on the Raw Water Arsenic.

B. Annual Production (O&M Scenario): The vendors shall evaluate operation and maintenance costs of the system based on two treatment amounts of annual production from the treatment system. Predominately, this relates with the exchange rate of media replacements for an adsorptive media system; however, Vendors shall inform us of any other O&M costs factors based on production from their system whether it is adsorptive or coagulation/filtration.

O&M Scenario 1: Well 2 annual production is 12 Million Gallons (i.e. 25% of total annual demand). If blending, then the treatment production is reduced according to the proportional blending rate.

O&M Scenario 2: Well 2 annual production is 24 Million Gallons (i.e. 50% of total annual demand). If blending, then the treatment production is reduced according to the proportional blending rate.

C. Seasonal Operation: RNVWD may prefer to use Well No. 2 seasonally, in which case Well No. 2 could be offline for up to 9 months at a time. Vendors shall state if the treatment system can sit idle for this extended period, and what protocols must take place for bring the system online and offline seasonally.

4 PROPOSAL REQUIREMENTS

Vendors are advised to adhere to the submittal requirements of this RFP. By submitting a response to this RFP, Vendors acknowledge that if its Proposal is accepted by the Owner, its proposal and related submittal may become part of the agreement.

The proposal must include the following information:

4.1 Company Overview

Provide an executive summary or cover letter that addresses the following information.

1. Number of years your company has been in business and identify the Company's name and headquarters address. Include affiliated companies that may be involved in the contracting and procurement of the system.
2. Indicate the name, mailing address, email address, and telephone number(s) of the principal contact.
3. Briefly explain its understanding of the Owner's intent and objectives and their approach to achieve those objectives as described in this RFP.
4. Provide a brief description of the qualification, experience and background of the key personnel. Indicate proposed person's areas of expertise and prime responsibilities for various aspects of the project. Any subcontractors who will be performing services on this project shall be listed with the discussion of their roles and responsibilities.

4.2 References

Provide at least three projects of similar scope and complexity with contact information. Projects should be limited to arsenic treatment systems of similar size completed in the past five (5) years. Discuss O&M replacements costs where information is available. Discuss any unique challenges in the design and how they were addressed by the treatment system.

4.3 Proposed Treatment System for Well No. 2

The proposal must provide for the two scenarios presented in **3.3** with a brief description on:

1. Proposed treatment system technology.
2. System operation, controls and regular backwash or regeneration requirements. Disclose any components that are optional or are not included in the treatment system.
3. Pre-treatment or post-treatment requirements. Disclose any components that are optional or are not included in the treatment system.
4. System component layouts, dimensions, volumes of media, footprint area, and whether it is on a skid or no skid.
5. Provide listing of the certifications and approvals.

4.4 System Parameters

At a minimum, provide the following technical information for the proposed system:

1. Design flow rate;
2. Surface loading rate;
3. Flow controls;
4. Service run-time between backwash or regeneration;
5. Backwash or regeneration flow rates, duration and waste volume produced;
6. Arsenic solid concentration of backwash waste;
7. Anticipated media replacement cycles and cost (for both adsorptive or coagulation/filtration);
8. Pre- or post-chemical system dosing requirements and sizing of chemical pumps and storage;
9. Anticipated effluent water quality included arsenic;
10. Startup and seasonal operation protocols.
11. Expected service life for system.
12. All the above shall be provided for each of the Scenarios in Section 3.3.

4.5 Purchase Cost Estimate

Vendor shall provide a cost estimate for the purchase of the arsenic treatment system. Cost shall be all inclusive for the treatment system, Vendor services, submittals and O&M manuals, shipping costs, AutoCAD drawings, services during startup and commissioning, and assistance to the Design Civil Engineer for design and permitting.

This Cost Estimate shall be broken down into the individual system costs shown below, or similar. Vendors to disclose any materials or components that are "Optional" and provide the optional cost increase. Very clearly indicate any disclaimers, assumptions or caveats to the cost. If Pilot Testing is required to confirm the cost, then the Vendor shall provide a pilot testing proposal as described in Section **4.8**. If other design information is required to determine the final cost, clearly indicate the assumptions that are made in preparing the Cost Estimate.

Example Cost Estimate Breakdown (Vendors to follow closely to this breakdown):

A. Base price for packaged unit components (filter vessels, skid system).
B. Accessories (piping, valves and controls).
C. Filtration or Adsorptive Media, cost and volume.
D. Submittals, O&M manuals.
E. Onsite startup and commissioning services after installation.
F. Training for SID and RNVWD staff.
G. Post-Startup Technical Support (10 instances totaling 80 hours).
H. (Optional) Programmable Logic Controller pre-programmed for automation of the unit. This item may be deducted and programmed separately.
I. (Optional) Pre-packaged residual waste management systems for backwash storage and recovery and for solids drying and disposal.

4.6 Treatment System Schedule

Indicate the lead time for submittals, fabrication and delivery of the treatment system once a final selection is approved.

4.7 Performance Guarantee

RNVWD requires a Performance Guarantee from the Vendor for ensuring the effluent arsenic concentration will meet the MCL for arsenic. This will be accomplished with a Performance Bond (example below) or another similar method agreed upon by the RNVWD and the Vendor. The Performance Guarantee will cover a period of 2 years effective starting after installation and commissioning. Vendors to disclose whether Pilot Testing is required secure a Performance Guarantee. If pilot testing is required, provide a Pilot Testing proposal in Section **4.8**.

The Vendor will also provide a warranty that covers failure of system components for at least 2 years. Provide specifics of the 2-year equipment warranty, indicating what components of the system, if any, are not warrantied, and what circumstances could void the warranty.

Example Language for the Performance Bond

A Performance Bond will be posted by the Vendor. The amount of this bond will be equal to the cost of replacing the system, prorated to the expected service life of the system as defined by the Vendor in the Proposal.

If the water treatment equipment fails to meet provisions of the Performance Guarantee, or equipment requires replacement under the 2-year warranty, the following remedies will be implemented:

- Vendor will repair water treatment equipment at Vendor's expense and repeat performance testing to verify correction of problem leading to noncompliance with requirements of Performance Guarantee. Vendor is responsible for all costs associated with repeat testing including those incurred by RNVWD and/or SID such as but not limited to RNVWD and/or SID personnel, LSCE's personnel and miscellaneous expenses incurred due to the failure. This shall be accomplished within a two-week period.
- If repairs will not permit water treatment equipment to meet requirements of Performance Guarantee, Vendor will replace defective items or entire treatment plant, and repeat performance testing to satisfaction of RNVWD. This shall take place within one month of written notification from RNVWD.
- If repairs and equipment replacement made by Vendor fail to meet the requirements of the Performance Guarantee as substantiated by repeat performance testing, and in the opinion of RNVWD the water treatment process is determined to be unable to meet Performance Guarantee standards, the Vendor will forfeit the amount of the Performance Bond.

4.8 Pilot Testing Program Requirements (If Required by Vendor)

Provide a scope and budget for Pilot Testing. Note that Well No, 2 is currently equipped with a well pump and a pilot trailer can readily be connected to Well No. 2 discharge piping at the Well No. 1 site.

The Vendor’s proposed pilot testing scope shall describe the following:

- Objectives of Pilot Testing (see list below);
- Connections and Waste Disposal Requirements;
- Test Duration Minimum and Expected;
- Samples to be collected by Vendor and by Owner;
- Owner responsibilities during testing;
- Pilot Test Costs.

The Pilot Testing study should be used to refine the design of the system and indicate the optimal operating parameters or system sizing. As indicated in LSCE Technical Memorandum, Pilot Testing would be used to:

1) To determine whether and under what operating conditions the technology can remove arsenic to meet the 5-ppb target effluent requirement;
2) To determine residuals characteristics when the technology is operated to achieve sufficient arsenic removal;
3) To determine optimum operating parameters to remove sufficient arsenic while maintaining non-hazardous residual generation; and,
4) To establish a guaranteed treatment removal effectiveness (if required by Vendor).

APPENDIX A – Water Quality

BSK Associates Well 2 Arsenic Study Data for October 2016, December 2016, January 2017

Cal Aqua Well 2 Arsenic Study Data for May 2014

RNVWD Drinking Water Well #2

General Mineral, Physical, and Inorganic Analyses

Common Name	Units	MCL	PHG or (MCLG)					
Sample Dates:				1/11/17	12/20/16	10/3/16		
Agress. Ind.	none			12	12	12		
Alkalinity	mg/L			230	240	210		
Aluminum	µg/L	1000	600	ND	ND	ND		
Antimony	µg/L	6	20	ND	ND	ND		
Arsenic	µg/L	10	0.004	6.9	12.0	4.2		
Barium	µg/L	1000	2000	0.081	0.056	0.074		
Beryllium	µg/L	4	1	ND	ND	ND		
Bicarbonate	mg/L			230	240	210		
Boron	mg/L			0.14	0.22	NS		
Cadmium	µg/L	5	0.04	ND	ND	ND		
Calcium	mg/L			25	16	25		
Carbonate	mg/L		9.3	ND	ND	ND		
Chloride	mg/L	*500*		9.6	8.3	10		
Chromium	µg/L	50	100	ND	ND	ND		
Chrom 6	µg/L	10	0.2	3.2	NS	3.2		
Color	units	*15*		ND	NS	ND		
Copper	µg/L	1300	300	ND	ND	ND		
Cyanide	µg/L	150	150	ND	ND	ND		
Fluoride	mg/L	2.0	1	0.28	0.21	0.36		
Hardness	mg/L			120	75	120		
Hydroxide	mg/L			ND	ND	ND		
Iron	mg/L	*0.3*		0.094	0.097	0.52		
Langelier	none			0.31	0.38	0.47		
Lead	µg/L	15	0.2	ND	ND	ND		
Magnesium	mg/L			15	8.3	14		
Manganese	mg/L	*0.05*		0.021	0.016	0.018		
MBAS	mg/L	*0.5*		ND	ND	ND		

Common Name	Units	MCL	PHG or (MCLG)					
Sample Dates:				1/11/17	12/20/16	10/3/16		
Mercury	µg/L	2	1.2	ND	ND	ND		
Nickel	µg/L	100	12	ND	ND	ND		
Nitrate as N	mg/L	10	10	0.065	ND	0.065		
Nitrite	mg/L	1	1	ND	ND	ND		
Odor	TON	*3*		0.071	NS	ND		
Orthophosphate	mg/L			0.076	0.014	0.076		
pH	none	*6.5-8.5*		8.1	8.0	8.3		
Perchlorate	µg/L	6	6	ND	ND	ND		
Potassium	mg/L			5.5	4.3	4.9		
Selenium	µg/L	50	30	ND	ND	ND		
Silica-dissolved	mg/L			92	95	91		
Silver	µg/L	*100*		ND	ND	ND		
Sodium	mg/L			72	86	68		
Spec cond	µmhos/cm	*1600*		500	500	500		
Sulfate	mg/L	*500*		34	20	30		
TDS	mg/L	*1000*		380	360	370		
Thallium	µg/L	2	0.1	ND	ND	ND		
Turbidity	NTU	5		0.44	NS	2.9		
Vanadium	µg/L		50 NL	18	16	23		
Zinc	mg/L	*5.0*		ND	ND	ND		

Italic MCLs are secondary MCLs

NL is a notification level
NS - not sampled

BSK ASSOCIATES

Certificate of Analysis

Sample ID: A7A1318-01
Sampled By: Dean Miner
Sample Description: well #2

Sample Date - Time: 01/11/17 - 11:30
Matrix: Drinking Water
Sample Type: Grab

BSK Associates Laboratory Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Aggressive Index		**12**				A700945	01/23/17	01/23/17	
Alkalinity as CaCO3	SM 2320B	**230**	3.0	mg/L	1	A700575	01/15/17	01/15/17	
Bicarbonate as CaCO3	SM 2320B	**230**	3.0	mg/L	1	A700575	01/15/17	01/15/17	
Carbonate as CaCO3	SM 2320B	ND	3.0	mg/L	1	A700575	01/15/17	01/15/17	
Hydroxide as CaCO3	SM 2320B	ND	3.0	mg/L	1	A700575	01/15/17	01/15/17	
Chloride	EPA 300.0	**9.6**	1.0	mg/L	1	A700625	01/16/17	01/16/17	
Color, Apparent	SM 2120B	ND	5.0	CU	1	A700491	01/13/17 17:08	01/13/17	HT1.1
Cyanide (total)	SM 4500-CN E	ND	0.0050	mg/L	1	A700705	01/18/17	01/19/17	
Conductivity @ 25C	SM 2510B	**500**	1.0	umhos/cm	1	A700575	01/15/17	01/15/17	
Fluoride	EPA 300.0	**0.28**	0.10	mg/L	1	A700625	01/16/17	01/16/17	
Langelier Index	SM 2330B	**0.31**				A700945	01/23/17	01/23/17	
Orthophosphate as PO4	SM 4500-P E	**0.071**	0.030	mg/L	1	A700644	01/17/17 12:34	01/17/17	HT1.1
Perchlorate	EPA 314.0	ND	2.0	ug/L	1	A700833	01/19/17	01/19/17	
pH (1)	SM 4500-H+ B	**8.1**		pH Units	1	A700575	01/15/17	01/15/17	
pH Temperature in °C		**20.5**							
Sulfate as SO4	EPA 300.0	**34**	1.0	mg/L	1	A700625	01/16/17	01/16/17	
Total Dissolved Solids	SM 2540C	**380**	5.0	mg/L	1	A700714	01/18/17	01/23/17	
Turbidity	SM 2130B	**0.44**	0.10	NTU	1	A700491	01/13/17 17:23	01/13/17	HT1.1

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Aluminum	EPA 200.7	ND	0.050	mg/L	1	A700672	01/18/17	01/18/17	
Antimony	EPA 200.8	ND	2.0	ug/L	1	A700672	01/18/17	01/24/17	
Arsenic	EPA 200.8	**6.9**	2.0	ug/L	1	A700672	01/18/17	01/24/17	
Barium	EPA 200.7	**0.081**	0.050	mg/L	1	A700672	01/18/17	01/18/17	
Beryllium	EPA 200.8	ND	1.0	ug/L	1	A700672	01/18/17	01/24/17	
Boron	EPA 200.7	**0.14**	0.10	mg/L	1	A700672	01/18/17	01/18/17	
Cadmium	EPA 200.8	ND	1.0	ug/L	1	A700672	01/18/17	01/24/17	
Calcium	EPA 200.7	**25**	0.10	mg/L	1	A700672	01/18/17	01/18/17	
Chromium	EPA 200.8	ND	10	ug/L	1	A700672	01/18/17	01/24/17	
Copper	EPA 200.8	ND	5.0	ug/L	1	A700672	01/18/17	01/24/17	
Iron	EPA 200.7	**0.094**	0.030	mg/L	1	A700672	01/18/17	01/18/17	
Lead	EPA 200.8	ND	5.0	ug/L	1	A700672	01/18/17	01/24/17	
Magnesium	EPA 200.7	**15**	0.10	mg/L	1	A700672	01/18/17	01/18/17	
Manganese	EPA 200.7	**0.021**	0.010	mg/L	1	A700672	01/18/17	01/18/17	
Mercury	EPA 200.8	ND	0.20	ug/L	1	A700672	01/18/17	01/24/17	
Nickel	EPA 200.8	ND	10	ug/L	1	A700672	01/18/17	01/24/17	
Potassium	EPA 200.7	**5.5**	2.0	mg/L	1	A700672	01/18/17	01/18/17	
Selenium	EPA 200.8	ND	2.0	ug/L	1	A700672	01/18/17	01/24/17	
Silica (SiO2) - Dissolved (1)	EPA 200.7	**92**	0.20	mg/L	1	A700641	01/17/17	01/18/17	
Silver	EPA 200.8	ND	10	ug/L	1	A700672	01/18/17	01/24/17	
Sodium	EPA 200.7	**72**	1.0	mg/L	1	A700672	01/18/17	01/18/17	MS1.4
Thallium	EPA 200.8	ND	1.0	ug/L	1	A700672	01/18/17	01/24/17	

ASSOCIATES

Certificate of Analysis

Sample ID: A7A1318-01
Sampled By: Dean Miner
Sample Description: well #2

Sample Date - Time: 01/11/17 - 11:30
Matrix: Drinking Water
Sample Type: Grab

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Hardness as CaCO3	SM 2340B	**120**	0.41	mg/L					
Vanadium	EPA 200.8	**18**	3.0	ug/L	1	A700672	01/18/17	01/24/17	
Zinc	EPA 200.7	ND	0.050	mg/L	1	A700672	01/18/17	01/18/17	

ASSOCIATES

Certificate of Analysis

Sample ID: A6L2216-01
Sampled By: Dean Miner
Sample Description: Well #2

Sample Date - Time: 12/20/16 - 09:20
Matrix: Drinking Water
Sample Type: Grab

BSK Associates Laboratory Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Aggressive Index		**12**				A617597	12/30/16	12/30/16	
Alkalinity as CaCO3	SM 2320B	**240**	3.0	mg/L	1	A617366	12/26/16	12/26/16	
Bicarbonate as CaCO3	SM 2320B	**240**	3.0	mg/L	1	A617366	12/26/16	12/26/16	
Carbonate as CaCO3	SM 2320B	ND	3.0	mg/L	1	A617366	12/26/16	12/26/16	
Hydroxide as CaCO3	SM 2320B	ND	3.0	mg/L	1	A617366	12/26/16	12/26/16	
Chloride	EPA 300.0	**8.3**	1.0	mg/L	1	A617171	12/21/16	12/21/16	
Cyanide (total)	SM 4500-CN E	ND	0.0050	mg/L	1	A617331	12/23/16	12/30/16	
Conductivity @ 25C	SM 2510B	**500**	1.0	umhos/cm	1	A617366	12/26/16	12/26/16	
Fluoride	EPA 300.0	**0.21**	0.10	mg/L	1	A617171	12/21/16	12/21/16	
Langelier Index	SM 2330B	**0.038**				A617597	12/30/16	12/30/16	
MBAS, Calculated as LAS, mol wt 340	SM 5540C	ND	0.050	mg/L	1	A617217	12/21/16 20:20	12/21/16	
Nitrate + Nitrite as N	EPA 300.0	ND	0.23	mg/L	1	A617171	12/21/16 18:52	12/21/16	
Nitrate as N	EPA 300.0	ND	0.23	mg/L	1	A617171	12/21/16 18:52	12/21/16	
Nitrite as N	EPA 300.0	ND	0.050	mg/L	1	A617171	12/21/16 18:52	12/21/16	
Orthophosphate as P	SM 4500-P E	**0.014**	0.010	mg/L	1	A617229	12/22/16 08:42	12/22/16	
Perchlorate	EPA 314.0	ND	2.0	ug/L	1	A617469	12/28/16	12/28/16	
pH (1)	SM 4500-H+ B	**8.0**		pH Units	1	A617366	12/26/16	12/26/16	
pH Temperature in °C		**22.9**							
Sulfate as SO4	EPA 300.0	**20**	1.0	mg/L	1	A617171	12/21/16	12/21/16	
Total Dissolved Solids	SM 2540C	**360**	5.0	mg/L	1	A617328	12/23/16	12/29/16	

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Aluminum	EPA 200.7	ND	0.050	mg/L	1	A617273	12/23/16	12/29/16	
Antimony	EPA 200.8	ND	2.0	ug/L	1	A617273	12/23/16	01/04/17	
Arsenic	EPA 200.8	**12**	2.0	ug/L	1	A617273	12/23/16	01/04/17	
Barium	EPA 200.7	**0.056**	0.050	mg/L	1	A617273	12/23/16	12/29/16	
Beryllium	EPA 200.8	ND	1.0	ug/L	1	A617273	12/23/16	01/04/17	
Boron	EPA 200.7	**0.22**	0.10	mg/L	1	A617273	12/23/16	12/29/16	
Cadmium	EPA 200.8	ND	1.0	ug/L	1	A617273	12/23/16	01/04/17	
Calcium	EPA 200.7	**16**	0.10	mg/L	1	A617273	12/23/16	12/29/16	
Chromium	EPA 200.8	ND	10	ug/L	1	A617273	12/23/16	01/04/17	
Copper	EPA 200.7	ND	0.050	mg/L	1	A617273	12/23/16	12/29/16	
Hardness as CaCO3		**75**	0.41	mg/L					
Iron	EPA 200.7	**0.097**	0.030	mg/L	1	A617273	12/23/16	12/29/16	
Lead	EPA 200.8	ND	5.0	ug/L	1	A617273	12/23/16	01/04/17	
Magnesium	EPA 200.7	**8.3**	0.10	mg/L	1	A617273	12/23/16	12/29/16	
Manganese	EPA 200.7	**0.016**	0.010	mg/L	1	A617273	12/23/16	12/29/16	
Mercury	EPA 200.8	ND	0.20	ug/L	1	A617273	12/23/16	01/04/17	
Nickel	EPA 200.8	ND	10	ug/L	1	A617273	12/23/16	01/04/17	
Potassium	EPA 200.7	**4.3**	2.0	mg/L	1	A617273	12/23/16	12/29/16	
Selenium	EPA 200.8	ND	2.0	ug/L	1	A617273	12/23/16	01/04/17	
Silica (SiO2) - Dissolved (1)	EPA 200.7	**95**	0.20	mg/L	1	A617550	12/30/16	01/04/17	

ASSOCIATES

Certificate of Analysis

Sample ID: A6L2216-01
Sampled By: Dean Miner
Sample Description: Well #2

Sample Date - Time: 12/20/16 - 09:20
Matrix: Drinking Water
Sample Type: Grab

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Silver	EPA 200.7	ND	0.010	mg/L	1	A617273	12/23/16	12/30/16	
Sodium	EPA 200.7	**86**	1.0	mg/L	1	A617273	12/23/16	12/29/16	
Thallium	EPA 200.8	ND	1.0	ug/L	1	A617273	12/23/16	01/04/17	
Vanadium	EPA 200.8	**16**	3.0	ug/L	1	A617273	12/23/16	01/04/17	
Zinc	EPA 200.7	ND	0.050	mg/L	1	A617273	12/23/16	12/29/16	

ASSOCIATES

Certificate of Analysis

Sample ID: A6J0174-02
Sampled By: Dean Miner
Sample Description: Well #2

Sample Date - Time: 10/03/16 - 09:25
Matrix: Drinking Water
Sample Type: Grab

BSK Associates Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Aggressive Index		**12**				A614103	10/13/16	10/13/16	
Alkalinity as CaCO3	SM 2320B	**210**	3.0	mg/L	1	A613515	10/05/16	10/05/16	
Bicarbonate as CaCO3	SM 2320B	**210**	3.0	mg/L	1	A613515	10/05/16	10/05/16	
Carbonate as CaCO3	SM 2320B	ND	3.0	mg/L	1	A613515	10/05/16	10/05/16	
Hydroxide as CaCO3	SM 2320B	ND	3.0	mg/L	1	A613515	10/05/16	10/05/16	
Chloride	EPA 300.0	**10**	1.0	mg/L	1	A613464	10/04/16	10/04/16	
Color, Apparent	SM 2120B	ND	5.0	CU	1	A613409	10/04/16 12:16	10/04/16	
Cyanide (total)	SM 4500-CN E	ND	0.0050	mg/L	1	A613845	10/10/16	10/10/16	
Conductivity @ 25C	SM 2510B	**500**	1.0	umhos/cm	1	A613515	10/05/16	10/05/16	
Fluoride	EPA 300.0	**0.36**	0.10	mg/L	1	A613464	10/04/16	10/04/16	
Hexavalent Chromium	EPA 218.7	**3.2**	0.050	ug/L	1	A613709	10/06/16	10/06/16	
Langelier Index	SM 2330B	**0.47**				A614103	10/13/16	10/13/16	
MBAS, Calculated as LAS, mol wt 340	SM 5540C	ND	0.050	mg/L	1	A613469	10/04/16 15:13	10/04/16	
Nitrate + Nitrite as N	EPA 300.0	**0.65**	0.23	mg/L	1	A613464	10/04/16 19:11	10/04/16	
Nitrate as N	EPA 300.0	**0.65**	0.23	mg/L	1	A613464	10/04/16 19:11	10/04/16	
Nitrite as N	EPA 300.0	ND	0.050	mg/L	1	A613464	10/04/16 19:11	10/04/16	
Orthophosphate as PO4	SM 4500-P E	**0.076**	0.030	mg/L	1	A613481	10/04/16 13:25	10/04/16	
Perchlorate	EPA 314.0	ND	2.0	ug/L	1	A613883	10/11/16	10/11/16	
pH (1)	SM 4500-H+ B	**8.3**		pH Units	1	A613515	10/05/16	10/05/16	
pH Temperature in °C		**22.4**							
Sulfate as SO4	EPA 300.0	**30**	1.0	mg/L	1	A613464	10/04/16	10/04/16	
Total Dissolved Solids	SM 2540C	**370**	5.0	mg/L	1	A613583	10/05/16	10/07/16	
Turbidity	SM 2130B	**2.9**	0.10	NTU	1	A613409	10/04/16 12:32	10/04/16	

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Aluminum	EPA 200.7	ND	0.050	mg/L	1	A613770	10/09/16	10/12/16	
Antimony	EPA 200.8	ND	2.0	ug/L	1	A613770	10/09/16	10/14/16	
Arsenic	EPA 200.8	**4.2**	2.0	ug/L	1	A613770	10/09/16	10/14/16	
Barium	EPA 200.7	**0.074**	0.050	mg/L	1	A613770	10/09/16	10/12/16	
Beryllium	EPA 200.8	ND	1.0	ug/L	1	A613770	10/09/16	10/14/16	
Cadmium	EPA 200.8	ND	1.0	ug/L	1	A613770	10/09/16	10/14/16	
Calcium	EPA 200.7	**25**	0.10	mg/L	1	A613770	10/09/16	10/12/16	
Chromium	EPA 200.8	ND	10	ug/L	1	A613770	10/09/16	10/14/16	
Copper	EPA 200.8	ND	5.0	ug/L	1	A613770	10/09/16	10/14/16	
Iron	EPA 200.7	**0.52**	0.030	mg/L	1	A613770	10/09/16	10/12/16	
Lead	EPA 200.8	ND	5.0	ug/L	1	A613770	10/09/16	10/14/16	
Magnesium	EPA 200.7	**14**	0.10	mg/L	1	A613770	10/09/16	10/12/16	
Manganese	EPA 200.7	**0.018**	0.010	mg/L	1	A613770	10/09/16	10/12/16	
Mercury	EPA 200.8	ND	0.20	ug/L	1	A613770	10/09/16	10/14/16	
Nickel	EPA 200.8	ND	10	ug/L	1	A613770	10/09/16	10/14/16	
Potassium	EPA 200.7	**4.9**	2.0	mg/L	1	A613770	10/09/16	10/12/16	
Selenium	EPA 200.8	ND	2.0	ug/L	1	A613770	10/09/16	10/14/16	

Certificate of Analysis

Sample ID: A6J0174-02
Sampled By: Dean Miner
Sample Description: Well #2

Sample Date - Time: 10/03/16 - 09:25
Matrix: Drinking Water
Sample Type: Grab

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Silica (SiO2) - Dissolved (1)	EPA 200.7	**91**	0.20	mg/L	1	A614062	10/13/16	10/18/16	
Silver	EPA 200.8	ND	10	ug/L	1	A613770	10/09/16	10/14/16	
Sodium	EPA 200.7	**68**	1.0	mg/L	1	A613770	10/09/16	10/12/16	
Thallium	EPA 200.8	ND	1.0	ug/L	1	A613770	10/09/16	10/14/16	
Hardness as CaCO3	SM 2340B	**120**	0.41	mg/L					
Vanadium	EPA 200.8	**23**	3.0	ug/L	1	A613770	10/09/16	10/17/16	
Zinc	EPA 200.7	ND	0.050	mg/L	1	A613770	10/09/16	10/12/16	

APPENDIX B – LSCE Technical Memorandum: Well No. 2 Options to Reduce Arsenic for Rural North Vacaville Water District

Technical Memorandum

DATE: March 14, 2017 PROJECT: 15-2-112

TO: Gordon Stankowski & Paul Fuchslin
Rural North Vacaville Water District (Solano Irrigation District)

FROM: John Fawcett & Gregory Garrison

SUBJECT: **WELL 2 OPTIONS TO REDUCE ARSENIC**
RURAL NORTH VACAVILLE WATER DISTRICT

INTRODUCTION

Well 2 was constructed in 2001. Since the well's construction, samples from Well 2 have had arsenic concentrations ranging from about 5 to 21 parts per billion (ppb). In 2001, the Well 2 water quality samples met the Department of Drinking Water (DDW) maximum contaminant level (MCL) standard of 50 ppb for arsenic; in 2008 the arsenic MCL standard was lowered to 10 ppb. The Well 2 water quality exceeds the current arsenic MCL standard. The current Rural North Vacaville Water District (RNVWD) water supply permit issued by the DDW allows the well to be used as a domestic well supply on an emergency standby basis.

RNVWD desires to improve water supply reliability by reducing arsenic levels in Well 2 and retained Luhdorff and Scalmanini Consulting Engineers (LSCE) for assessing possible the following options that could lower arsenic levels in Well 2 water:

1. Blending Well 2 water with Well 1 to achieve an arsenic level that meets the 10 ppb standard;
2. Construction of a new, low arsenic well to replace Well 2;
3. Modifications to the existing Well 2 structure to limit arsenic entry into the well casing;
4. Groundwater treatment to remove arsenic.

This report includes a review and analysis of the available well information; water quality data including the results of recent groundwater sampling conducted in October 2016, December 2016, and January 2017; and a summary of findings and recommendations associated with each of the above options that may reduce the concentration of arsenic in water produced from Well 2.

DESCRIPTION OF RNVWD WATER SYSTEM

Per the DDW 2013 Sanitary Survey Report, RNVWD is a community water system that serves a population of approximately 900 through 372 metered service connections. The water supply consists of two wells drilled to a depth of 1,400 feet (ft), each having a capacity of 450 gallons per minute. Well 2 has been placed on emergency standby since the average arsenic concentration has consistently exceeded the 10 ppb MCL. Well 1 remains the only source for reliable production, with arsenic levels consistently holding at 6 ppb or less.

RNVWD operates and maintains two water supply wells, discussed previously, along with one booster pump station (two booster pumps each that pump 250 gallons per minute), two 300,000-gallon storage tanks, two chlorine injection systems, and a Supervisory Control and Data Acquisition (SCADA) System. RNVWD maintains a water distribution infrastructure that includes 43 miles of PVC and cast iron pipelines that deliver water over variable terrain to different pressure zones and 67 fire hydrants. All potable water distributed by RNVWD contains chlorine residual for disinfection purposes.

The DDW issued water supply permit No. 02-04-00P-4810013 on June 16, 2000, classifying RNVWD as a small community water system based upon both population and number of service connections.

WATER SUPPLY

RNVWD has one active groundwater source (Well 1) and one emergency standby groundwater source (Well 2). Well 1 and Well 2 are located in North Vacaville at the end of Buena Vista Lane and are approximately 1,000 feet apart. Hydrogeologically, the wells are in the Solano subbasin of the Sacramento Valley Groundwater Basin (DWR Basin No. 5-21.66). The well construction details for both wells are summarized in **Table 1** (DDW/CDPH, 2013 Sanitary Survey Report). Well profiles for both Well 1 and Well 2 are included in **Figure 1**.

Table 1: Well Construction Summary Wells 1 & 2

Source (PS Code)	Status	Capacity (gpm)	Well Depth (ft.)	Drilling Date	Pump
Well 1 (4810013-001)	Active	450	1391	10/11/2001	75 hp Vert. Turbine
Well 2 (4810013-002)	Standby	450	1284	10/29/2001	75 hp Vert. Turbine

Source	Casing Material	Casing Diameter	Annular Seal Depth (ft.)	Annular Seal Material
Well 1	Steel	16.625”	902	Cement Grout
Well 2	Steel	16.625”	901	Cement Grout

Source	Openings Sealed	Casing Vent	Air Relief Valve	Screen Intervals (feet below ground surface elevation)
Well 1	Yes	Yes	Yes	1017/1047; 1169/1189; 1245/1261; 1271/1291; 1351/1361
Well 2	Yes	Yes	Yes	1071/1099; 1210/1240

The original design capacity of each well was 500 gallons per minute (gpm). During development pumping in 2001, each well was fully developed at flow rates of approximately 1,400 gpm. Well and aquifer tests were performed on each well. Constant-rate tests for both wells were conducted at the design capacity of 500 gpm. Well 1 was continuously pumped for 16 hours and Well 2 was continuously pumped for 24 hours. The specific capacity and aquifer transmissivity is summarized in **Table 2**.

Table 2: Well Specific Capacity & Aquifer Transmissivity

	Specific Capacity (gpm/ft)	Aquifer Transmissivity (gpd/ft)
Well 1	9	18,000
Well 2	5	12,750

Water Demand & Adequacy of Supply

DDW requires RNVWD's water supply to meet the Maximum Day Demand (MDD). MDD is defined as the largest volume of water delivered to the system in a single day expressed in gallons per day. For purposes of this report, LSCE assumes that the MMD demand is 0.494 million gallons (MG) or 350 gpm, as reported in the CDPH 2013 Sanitary Survey Report, is still applicable (i.e. LSCE's scope for this project did not include a water demand update or an assessment of the current MDD).

The capacity of active Well 1 is 0.648 million gallons per day (MGD), or 450 gpm. Well 2 is an additional emergency source that is approximately equal to Well 1. RNVWD has an additional 0.600 MG of water storage capacity in their tanks. Per the DDW, RNVWD has sufficient water available to meet its MDD and comply with the CDPH requirements for reliable source, storage, emergency capacity, and fire suppression (DDW/CDPH, 2013 Sanitary Survey Report).

Although RNVWD is pursuing options to reduce arsenic in groundwater pumped from Well 2, RNVWD's desire to add arsenic treatment is not strictly regulatory driven; meaning RNVWD is pursuing the treatment option for Well 2 not because there is a regulatory directive, but because of a desire to improve source water reliability and redundancy.

As discussed above, the DDW classifies Well 2 as an emergency standby groundwater source. Title 22 restrictions on standby wells include:

- Well 2 can only be used for short term emergencies of 5 consecutive days or less and less than 15 calendar days a year;
- Within 3 days after use of Well 2 as standby source, RNVWD must notify the DDW; and
- Well 2 must be monitored a minimum of once every compliance cycle.

Compliance with DDW Well 2 standby regulations apply to the situation of Well 1 being off-line for 5 consecutive days or less. Should Well 1 fail due to a well pump or motor problem, the problem could be addressed within 5 days provided spare parts and a well pump contractor is available. However, problems associated with the well itself could be more time consuming to address. For example, should the well experience a decline in well yield, an investigation and implementation of a well rehabilitation plan could be needed, and this work could require more than 5 days to completed. For certain, well structure damage caused by corrosion, settlement, or earthquakes would take longer than 5 days to address and having Well 2 available, and in “active” status instead of “standby”, would improve RNVWD’s system reliability.

Water Quality

The DDW requires that the Well 1 and Well 2 groundwater meet Title 22 water quality requirements. Historically, both wells met maximum contaminant level (MCL) standards except for the concentration of arsenic levels in Well 2. First sampled in 2001, arsenic concentrations in Well 1 have ranged from 4 to 7.5 ppb. Whereas, arsenic concentrations in Well 2 have been reported to range from about 5 to 23 ppb, but more generally levels range from 15 to 20 ppb, exceeding the 10 ppb MCL standard. Well 2 arsenic levels increase with pumping duration and pumping flow rate as described further below.

Arsenic Water Quality

Arsenic levels in Well 1 and Well 2 were investigated on many occasions since originally tested in 2001 and can be summarized as follows:

- October 2016, December 2016, and January 2017: RVNWD collected samples from Well 2 on three occasions and arsenic levels were 4.2, 12, and 6.9 ppb, respectively. The water quality laboratory reports prepared by BSK Laboratories are included in **Appendix A**. The variation in water quality may relate with the flow rate and duration of pumping. As discussed below, concentrations of arsenic that exceed the 10 ppb standard may be representative of the water quality associated with longer term pumping, whereas the lower arsenic levels may be representative of samples obtained from well casing storage and less representative of the hydrogeologic formation water quality. Well 1 was sampled on October 2016 only and the arsenic level was measured at 6.2 ppb. The December sample was obtained following pumping for 5 minutes. The December and January samples were obtained following pumping at a rate of 400 gpm for 12 minutes.

- 2015: RVNWD collected and analyzed several samples in March (3/19 through 3/24) from Well 2. A total of 14 samples were obtained. Arsenic levels ranged from 11 to 15 ppb. One of the 14 samples was also tested for manganese and hexavalent chromium and the concentrations were reported as non-detect. No information was available regarding well pumping rate.

- 2005: LSCE conducted Well 1 and Well 2 time series sampling in August 2005 as follows:
  Well 1: Time-series samples with the well running were obtained on August 8th at 9:00 AM, 10:00 AM, 12:00 PM, and 4:00 PM. All the analyzed samples had arsenic concentrations of

about 5 ppb. The arsenic concentration did not vary with time, and did not exceed the MCL. Well 2: Was not running when LSCE arrived at the site, so time-series samples were obtained from start-up. Samples were collected on August 6 at 5 minutes and at 1, 2, 4, and 8 hours into the pumping cycle. The analyzed samples had arsenic concentrations that ranged from 6.7 to 23.1 ppb. The samples that were obtained at 5 minutes into the pumping cycle had arsenic concentrations below MCL, however, these samples may represent water stored in the well casing and not the formation water. Similarly, the two samples that were at approximately 5 ppb in January 2004 were likely obtained from casing storage and not representative of a change in formation water quality. The arsenic concentration in subsequent time-series samples did not vary with time and ranged from 17.2 to 23.1 ppb.

- 2001: Well 1 water quality met the 10 ppb MCL level and samples from Well 2 had arsenic concentrations ranging from 15 to 21 ppb during LSCE test pumping discussed above. During the 24 hour aquifer test, the arsenic concentration in Well 2 was 16 ppb. Water quality samples were collected during the constant-rate tests conducted at each well.

Water Quality Parameters that Affect Arsenic Treatment

Water samples collected from Well 2 in October 2016, December 2016, and January 2017 were also analyzed for metals and general chemistry parameters by BSK Laboratories. The water quality data is presented in **Appendix A. Appendix A** also includes similar analytical testing conducted by Cal Aqua Lab in May 2014.

LSCE provided the BSK and Cal Aqua **Appendix A** analytical data to several arsenic treatment companies as part of the solicitation of technical feasibility and cost information needed to assess Well 2 treatment options. Several parameters tested, including silica, phosphorus, and vanadium, present adverse impacts to arsenic treatment as discussed further in the water treatment option assessment, below.

ASSESSMENT OF WELL 2 ARSENIC REDUCING OPTIONS

As discussed above, Well 2 has been placed on emergency standby as the average arsenic concentration has consistently exceeded the 10 ppb MCL standard. Well 1 remains the only source for reliable production, with arsenic levels consistently measured at 6 ppb or less.

The RNVWD desires to upgrade Well 2 for domestic supply and is interested in options to reduce the concentration of arsenic in the water to below DDW standards. RNVWD Well 2 options for reducing the arsenic concentration include the following:

Option 1: Blending Well 2 with Well 1;
Option 2: Construction of a new, low arsenic well to replace Well 2;
Option 3: Well structure modifications to preclude entry of arsenic into to the well casing;
Option 4: Well head treatment.

Option 1: Blending Well 2 with Well 1

The first arsenic-reducing option examined was the feasibility of using an alternate water source for blending purposes. In this case, RNVWD could combine (blend) water pumped from Well 1 (arsenic <5 µg/L) with Well 2 (arsenic ranging from about 5 to 23.1 ppb) by pumping both wells into the existing hydropneumatic tank located at the Well 1 site and then into the RNVWD distribution system where the blended supply is served to customers.

The blending concept with Well 1 and Well 2 is not feasible because if Well 1 is out-of-service for any reason, Well 2 would not be able to produce water that meets the arsenic MCL standard of 10 ppb. For these reasons, Option 1 is eliminated from further consideration or analyses.

Option 2: Construct New Production Well

Conceptually, Well 2 could be replaced with a new production well that is located, designed, and installed to have arsenic levels below the 10 ppb MCL. As describe earlier in Section 3 above, Well 1 and Well 2 are completed in the same Solano subbasin (Tehama formation) and are located only 1,000 feet apart. To best ensure that the new production well has the same water production capability and produces water with arsenic levels lower that the 10 ppb, the well should be located as close as possible to Well 1.

As discussed in Section 4, the MDD can be met with a single well. Therefore, it is not required that Well 1 and the new well operate at the same time, thus there would not be a concern with mutual pumping interference.

The main down-side for the new well option is the cost. **Table 3** includes a cost summary for a new well replacement project ($1,350,000). The well cost component ($750,000) is based upon the Well 1 design, well development, testing, and LSCE's experience with recent wells constructed and equipped with steel well casing, stainless steel blank casing, stainless steel louvered well screen(s), a sounding pipe, and a gravel fill pipe. The well pump station upgrade cost component associated with this option ($250,000) includes a new well pump and motor, pump pedestal, piping and controls, chemical disinfection system upgrades, and electrical improvements. **Table 3** includes a summary of the contingency costs that cover unanticipated construction costs, design and planning, construction management, and program administration.

Another con of constructing a new well, besides cost, is that there is still some risk that the water quality could still exceed the 10 ppb arsenic standard. A pro of the new well option is that the long-term cost for operating the well would be less than the well treatment to remove arsenic discussed below. In addition, having a new well enhances long term system reliability, i.e. both Well 1 and No. 2 are already 16 years old (the life expectancy of a new well is expected to be about 40 to 50 years).

Table 3: Planning Level Cost Estimate for New Well & Pump Station

Item	Planning Level Cost Estimate
Well Construction	$750,000
Well Pump and Station Piping Construction	$250,000
Capital Cost Subtotal:	$1,000,000
Construction Contingency (10%)	$100,000
Design & Planning (10%)	$100,000
Construction Management (10%)	$100,000
Project Administration/Management (5%)	$50,000
Total:	$1,350,000

Notes:

1) Construction (10% contingency allowance): Costs are representative of the construction under normal construction conditions and schedules. Consequently, it is appropriate to allow for estimating and construction uncertainties unavoidably associated with conceptual planning of projects. Factors such as unexpected construction conditions, the need for unforeseen mechanical items, variations, and final quantities are only a few of the items that can increase project costs.

2) Design and Planning (10% contingency allowance): Design and planning services associated with new facilities include preliminary investigations and reports, right-of-way acquisition, foundation explorations, preparation of drawings and specifications for construction, surveying and staking, sampling of testing material, and start-up services. The cost of these items may vary, for example, the new well cost will be on or close to the Well 1 site, reducing the need for a design/planning contingency.

3) Construction Management (10% contingency allowance): Construction management covers contract management and inspection during construction. For this study, it is assumed that construction management costs will equal 10 percent of the base construction cost.

4) Program Administration (5% contingency allowance): Program administration covers items such as legal fees, environmental/CEQA compliance requirements, financing expenses, and interest during construction. The cost of these items may vary, but for this study, it is assumed that program administration costs will equal 5 percent of the base construction cost.

Option 3: Well 2 Structure Modifications to Limit Arsenic Levels

As indicated in **Table 1** and **Figure 1**, Well 2 is screened across two depth intervals. The uppermost screen was constructed from 1,071 to 1,099 feet below ground surface (bgs), and the lower screen was constructed from 1,210 to 1,240 feet bgs. Conceptually, it is possible, if information was available on which screened section is the source of arsenic that is entering the well, to physically modify the well to limit the entry of arsenic. Example well modifications include installation of a well liner/sleeving, packer installation, swaging, and well plug-backing. It should be recognized that well modifications that limit the entry of water into the well casing will result in an increase of pumping water level and a resulting increase in power costs.

LSCE conducted packer testing in 2001 to evaluate the technical feasibility of making Well 2 structural modifications to limit entry of arsenic; i.e. packer tests were conducted to define the vertical distribution of water quality (arsenic) and hydraulic conductivity (pathways for water and contaminant movement). A packer test consists of isolating sections of a well using inflatable packers (bladders) so that water-quality samples can be collected and aquifer tests can be conducted.

The results of LSCE packer testing are summarized in **Table 4.** The packer tests results show that arsenic is entering the well through both well screen intervals at concentrations that exceed the MCL limit (see **Table 4**). Therefore, the packer test results suggest that Option 3 of implementing Well 2 structural modifications to limit entry of arsenic by restricting flow through either well screen is technically unfeasible and therefore Option 3 is dropped from further consideration.

Table 4: Well 2 Packer Test Results

Screened Area	Upper Screened Interval 1071 – 1099' bgs			Lower Screened Interval 1210 – 1240' bgs		
Date	11/07/2001			11/08/2001		
Test Duration	8 Hours			8 Hours		
Static Water Level	126.9 feet			129.8 feet		
Average Discharge Rate	111 gpm			162 gpm		
Drawdown	78.9 feet			37.6 feet		
Specific Capacity (24 Hours)	1.3 gpm/ft.			4.2 gpm/ft.		
Testing Interval	**As**	**Mn**	**Fe**	**As**	**Mn**	**Fe**
2-Hour	0.016	ND	0.250	0.016	0.069	0.250
4-Hour	0.015	ND	0.220	0.018	0.071	0.300
6-Hour	0.016	ND	0.190	0.018	0.070	0.280
8-Hour, Filtered	0.015	ND	0.130	0.019	0.069	0.250
8-Hour	0.017	0.015	0.250	0.016	0.066	0.250

Notes:

1) All units ppm.
2) Arsenic (As) MCL= 0.010 ppm; Manganese (Mn) MCL= 0.050 ppm, Iron (Fe)= 0.300 ppm.

Option 4: Water Treatment Options

As discussed above, for purposes of this report, the proposed Well 2 water treatment system must be capable of treating 350 gpm (MDD), and enough arsenic must be removed to meet the 10 ppb MCL water quality standard for arsenic.

A wide range of technologies has been developed for the removal of high concentrations of arsenic from drinking water. The most common arsenic removal technologies use oxidation, coagulation, precipitation adsorption, ion exchange, and membrane techniques.

There are several Well 2 treatment option available for removing arsenic. Most arsenic removal technologies will fall into three treatment categories and treatment subgroups:

- Adsorption media processes:
  - Activated alumina
  - Granular ferric hydroxide
  - Ion Exchange
- Chemical Precipitation Processes:
  - Iron and manganese removal with co-precipitation of arsenic
- Membrane processes: processes:
  - Reverse osmosis
  - Nanofiltration
  - Electrodialysis (ED) and Electrodialysis Reversal (EDR)

Of the various treatment technologies listed above, ion exchange and all membrane processes (reverse osmosis, nanofiltration, and electrodialysis and electrodialysis reversal), although capable of removing arsenic, were ruled out because of high process operation and maintenance costs and because of the technical challenges and costs for managing residuals generated as part of the treatment process. Both the adsorptive media process and the chemical precipitation process were retained for further consideration and are discussed further below.

Adsorptive Media Versus Chemical Precipitation

This section presents a brief discussion of various adsorptive media and the chemical precipitation process technologies and includes a comparison based upon four main criteria:

1. Water quality characteristics (including pH levels and initial concentrations of Fe, As(III), As(V), and other ions present in the water that can interfere with treatment);
2. Ease of implementation with current system (Well 2 treatment will occur at the Well 1 site);
3. Residual management (all treatment options include the generation of a waste product that must be managed); and
4. Cost.

Adsorption Media Processes

Arsenic can be removed by passing untreated water though adsorptive granular media contained in a pressure vessel. As the water passes through the media, the negatively charged arsenic ions are adsorbed onto the surfaces of the positively charged media particles. There are several adsorption media available: activated alumina (AA), titanium based media, zirconium based media, and iron based sorbents. The most common media include modified activated alumina and iron-based materials.

RNVWD has pursued adsorption media treatment and has contacted many vendors over the past three years that offer skid-type well head treatment units. LSCE re-established contact with the following adsorptive media vendors:

- Denova/Severn Trent Services (media type: Sorb 33/E33)
- AdEdge Technologies (media type: granular iron media/E33)
- Applied Process Equipment (APE Water) (media type: Purolite-Bayoxide E33 replacement, Isolux – zirconium base; and EP Minerals – lanthanum based).

Generally, adsorptive type well head treatment units are relatively low-cost and simple to operate. However, competing ions present in Well 2 groundwater will cause the media to be inefficient in terms of adsorption of arsenic, and the therefore the operational cost to replace media can be very high depending upon the volume of water to be treated. As discussed in Section 5 above, recent analytical testing of Wells 1 and 2 for both metals and general chemistry indicate that Well 2 has elevated levels of silica, phosphorus, and vanadium. These ions compete for adsorption sites and negatively impact arsenic removal performance using adsorptive media. The vendors all reported (based upon media model runs) that the adsorptive media is not well suited for treatment of Well 2 because of the silica, orthophosphate, and vanadium constituents that are consuming the media. The only way that the adsorptive media process can compete with the chemical precipitation process in terms of operational cost is if the volume of Well 2 water is minimized (i.e. treating less volume means the adsorptive media will last longer before being spent and having to be replaced with new media).

Conversation with the RNVWD general manager indicated a reasonable assumption may be to assume that Well 1 could be off-line for a two-month period, and therefore Well 2 treatment would be needed for this two-month down-time. LSCE evaluated recent water use records and determined the maximum volume to be treated for a two-month period occurs during the summer months. As illustrated, in **Figure 2**, the maximum two-month volume of water to be treated is about 12 MG. Therefore, for operational cost purposes, it is assumed that the Well 2 treatment system will operate for a two-month period and treat 12 MG.

The adsorptive media systems require backwash to remove particulates and redistribute the bed material. The liquid residuals from the filter backwashing step contain low concentrations of arsenic that may have to be managed. Spent media will also need to be tested/disposed of as either a solid or hazardous waste. In some cases, spent media can be regenerated off-site.

Chemical Precipitation Processes

Oxidation/filtration is a precipitative process used to remove arsenic. In oxidation/filtration processes, groundwater pumped from Well 2 is passed through a vessel of manganese-oxide (MnOx) media which adsorbs and catalyzes the oxidation of the iron and manganese. The filtering capacity of the granular manganese-oxide media then retains the precipitated iron, manganese, and arsenic until it is backwashed out of the vessel. Backwashing creates wastewater and sludge that must be properly disposed as discussed below. Arsenic appears to be removed primarily by the iron precipitates as opposed to those of manganese. Because the Well 2 groundwater has low levels of influent iron (less than 1.5 mg/L or less than 20:1 ratio with arsenic) adding ferric chloride prior to oxidation will likely be required. Recent water quality data is included in **Appendix A**.

Manganese-oxide (MnOx) media, which include manganese greensand and pyrolusite, are commonly used in oxidation/filtration processes because of their unique adsorptive and catalytic capabilities. Greensand is manufactured by coating glauconite with manganese dioxide, while pyrolusite is a naturally mined ore composed of solid manganese dioxide. Greensand media has been shown to be capable of removing up to 80% of arsenic by oxidation and adsorption. It is generally recommended that greensand be preceded by a 12-inch anthracite cap to filter any precipitated iron particulates before the green sand.

For greensand to retain its adsorption and catalytic oxidation capabilities for iron and manganese removal, the media must be regenerated, typically using chlorine. The sodium hypochlorite oxidant is added ahead of the filter where it provides continuous oxidation of the contaminants as well as regeneration of the MnOx media. Arsenic adsorbs to the iron floc formed in this chemical oxidation step and is physically filtered from solution by the greensand. Any arsenic that is not oxidized is adsorbed onto the MnO_2 surface of the greensand particles.

RNVWD has considered Well 2 oxidation/filtration treatment processes and has contacted many vendors over the past three years that offer skid-type well head treatment units. In addition, LSCE contacted two additional vendors. Vendors that provided input on the Well 2 project include:

- Tonka Water/Hopkins Technical Products (media type: Tonka Water IMAR™ filter media)
- AdEdge Technologies (media type: APU26 Coagulation/Filtration)
- Hungerford & Terry/Ward Technical Products (media type: Greensand Plus Filtration System)
- ATEC Systems (media type: AS 741 M pyrolusite)
- Loprest Water Treatment (media type: Greensand or Filter Sand/Anthracite)

Comparison Summary - Adsorptive Media vs Chemical Precipitation

A comparison the adsorptive media and chemical precipitation options are presented in **Table 5.** Both adsorptive media and chemical precipitation processes are effective in removing arsenic to levels below the 10 ppb MCL standard. Adsorptive media units can achieve a relatively lower concentration of arsenic and this in turn may allow for blending of Well 2 (i.e. the incoming flow from Well 2 can be split prior to treatment resulting in a blend of Well 2 treated water with Well 2 untreated water, effectively reducing the filter unit size and cost). Also, should the DDW lower the arsenic standard in the future, the adsorptive media option is preferred as it can achieve a finished water quality that has a much lower concentration of arsenic than the current MCL.

As discussed above, recent RNVWD testing indicates that Well 2 has elevated levels of silica, phosphorus, and vanadium. These ions compete for adsorption sites and negatively impact arsenic removal performance using adsorptive media. The adsorptive media is not well suited for treatment of Well 2 because of the silica, orthophosphate, and vanadium constituents that would consume the media. Because of the unique Well 2 water quality and the presence of competing ions for adsorption, the only way that the adsorptive media process can compete with the chemical precipitation process would be if the total volume of water to be treated is relatively low (i.e. Well 2 well head treatment will only operate if Well 1 is brought off-line for maintenance).

Table 5 indicates that the chemical feed requirements are similar for adsorptive media and chemical precipitation process, except that ferric chloride addition is required for chemical precipitation.

The ease of operation for an adsorptive media is less because of the need for additional chemical treatment and because of the operational needs associated with more sludge production in the case of chemical precipitation. In addition, the level of operator training and expertise required to operate an adsorptive media is less that the coagulation/filtration treatment process.

In terms of residual management, the adsorption process will generate spent media that retains the arsenic and therefore must be tested for hazardous waste and disposed at approved disposal site. However, the adsorption process generates a relatively low volume of filter media backwash water/sludge that must tested and disposed. It is likely that the backwash solids will be non-hazardous because the media will retain the arsenic. With the chemical precipitation, the volume of backwash water will be significantly more due to the addition of ferric chloride, and the arsenic will be present in the filter backwash water making disposal more of a potential problem because the backwash solids could require testing and judged to be hazardous, which increases disposal costs.

Finally, as shown on **Table 5**, the capital, construction cost, and probably the annual operation and maintenance costs, will be lower for the adsorptive media option. Again, this assumes that the total volume treated is 12 MG (the volume associated with having to treat for a two-months period). The annual operating cost will depend upon the residuals generated by the treatment process and the cost for residual permitting, transportation, and disposal.

Option 4 capital costs for adsorptive media treatment ($750,000) is estimated to be lower than chemical precipitation treatment ($950,000). The operational costs for an adsorptive media is also less than the coagulation/filtration treatment process because of the need for additional chemical treatment and because of the operational needs associated with more sludge production in the case of chemical precipitation. Both adsorptive media chemical precipitation units will have media filters that must be conditioned and have chemical feed systems that must be operated more-or-less monthly to ensure an ability to effectively remove arsenic when called upon to operate (when Well 1 fails to operate and must be brought off-line). Although well head treatment may be used infrequently, the operating costs and ease for the RNVWD operators to carry out routine operations to ensure the Well 2 treatment system is available at a moment's notice, is expected to be lower for adsorptive media units than for chemical precipitation units. Pilot testing (discussed below) will be used to verify cost assumptions.

Table 5: Comparison of Treatment Technologies

Treatment Process	Adsorption Media	Coagulation/Filtration
Arsenic Species	As (V) > As (III)	As (V) > As (III)
Competing Ions in Well 2 (silica, phosphorus, and vanadium)	Large Impact on treatment efficiency	Moderate Impact
Chemical Feed	• Acid to depress pH • NaOH base to raise pH for corrosion • Coagulant for solids	• Pre-oxidation • Acid to depress pH • NaOH base to raise pH for corrosion • Requires ferric chloride addition • Coagulant for solids
Ease of Operation	Relatively simple	Relatively more complex
Residual Management	• Spent media is tested for hazardous waste and disposed at approved disposal site • Generates relatively low volume of filter media backwash water/sludge that must tested and disposed—likely non-hazardous, but could involve dewatering	• Generates backwash water and more sludge than adsorption, it also contains arsenic and must be tested • POTW may not accept • Dewatering backwash sludge may be required, may be tested, and judged to be hazardous
Vendors Capital Cost	$300,000	$400,000
Construction Capital Cost	$250,000	$300,000
Total Capital Cost	$550,000 (not including sludge dewatering if required) $750,000 with contingency costs that cover unanticipated construction costs, plus design and planning, construction management and program administration (see Table 3)	$700,000 (not including sludge dewatering if required) $950,000 with contingency costs that cover unanticipated construction costs, plus design and planning, construction management and program administration (see Table 3)
Annual O&M (assumes total volume treated is 12 MG- the volume associated with max two-month flow)	• Depends upon media replacement rate to be determined by Pilot Testing • Cost will be lower than coagulation/filtration option	• Depends upon sludge production rate and testing determined by Pilot Testing • Cost will be higher than adsorption media option

Conclusions Regarding Options 1 through 4

Option 1: Blending Well 2 water with Well 1 to achieve an arsenic level that meets the 10 ppb standard is not feasible because if Well 1 is out-of-service for any reason, Well 2 would not be able to produce water that meets the arsenic MCL of 10 ppb.

Option 2: Construction of a new, low arsenic well to replace Well 2 is technically feasible. Well 1 produces water with arsenic levels about half the 10 ppb MCL. Therefore, this option would involve constructing a new well located as close as possible to Well 1. A new well replacement project is estimated to cost $1,350,000. Unfortunately, there would still be some risk that the water quality could still exceed the 10 ppb arsenic standard.

Option 3: LSCE conducted packer testing which suggests that modifications to the existing Well 2 structure to limit arsenic entry into the well casing is technically unfeasible.

Option 4: Well 2 treatment is technically feasible and can more reliably meet the 10 ppb arsenic standard when compared to all options. In addition, the capital cost for Option 4 is less than the only other technically feasible option (Option 2). The annual operating cost for Option 4 is more than Option 2, but the lower operating cost for Option 2 is judged to not be significant enough to off-set the risk of not meeting the 10 ppb arsenic standard.

If RNVWD will pursue Well 2 treatment, the next steps in the process includes pilot testing and preparation of an engineering feasibility report as described further below.

Pilot testing

Well 2 pilot testing is required to determine the optimum configurations and operating conditions for meeting the drinking water standard for arsenic. The pilot testing will also provide information on the quantity of residuals generated by treatment and whether the residuals are hazardous or nonhazardous. In summary, the purpose of performing a Well 2 pilot test are as follows:

1) To determine whether and under what operating conditions the technology can remove arsenic to meet the 10 ppb MCL requirement;
2) To determine residuals characteristics when the technology is operated to achieve sufficient arsenic removal;
3) To determine optimum operating parameters to remove sufficient arsenic while maintaining non-hazardous residual generation; and,
4) The pilot test is needed to establish a guaranteed treatment removal effectiveness (contractual commitment between the vendor and RNVWD).

Based on the analyses above, the adsorptive media process is preferred over the chemical precipitation process. However, because of competing ions present in Well 2 groundwater, and because of the uncertainty regarding residual management options and costs, LSCE recommends pilot testing both the adsorptive media and the chemical precipitation processes. Pilot testing costs about $10,000 to $20,000 per test. LSCE also recommends selecting a pilot testing company from the list of adsorptive media and chemical precipitation process vendors discussed above.

The Well 2 pilot testing will require that Well 2 be pumped to waste at the design flow of 350-gpm. Since the duration of the pilot testing could extend over a several week period, the pilot testing should be conducted during the summer months so that the water can used for irrigation purposes.

RNVWD has no information on the well pump and motor installed in Well 2. Therefore, additional well and pump field testing can be conducted in conjunction with the pilot testing to acquire information on Well 2 pump hydraulics, motor horsepower requirements, and overall operating efficiency. In addition, the well could be tested for specific capacity and the results compared to the specific capacity measured at the time Well 2 was originally constructed (see **Table 2**).

Engineering Feasibility Study and Conceptual Design

The engineering feasibility study and conceptual design of Well 2 treatment system should be completed following pilot testing. The engineering feasibility study would address the following:

- Summarize pilot testing results and compare the technical feasibility and treatment costs for adsorptive media versus chemical precipitation;
- Determine the optimum treatment unit configurations and conceptual layouts (space requirements);
- Summarize the quantity and quality of residuals generated as determined by pilot testing and costs for residual permitting, transportation, and disposal;
- Evaluate filter backwashing requirements and backwash source-water pros and cons for backwashing the units (compare using RNVWD distribution system water versus designing the filter units to be able to sequentially backwash using filter-unit treated water);
- Define chemical feed requirements and modifications needed to upgrade existing chemical feed and storage facilities.
- Assess system hydraulics (i.e. evaluate the need for Well 2 pump and motor modifications based upon head requirements for well head treatment);
- Define measures needed to prevent RNVWD from being locked into a single system/vendor with no option available to competitively bid future upgrades and media exchanges;

The proposed Well 2 water treatment system will be located at the Well 1 site as shown on **Figure 3.** Fortunately, when Well 1 was originally constructed, provisions were made to add future treatment of Well 2 water at Well 1 site. As **Figure 3** indicates the Well 2 water is currently routed to the Well 1 site and joins Well 1 just in front of the existing hydro-pneumatic tank. A picture of the Well 1 site (see **Figure 4**) shows many of the salient features included in **Figure 3**.

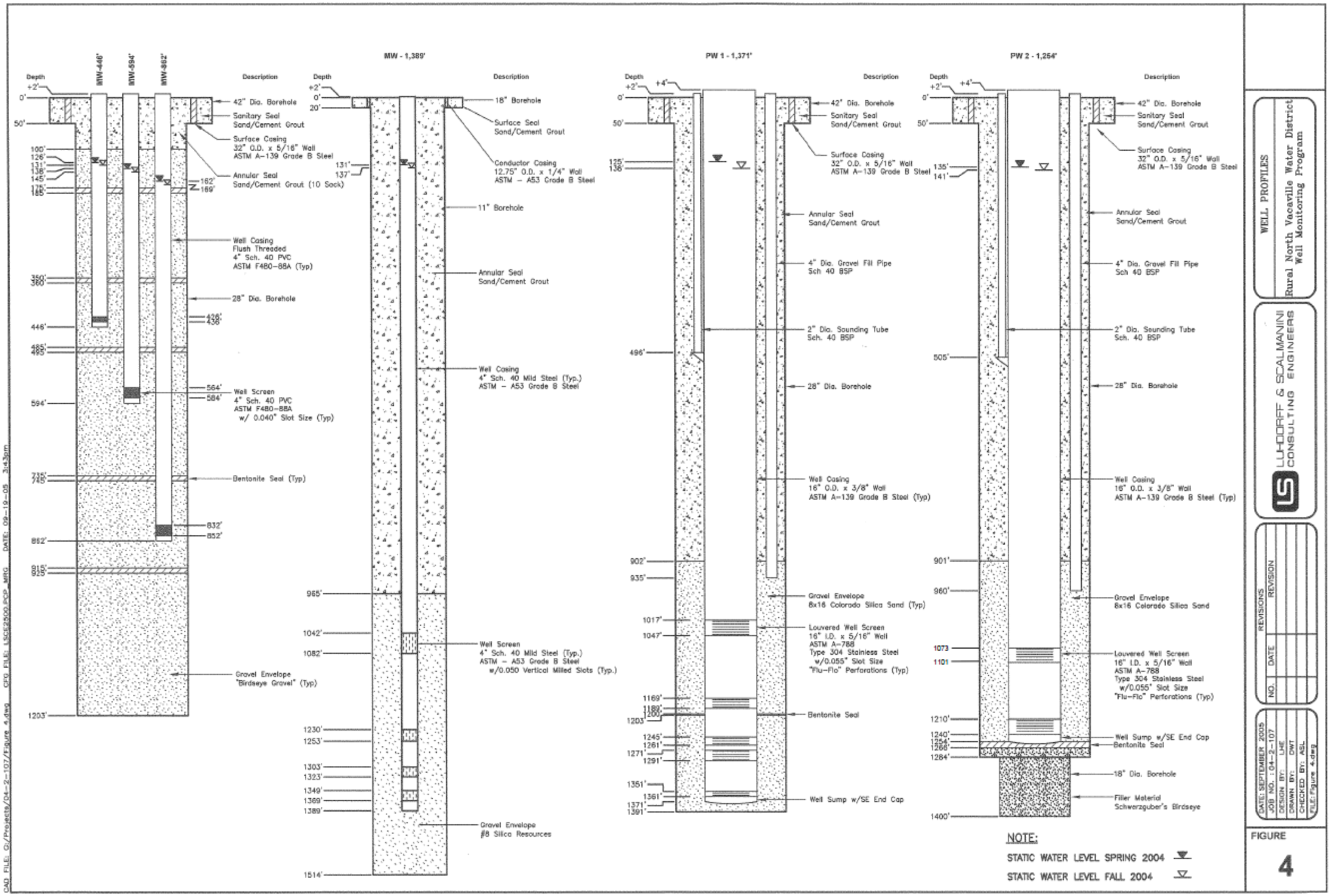
Conclusions and Recommendations

1) Well 2 has arsenic concentrations ranging from about 5 to 21 parts per billion (ppb) and exceed the 10 ppb regulatory standard.
2) RNVWD desires to improve water supply reliability by reducing arsenic levels in Well 2 and retained LSCE to assessing possible Well 2 options that could lower arsenic levels:
    5. Option 1- blending Well 2 water with Well 1 to achieve an arsenic level that meets the 10 ppb standard;
    6. Option 2- construction of a new, low arsenic well to replace Well 2;
    7. Option 3- make modifications to the existing Well 2 structure to limit arsenic entry into the well casing;
    8. Option 4- construct groundwater treatment facilities to remove arsenic.
3) DDW classifies Well 2 as an emergency standby groundwater source and therefore Well 2 can only be used for short term emergencies of 5 consecutive days or less and less than 15 calendar days a year. Changing Well 2 to "active" status instead of "standby" would improve RNVWD's system reliability.
4) DDW requires RNVWD's water supply to meet the Maximum Day Demand (MDD). MDD is defined as the largest volume of water delivered to the system in a single day expressed in gallons per day. LSCE assumes that any Well 2 improvement option to reduce arsenic must result in Well 2 being able to meet the MMD demand of 0.494 million gallons (MG) or 350 gpm.
5) Option 1- blending Well 2 water with Well 1 to achieve an arsenic level that meets the 10 ppb standard is not feasible because if Well 1 is out-of-service for any reason, Well 2 would not be able to produce water that meets the arsenic MCL of 10 ppb.
6) Option 2- construction of a new, low arsenic well to replace Well 2 is technically feasible. Well 1 produces water having arsenic levels about half the 10 ppb MCL. Therefore, this option would involve constructing a new well located as close as possible to Well 1. A new well replacement project is estimated to cost $1,350,000. Unfortunately, there would still be some risk that the water quality could still exceed the 10 ppb arsenic standard.
7) LSCE conducted packer testing which suggests that Option 3 modifications to the existing Well 2 structure to limit arsenic entry into the well casing is technically unfeasible.
8) A wide range of technologies has been developed for the removal of arsenic from well water. However, the two most feasible Option 4 treatment processes involve use of adsorptive media or chemical precipitation. Adsorptive treatment units are relatively low-cost and simple to operate; however, competing ions present in Well 2 groundwater will cause the media to be inefficient in terms of adsorption of arsenic. The only way that the adsorptive media process can compete with the chemical precipitation process, in terms of operational cost, is if the volume of Well 2 water is minimized (i.e. treating less volume means the adsorptive media will last longer before being

spent and having to be replaced with new media). Conversations with the RNVWD general manager indicated a reasonable assumption may be to assume that Well 1 could be off-line for a two-month period and therefore Well 2 treatment would be needed for this two month down-time.

9) Option 4 (Well 2 treatment) is technically feasible and can more reliably meet the 10 ppb arsenic standard when compared to all options. In addition, the capital cost for Option 4 ($750,000 to $950,000) is less than the only other technically feasible option (Option 2 - $1,350,000). The annual operating cost for Option 4 is more than Option 2 (the new well option); however, the lower operating cost for Option 2 is judged not to be significant enough to off-set the risk of possibly not being able to meet the 10 ppb arsenic standard.
10) Option 4 capital costs for adsorptive media treatment ($750,000), is estimated to be lower than chemical precipitation treatment ($950,000). The operational costs for an adsorptive media assuming infrequent operation (i.e. Well 2 is used only when Well 1 fails to operate and must be brought off-line) is also less than the coagulation/filtration treatment process because of the need for additional chemical treatment and because of the operational needs associated with more sludge production in the case of chemical precipitation. In addition, the level of operator training and expertise required to operate an adsorptive media system is less than the coagulation/filtration treatment. Both adsorptive media chemical precipitation units will have media filters that must be conditioned and have chemical feed systems that must be operated more-or-less monthly to ensure an ability to effectively remove arsenic when called upon to operate (when Well 1 fails to operate and must be brought off-line). Although well head treatment may be used infrequently, the operating costs for the RNVWD operators to carry out routine operations to ensure the Well 2 wellhead treatment system is available at a moment's notice is expected to be lower for adsorptive media units than for chemical precipitation units. Pilot testing will be used to verify cost assumptions.
11) Pilot testing is required to determine the optimum Well 2 water treatment configurations and operating conditions for meeting the drinking water standard for arsenic. The pilot testing will also provide information on the quantity of residuals generated by treatment and whether the residuals are hazardous or nonhazardous.
12) An engineering feasibility study and conceptual design would follow the pilot testing that would compare the technical feasibility and treatment costs for adsorptive media versus chemical precipitation, determine the optimum treatment unit configuration, quantity and quality of residuals generated, and costs for residual permitting, transportation, and disposal.
13) The proposed water treatment system will be located at the Well 1 site where provisions already exist for adding future treatment of Well 2 water at the Well 1 site.

LIST OF FIGURES



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CONSULTING ENGINEERS

Figure 1
Well 1 & 2 Profiles

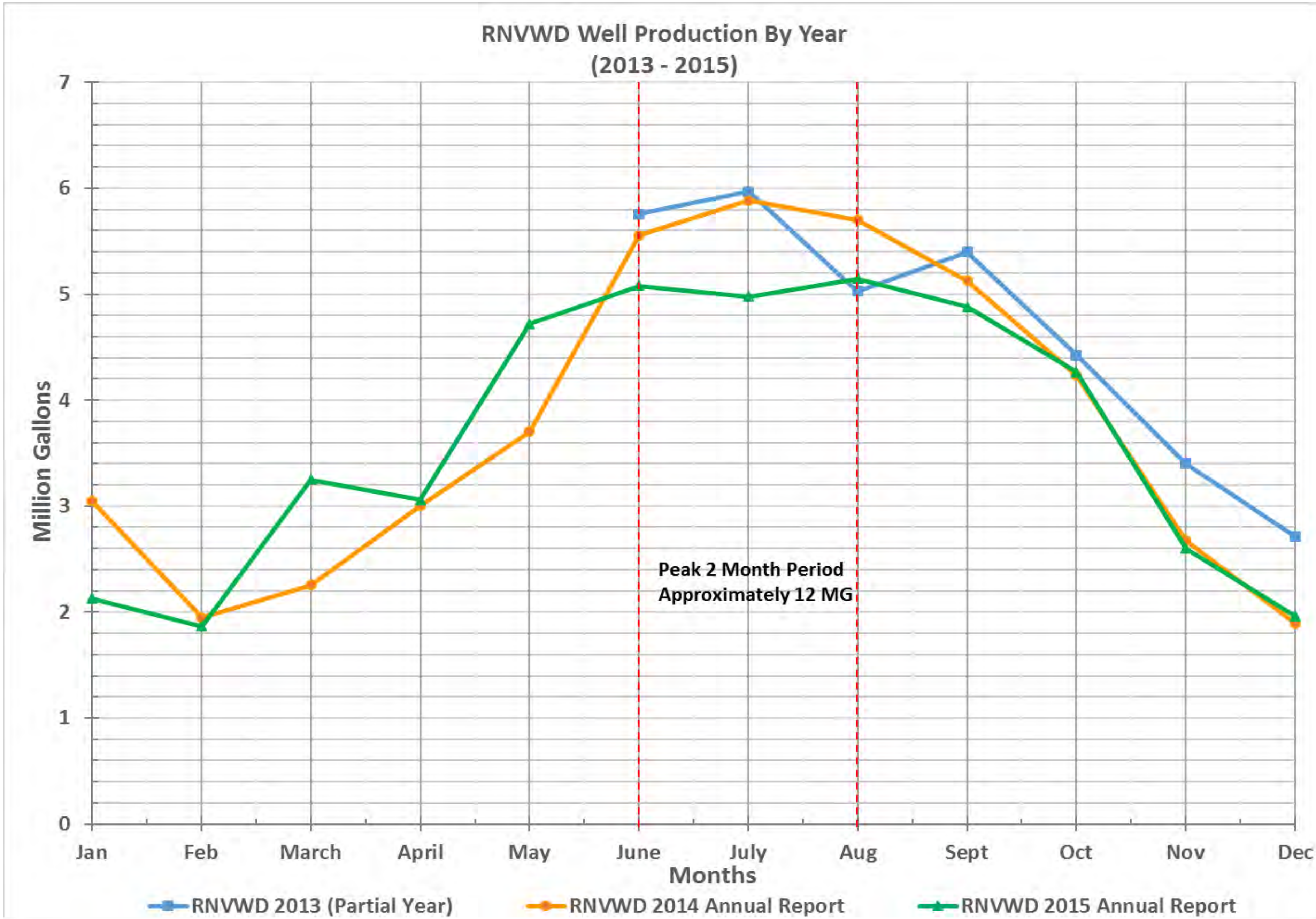

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Figure 2
Peak Volume for 2 Month Period

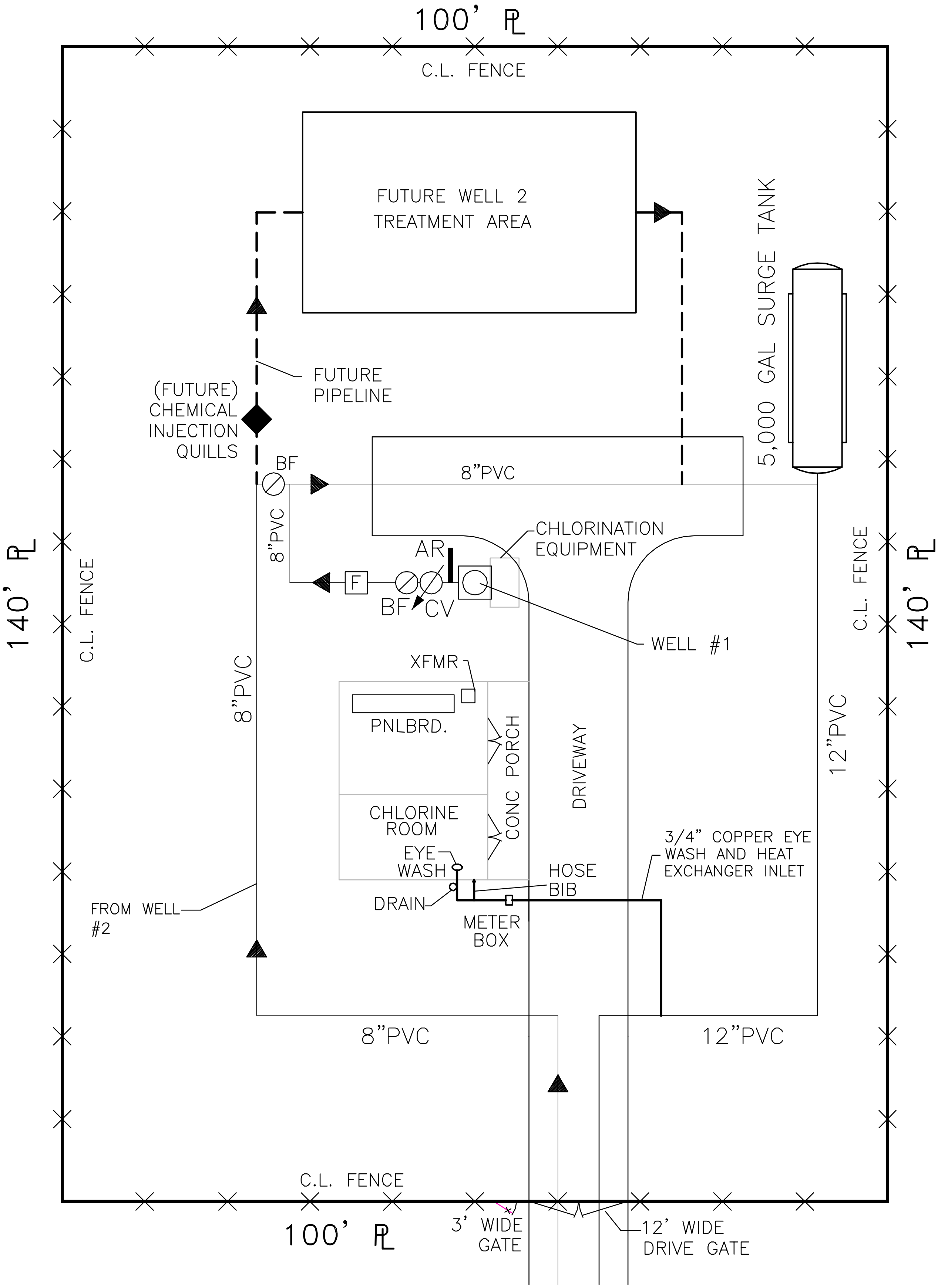

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Figure 3
Well 1 Layout with Provisions for Future Well 2 Treatment

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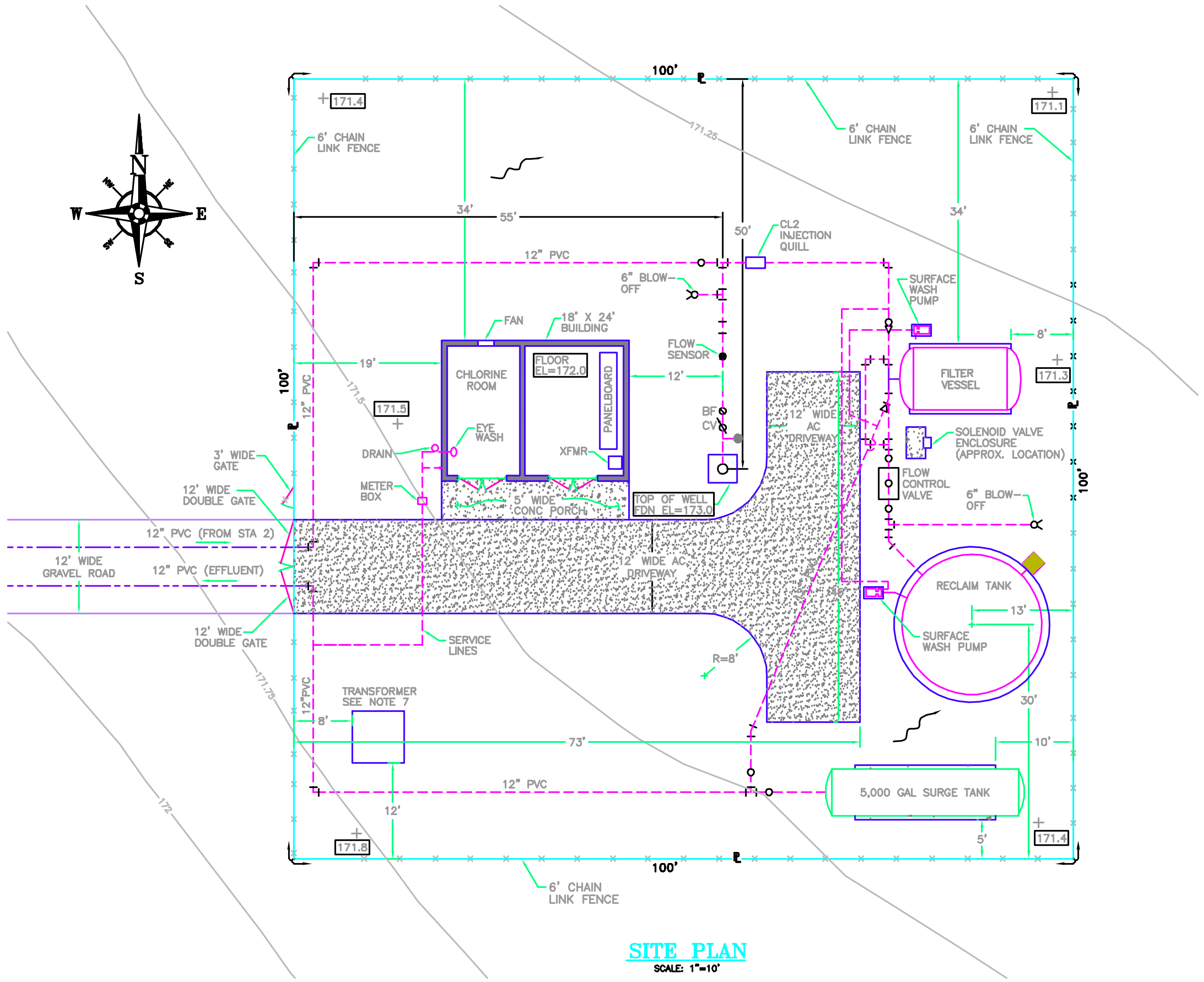
Figure 4 (Picture)
Well 1 Layout with Provisions for Future, Well 2 Treatment

APPENDIX C – Well No. 1 Site Plan

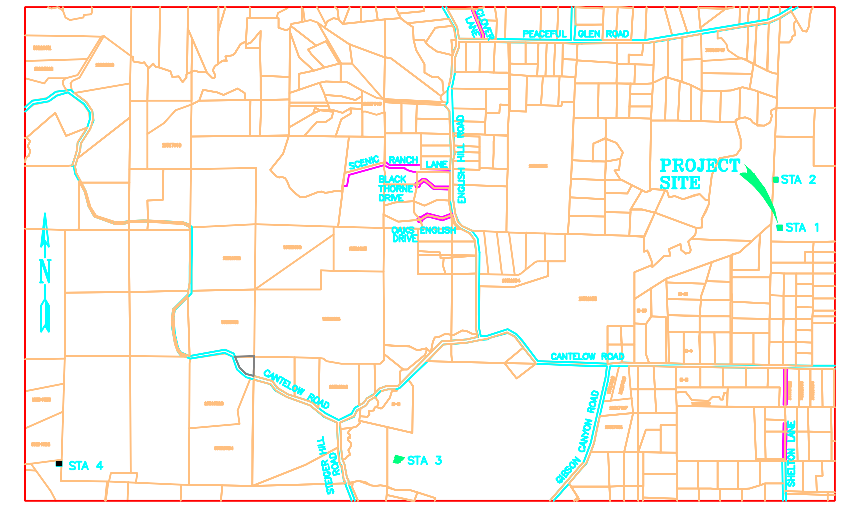
Site Plan

Pipe Schematic



SITE PLAN

SCALE: 1"=10'



VICINITY MAP

N.T.S.

PROPOSED FACILITIES

1. ONE–WELL
2. ONE–PUMP & MOTOR: 75 HP, 500 GPM±
3. ONE–CONC. BLOCK BUILDING: 18' X 24'
4. ONE–FILTER VESSEL
5. ONE–RECLAIM TANK
6. ONE–5,000 GAL SURGE TANK
7. ONE–ELECTRICAL PANELBOARD
8. ONE–TRANSFORMER

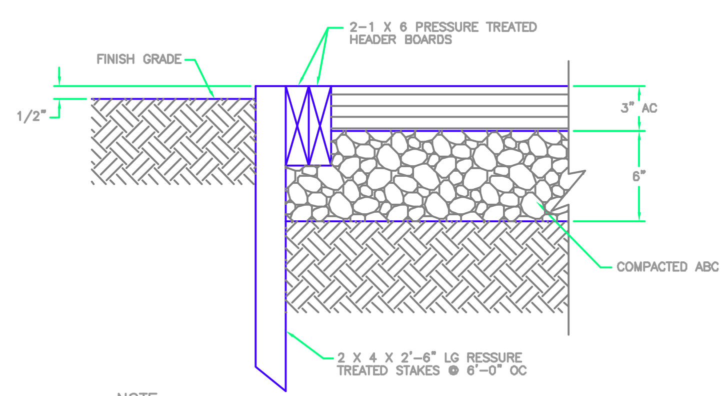
GENERAL NOTES

1. SITE PREPARATION: CONTRACTOR SHALL CLEAR AND GRUB ALL GRASS, WEEDS AND DEBRIS FROM SITE.
2. BUILDING AND SURGE TANK FOUNDATION PREPARATION: AREAS TO RECEIVED FILL SHALL BE SCARIFIED TO A DEPTH OF SIX INCHES AND WATERED TO PROVIDE A MOISTURE CONTENT COMMENSURATE WITH EFFICIENT DENSIFICATION, AND COMPACTED TO 90% OF THE MAXIMUM DRY DENSITY PER ASTM D1557.
3. NON STRUCTURAL AREA SHALL BE GRADED TO FINAL ELEVATIONS AND THEN SCARIFIED, WATERED, AND COMPACTED TO 85% OF MDD.
4. DRIVEWAY SHALL BE 3" ASPHALT CEMENT. SUBBASE SHALL BE GRADED AND COMPACTED AS DESCRIBED IN NOTE 2 ABOVE, EXCEPT THE AREA SHALL BE COMPACTED TO 95% MDD.
5. CONTRACTOR SHALL GRADE THE SITE TO FINAL ELEVATIONS AS SHOWN FOR PROPER SURFACE DRAINAGE.
6. CONTRACTOR SHALL PROVIDE AND INSTALL TRANSFORMER AND FOUNDATION, AND SHALL CONTACT PG&E FOR ALL SIZES AND REQUIREMENTS. THE REQUIREMENTS MAY INCLUDE FENCING AND/OR BARRIER POSTS. THE EXACT LOCATION IS UNKNOWN AT THIS TIME. IF THE FINAL LOCATION IS DIFFERENT FROM THIS PLAN, CONTRACTOR TO NOTIFY C.W.S.C. AS SOON AS POSSIBLE.
7. IMPORT FILL
   A) IMPORTED FILL MATERIAL FOR BUILDING, DRIVEWAY AND TURNAROUND AREA SHALL CONSIST OF ESSENTIALLY GRANULAR, SILTY SANDS WITH LOW EXPANSION POTENTIAL AND FREE OF GRASSES, WEEDS, ROCKS, DEBRIS, AND SOLUBLE SULFATES IN EXCESS OF 1000 PARTS PER MILLION. IMPORT SOIL SHALL ALSO MEET THE FOLLOWING CRITERIA:

MAXIMUM % PASSING #200 SIEVE	50
MAXIMUM LIQUID LIMIT	40
MAXIMUM PLASTICITY INDEX	14
MAXIMUM R–VALVE	50
MAXIMUM EXPANSION PRESSURE (TEST METHOD CALL 301–F)	10 PSF

   B) IMPORT FILL FOR REMAINING PORTION OF SITE SHALL BE SANDY LOAM SUITABLE FOR PLANTING.
8. NOT IN CONTRACT:
   – TREATMENT VESSEL SUPPLIES EXCEPT 30,000 GAL RECLAIM TANK (SEE NOTE 10)
   – CHEMICAL FEEDING SYSTEM
   – CONSTRUCTION OF WELL
   – DEEP WELL VERT. TURBINE PUMP
   – ELECTRICAL PANELBOARD
9. FENCE SHALL BE 6' HIGH CHAIN LINK FENCE, 9 GA. 3" WIDE REDWOOD SLATS WITH A 12" WIDE DOUBLE GATE AND A 3' WIDE WALK–IN GATE, SET ON PROPERTY LINES.
10. CONTRACTOR TO PROVIDE AND INSTALL ONE BOLTED RECLAIM TANK AND SLAB FOUNDATION. CONTRACTOR SHALL PROVIDE STRUCTURAL CALCULATION FOR FOUNDATION PER LATEST UBC.
11. PAINTING: ALL WORK WILL BE DONE IN ACCORDANCE WITH C.W.S.C. FACILITIES PAINT SPECIFICATION. REFER ALL SURFACE PREPARATION REFERENCES AND SPECIFICATION NUMBERS TO THE C.W.S.C. SPECIFICATIONS. C.W.S.C. WILL PROVIDE PAINT SPECIFICATIONS UPON REQUEST.

SUBSTRATE	SURF. PREP. REF.	COATS	SPEC NO.	DFT (MILS)
GALVANIZED, STAINLESS STEEL AND OTHER NON–FERROUS METALS	3.04 3.05–F	PRIMER INTERMEDIATE FINISH–INTERIOR PIPES AND PUMP HEAD LOUVERS, DOORS ETC FINISH–EXTERIOR	A–3 A–1 B16 B13 B–12	2~3 2~3 2~3 2~3 2~3



NOTE:
HEADER BOARDS AND STAKES SHALL BE ALL HEART REDWOOD.

AC DRIVEWAY DETAILS
REDWOOD HEADER

N.T.S.

LEGEND

PROPOSED AC DRIVEWAY

000.0 FINAL GRADE

172 EXISTING CONTOUR

FINAL SURFACE DRAINAGE FLOW DIRECTION

PIPING IN CONTRACT

PIPING NOT IN CONTRACT

Rural North Vacaville Water District
Solano County, California

DESIGNED FOR:
RURAL NORTH VACAVILLE WATER DISTRICT

ENGINEERING
CALIFORNIA WATER SERVICE CO.
DEPARTMENT

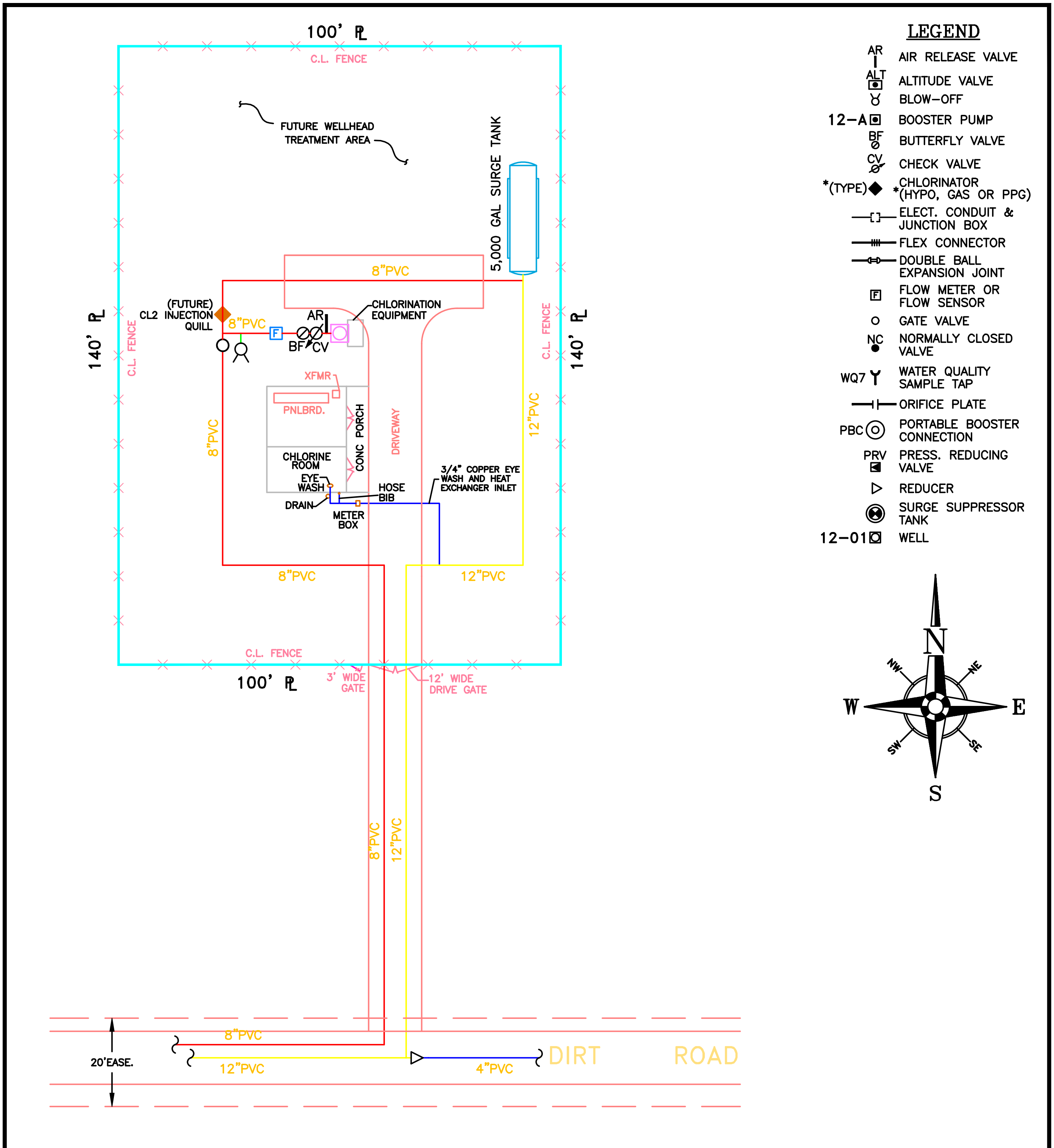
SCALE: AS SHOWN
DRAWN BY: M. FONG
DESIGNED BY: G. MeAMBER
CHECKED BY: DATE:
APPROVED BY: DATE:

REGISTERED PROFESSIONAL ENGINEER
HYOKSANG KWON
No. C51629
EXP. 6-30-02
CIVIL
STATE OF CALIFORNIA

TITLE:
STA 1-01 SITE PLAN

DISTRICT: RURAL NORTH VACAVILLE
DATE: 2/18/00
PROJECT ID.: GOD2391
DRAWING NO.: RNV-0002R1
SHT 1 OF 52

CADD FILE NUMBER: RNV0002-1



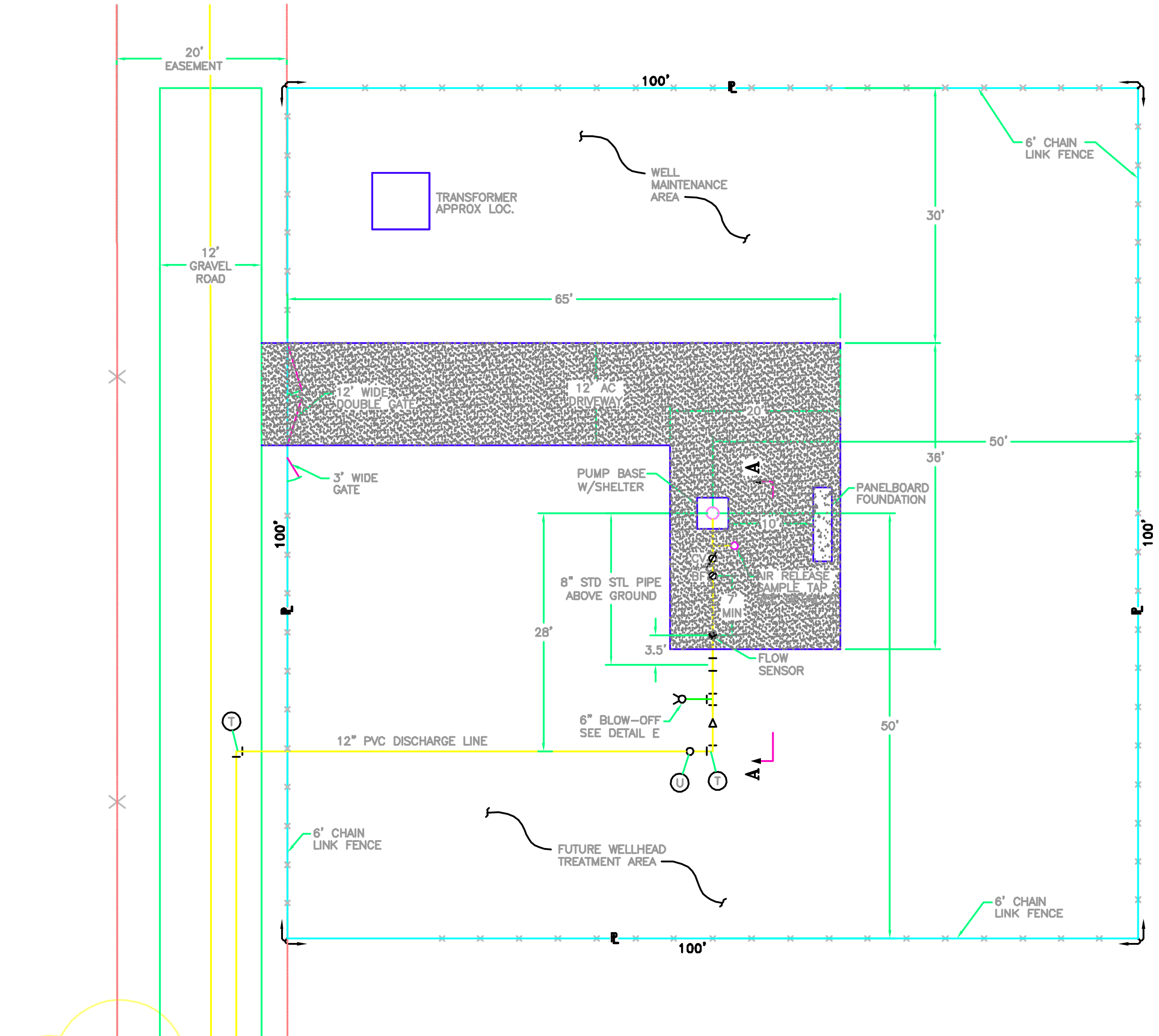
CADD DWG. FILE: RNV0005

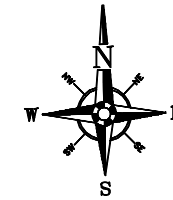
ENGINEERING DEPARTMENT CALIFORNIA WATER SERVICE CO.	TITLE: STATION 001 PIPING SCHEMATIC				REVISIONS:
	DISTRICT: RNV	DATE: 3-3-03	SCALE: 1"=30'	EST. NO.: 103000	PLAT NO.: L-15
	DRAWN BY: D.E.B.	CHECKED BY:	APPROVED BY:	DWG. NO.: RNV0005	

APPENDIX D – Well No. 2 Site Plan

Site Plan

Pipe Schematic





SITE PLAN

SCALE: 1"=10'

NOTES:

1) ALL FITTINGS ARE 125# PRESSURE RATED.

2) UNDERGROUND PROTECTION:
PROTECT UNDERGROUND FLEXIBLE COUPLINGS, BARE STEEL AND BOTS AS FOLLOWS:

a. THE ENTIRE AREA OF THE FITTING SHOULD BE DRY AND FREE OF DUST, DIRT OR OTHER FOREIGN MATTER, RUST OR OTHER FOREIGN MATERIAL SHOULD BE REMOVED BY SCRAPING OR WIRE BUSHING, WIPING WITH A DRY CLEAN CLOTH MAY BE NECESSARY TO REMOVE PARTICLES FROM BRUSH CLEANING. ANY OIL OR GREASE MUST BE REMOVED USING A LOW RESIDUE VOLATILE PETROLEUM SOLVENT BEFORE APPLICATION OF GREASE AND WRAPPING.

b. THE EXPOSED AREA SHOULD BE COATED WITH A HEAVY COATING OF METALGUARD #301 GREASE BY THE GLOVE METHOD TO A THICKNESS OF AT LEAST 1/4 INCH.

c. FIRMLY WRAP THE ENTIRE GREASE AREA WITH AT LEAST TWO LAYERS HALF LAPPED OF A WOVEN GLASS FILAMENT MESH (RES OR BIT WRAP, 4" WIDE) APPLY GREASE BETWEEN EACH LAYER DURING WRAPPING, WORKING THE GREASE INTO MESH OPENINGS.

d. COVER THE ENTIRE MESH WRAPPED AREA OF FITTING WITH AT LEAST 1/4" INCH THICK OF METALGUARD #301 GREASE BY GLOVE METHOD.

e. FIRMLY APPLY TWO LAYERS OF THE POLYWRAP TUBE OVER PROTECTED AREA BY SPLITTING THE TUBE AND TAPING THE POLYWRAP IN PLACE WITH THE PVC TAPE.

f. BACKFILLING MAY FOLLOW IMMEDIATELY AFTER THE POLYWRAP TUBE IS TAPED CLOSED.

3) THE PIPE FOOTAGE AND QUANTITY OF MATERIALS SHOWN ON DRAWINGS ARE ONLY ESTIMATES. CONTRACTOR SHALL DETERMINE HIS OWN ESTIMATES OF MATERIALS NEEDED.

4) WHEN ASSEMBLING A PVC C-900 PRESSURE PIPE TO AN IRON FITTING (PUSH-ON OR MECHANICAL JOINT), REMOVE ALL BUT 1/4 INCH OF THE FACTORY MADE BEVEL FROM THE SPIGOT END OF THE PIPE PRIOR TO INSTALLATION.

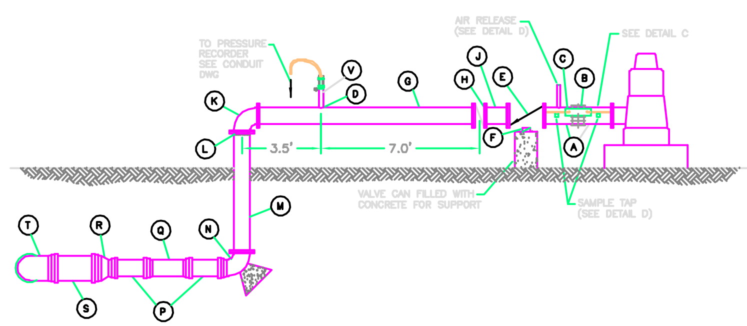
5) THRUST BLOCK ALL FITTINGS PER DETAIL.

LEGEND:

= TEE
= ELBOW, 45°
= ELBOW, 90°
= BLOWOFF (PROPOSED)
= BLOWOFF (EXISTING)
= GATE VALVE (PROPOSED)
= GATE VALVE (EXISTING)
= REDUCER (PROPOSED)
= REDUCER (EXISTING)
= SOLID PLUG
= PROPOSED WATER MAIN
= WATER MAIN NOT IN CONTRACT
= EXISTING WATER MAIN
SS = SANITARY SEWER
SD = STORM DRAIN
= FIRE HYDRANT (PROPOSED)
= FIRE HYDRANT (EXISTING)
= BUTTERFLY VALVE
= CHECK VALVE
= CPLG.

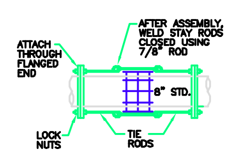
BILL OF MATERIALS

KEY	QTY.	DESCRIPTION
A	2	8" STD BLK PIPE FOE-POE, 1'-6" LONG
B	1	8" PIPE STD. FLEX CPLG. 5 SLV
C	1 SET	STAY RODS & CLIPS PER DETAIL
D	1	2" THREADOLET FOR 8" STD PIPE
E	1	8" CHECK VALVE FLG 125# LEVER & SPRING
F	1	3" X 6" WEDGEMOUNT AIR LOC HD
G	1	8" STD BLK PIPE FBE 10'-6" LONG
H	1	8" BUTTERFLY VALVE, FLG. 125#
J	1	8" FBE STL PIPE, 12" LONG
K	1	8" ELL DI CL 90° FLG 150#
L	1	8" SOW FLANGE 150#
M	1	8" STD BLK PIPE, FOE-POE, 5'-6" LONG (CUT TO FIT)
N	1	8" ELL DI CL 90° TJ X FLG 150#
P	2	8" PVC PIPE, 3' LONG (CUT TO FIT)
Q	1	8" X 6" TEE DI CL TJ
R	1	12" X 8" REDUCER DI CL TJ
S	1	12" PVC PIPE, 2'-6" LONG (CUT TO FIT)
T	2	12" ELL DI CL 90° TJ
U	1	12" GATE VALVE TJ
V	1	FLOW SENSOR (DATA INDUSTRIAL IR220B)
W	1	6" X 6" HYDRANT EXTENSION FLG. #150
X	1	6" COMPANION FLG. 6-HOLE
Y	1	6" PLUG THREADED
Z	1	6" X 36" HYDRANT BURY MJ X FLG 150#
AB	1	4" X 2" REDUCER STD GALV THREADED W/ 2" PLUG
AC	1	4" PIPE STD BLK TOE-POE 18" LONG
AD	2	2" THREADOLET F/ 4" STD BUTT WELD
AE	1	4" SOCKET F/ 8" STD BUTT WELD
AF	2	2" CLA-VAL #81-02 CHECK VALVE SCREWED, CL 125, C.I. BODY BRONZE TRIM, LESS OPENING SPEED CONTROL, CLOSING SPEED CONTROL ONLY
	55'	12" PVC C-900 PIPE
	1	VALVE CASING & COVER ASSY
	8	8" US FLANGE TYPE GASKET
	64	3/4" X 3 1/2" MACHINE BOLTS W/ HEX NUTS S.S.
	AS NEEDED	METAL GUARD #301
	AS NEEDED	RES-BIT WRAP
	60'	LINE GUARD TAPE MARKED "WATER"
	60'	TRACER WIRE AWG 12, STRAND COPPER W/ THW, THWN OR THHN RATED INSULATED
	5'	POLYWRAP F/ DI FITTINGS
	1	6" RINGS F/ TJ FITTINGS
	4	8" RINGS F/ TJ FITTINGS
	5	12" RINGS F/ TJ FITTINGS



SECTION A-A

N.T.S.



DETAIL C

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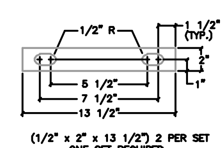

CLIP DETAIL

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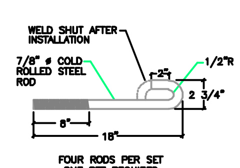

STAY ROD DETAIL

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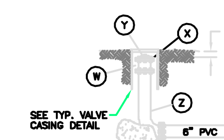

DETAIL E-BLOWOFF

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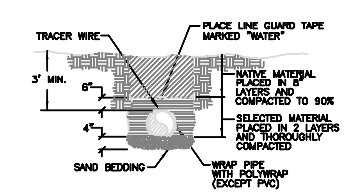

TRENCH DETAIL

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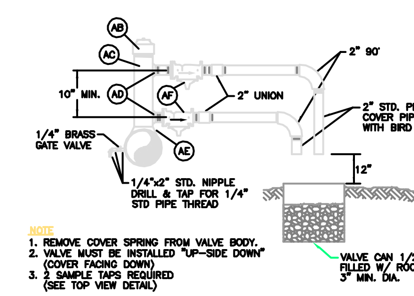
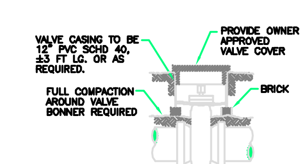


DETAIL D

SAMPLE TAP & AIR RELEASE

N.T.S.



TYP. VALVE CASING

N.T.S.

DESIGNED FOR:
RURAL NORTH VACAVILLE WATER DISTRICT

ENGINEERING DEPARTMENT

SCALE: AS SHOWN

DRAWN BY: M. FONG

DESIGNED BY: G. MeAMBER

CHECKED BY: DATE:

APPROVED BY: DATE:

REGISTERED PROFESSIONAL ENGINEER HYOKSANG KWON No. C51629 EXP. 6-30-02 CIVIL STATE OF CALIFORNIA

TITLE: STA 2-01 WELL PIPING

DISTRICT: RURAL NORTH VACAVILLE

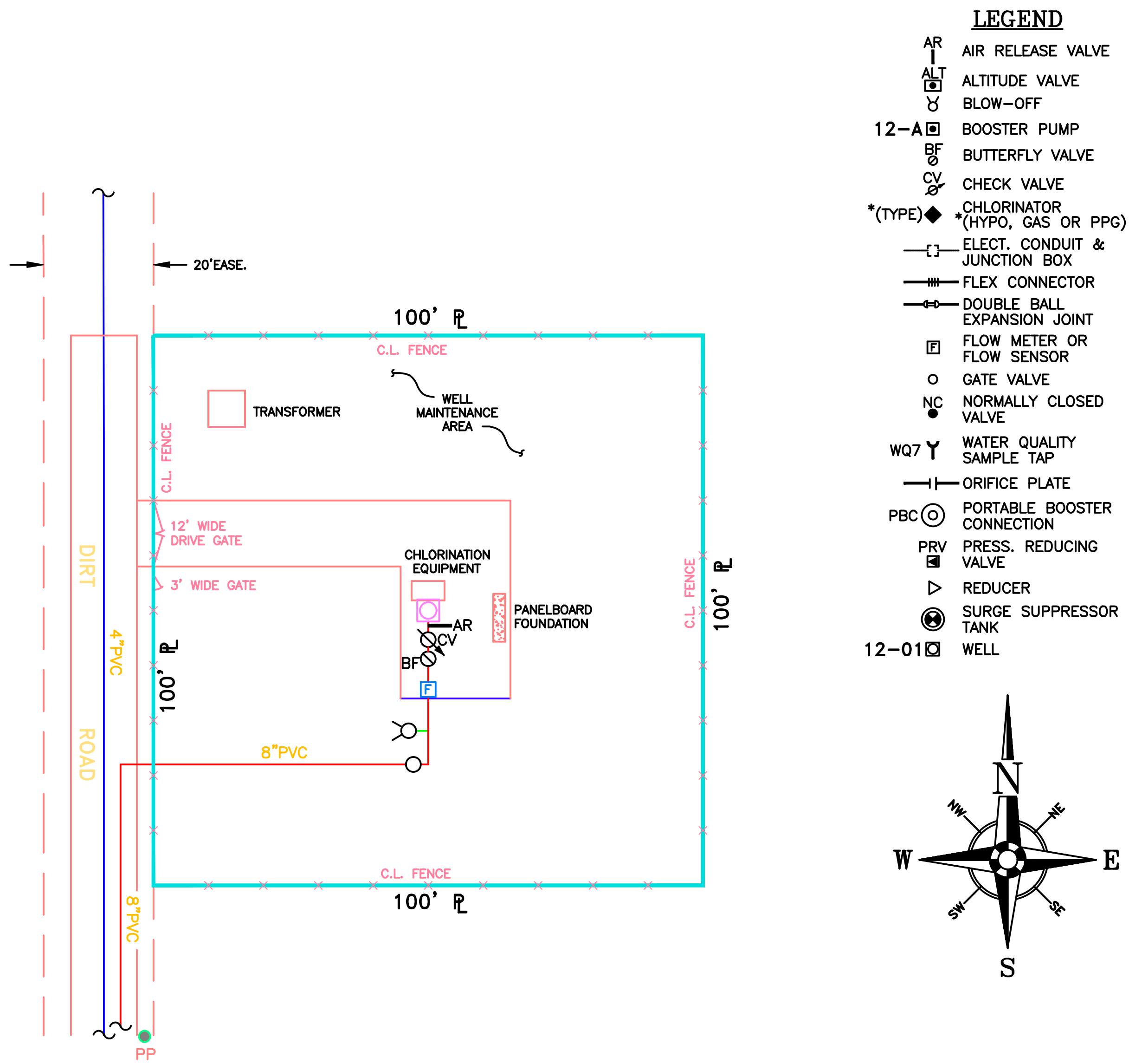
DATE: 2/18/00

PROJECT ID.: GOD2391

DRAWING NO.: RNV-0002R1

SHT 19 OF 52

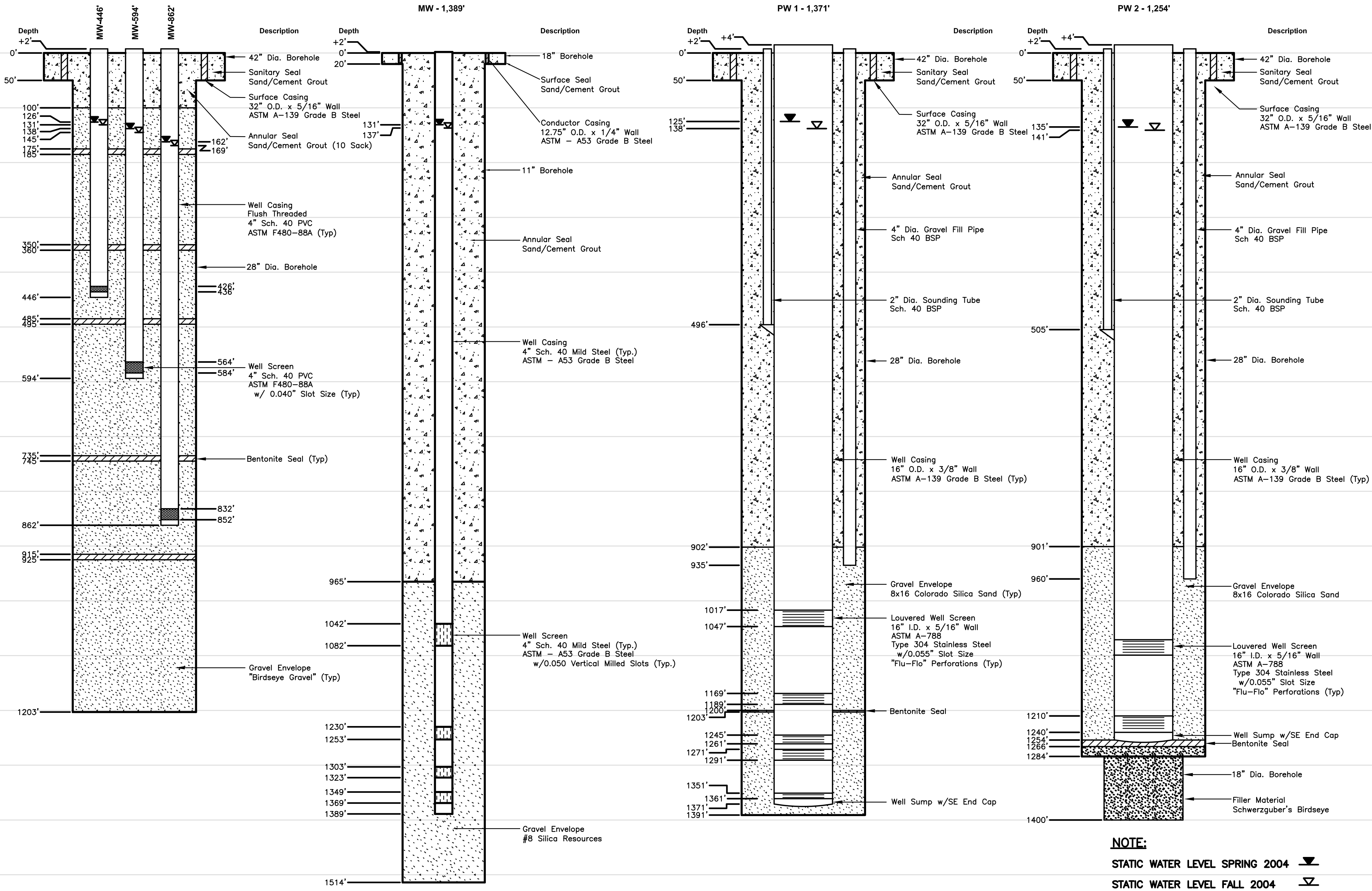
CADD FILE NUMBER: RNV0002-19



CADD DWG. FILE: RNV0006

ENGINEERING DEPARTMENT	TITLE: STATION 002 PIPING SCHEMATIC					REVISIONS:
CALIFORNIA WATER SERVICE CO.	DISTRICT: RNV	DATE: 3-4-03	SCALE: 1"=30'	EST. NO.: 103000	PLAT NO.: K-15	
	DRAWN BY: D.E.B.	CHECKED BY:	APPROVED BY:		DWG. NO.: RNV0006	

APPENDIX E – Well No. 2 Profile



NOTE:

STATIC WATER LEVEL SPRING 2004

STATIC WATER LEVEL FALL 2004

WELL PROFILES

Rural North Vacaville Water District
Well Monitoring Program

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

NO.	DATE	REVISION

REVISIONS

DATE: SEPTEMBER 2005
JOB NO.: 04-2-107
DESIGN BY: LHE
DRAWN BY: DWT
CHECKED BY: ASL
FILE: Figure 4.dwg

FIGURE

4

CAD FILE: G:/Projects/04-2-107/Figure 4.dwg CFG FILE: LSCE2500.PCP_MRG DATE: 09-19-05 3:43pm