Desalination Demonstration Report for Buena Vista Water Storage District

Buena Vista Water Storage District

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Disclaimer: This report summarizes the results of studies, which investigate the performance and fouling behavior of low-pressure reverse osmosis and nanofiltration membranes for treating subsurface agricultural drainage water for the California Department of Water Resources. Publication of any finding or recommendations in this report should not be construed as representing the concurrence of the Department. Also, mention of trade names or commercial products does not constitute Department endorsement or recommendation.

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Executive Summary

The area served by the Buena Vista Water Storage District (BVWSD), as well as other areas within the San Joaquin Valley, consists primarily of irrigated farmland. In order to prevent the dissolved salts in the irrigation water from concentrating in the root zone, it is necessary to apply irrigation water in excess of the crops' consumptive use to carry the salts below the crops' root zones. A semi-permeable clay layer about 100 feet to 200 feet below ground surface limits the depth to which the water can percolate resulting in a shallow, saline groundwater aquifer.

During the irrigation season, the water level rises to within a few feet of the ground surface. Evaporation of some of the water, adjacent saline subsurface flow, and long-term historical irrigation patterns have caused the shallow saline groundwater to increase the soil salinity in the crop root zones resulting in lower crop yields. This has forced some and is threatening to force more land out of agricultural production.

On-farm tile drainage systems are used in some areas of the San Joaquin Valley to keep the saline shallow groundwater below the crop root zone. Disposal of the collected drainage water is a major problem that must be addressed.

The drainage water, however, can also be considered as a potential water source. Desalting of the drainage water is necessary to make the water usable. A reverse osmosis (RO) desalination demonstration plant was implemented to demonstrate the feasibility of desalting the drainage water and converting what is now a liability into an asset.

The objectives and results of the RO desalination demonstration plant are summarized below:

OBJECTIVE	RESULT
1. Demonstrate the ability of commercially available reverse osmosis (RO) membranes to treat agricultural drainage water	Removed approximately 97% of dissolved solids and obtained a 75% water recovery.

OBJECTIVE	RESULT
2. Evaluate pretreatment methods to determine their effectiveness in providing suitable supply (feed water) for the RO system.	Both direct multi-media and sand filters as well as alum (coagulant) were used to pre-treat the feed water. Both filters successfully produced the desired RO feed water quality.
3. Evaluate the quality of water that can be expected from a typical tile drain system.	The water from the tile drain system proved to be high in total dissolved solids (TDS) concentration as expected, but also contained algae and suspended solids.
4. Demonstrate the level of effort necessary for operating a RO system designed to treat agricultural drainage water.	It was demonstrated that one operator could operate the system.
5. Provide data to support permitting of the construction and operation of a full-scale RO system treating agricultural drainage water.	Water quality data gained from the RO demonstration process will help to support the necessary permitting.
6. Provide data supporting potential marketing efforts for new water supplies produced by treating agricultural drainage water.	Water quality data gained from the RO demonstration process will help to support the potential for marketing.
7. Provide data supporting development of cost opinions for full-scale treatment.	Cost estimates to support full-scale implementation for irrigation supply are presented in **Tables 6** and **7**.
8. Determine the appropriate pretreatment filtration system necessary to facilitate maximum RO performance and RO membrane operation lifetime.	Data showed that either multimedia or sand filters would perform adequately with standard chemical coagulant.
9. Determine the effectiveness of shallow wells for reclaiming land impacted by drainage.	The shallow wells lowered the shallow saline water table elevation and provided a more reliable raw water supply for the demonstration project

This RO demonstration project, conducted during the growing seasons of 2000 and 2002, evaluated the possibility of desalting the shallow saline groundwater recovered by a tile drain system and two shallow wells to produce an irrigation water supply. The drainage water was treated using RO resulting in as much as 97% removal of the dissolved solids from the feed water. About 75% of the RO feedwater was recovered as potentially usable water. The remaining water, containing the dissolved solids removed from the raw water, required disposal.

The average total dissolved solids concentration in the desalted water and the shallow groundwater were 230 mg/L and 4,000 mg/L, respectively.

Based on the water quality analyses obtained from both the 2000 and 2002 irrigation seasons, the desalted water can be used for irrigation. Data obtained demonstrated that desalted water of this quality could be produced on a consistent basis using RO to provide a usable water supply.

Table ES-1 summarizes the range of capital and O&M costs for full-scale treatment at varying productions rates.

Table ES-1. Cost Estimates for Full Scale Treatment

Production (MGD)	1	2	5	10
Capital Cost (M$)	$2.9	$5.0	$10.6	$21.3
O&M Cost (M$)	$0.4	$0.6	$1.6	$3.1
Water Cost ($/AFY Produced)	$618	$490	$452	$443

Figure ES-2. Buena Vista RO Desalination Demonstration Pilot Trailer

Introduction

Saline agricultural drainage water within the Buena Vista Water Storage District is accumulating in shallow aquifers located below productive farmland. This saline water has risen to elevations where it increases the soil salinity in crop root zones resulting in reduced crop productivity and in some areas of the District, lands have been taken out of production because of the high saline groundwater table.

A reverse osmosis pilot plant was constructed to demonstrate the feasibility of desalting saline irrigation drainage water for use as a water supply for agricultural or municipal use. The demonstration plant was constructed in the Buena Vista Water Storage District northwest of Bakersfield, California. The plant operated during the irrigation seasons of 2000 and 2002.

Initially, the saline groundwater used as feedwater for the RO demonstration plant was collected by a tile drain system that was installed in November 1999. The water flowed into a sump. It was then pumped to the plant.

In 2001, however, the tile drain system did not produce enough water to operate the RO demonstration plant. Therefore, two shallow wells were drilled in December of 2001 to provide a more reliable feedwater source to the RO demonstration unit.

Definition of Terms

- Permeate: desalted water exiting RO process
- Concentrate: wastewater exiting RO process
- Filtrate: water exiting pretreatment filters
- Feed: source water entering pretreatment filters (saline drainage water)
- Recovery: percentage of feed water recovered as permeate

Participants

A number of organizations participated in the preparation and operation of the demonstration plant.

The Buena Vista Water Storage District served as the contractor and the project administrator for the California Department of Water Resources (DWR), the main project sponsor. Dave Bloemhof of Bloemhof Farms provided the RO demonstration site. Supplemental funding was provided by:

- Kern County Water Agency
- Lost Hills Water Storage District
- Semitropic Water Storage District
- Wheeler Ridge – Maricopa Water Storage District

Boyle Engineering Corporation provided engineering services, the RO demonstration plant, and plant operators. The sampling and analysis plan, engineering services, laboratory services, and pretreatment filters were provided by DWR. Technical support was provided by UCLA and field support was provided by BVWSD staff as needed from time to time.

Study Objectives

The study was intended to meet several objectives:

1. Demonstrate the ability of commercially available RO membranes to treat agricultural drainage water.
2. Evaluate pretreatment methods to determine their effectiveness in providing suitable feed water for the RO system.
3. Evaluate the quality of water that can be expected from a tile drain system.
4. Demonstrate the level of effort necessary for operating a RO system designed to treat agricultural drainage water.
5. Provide data to support permitting of the construction and operation of a full-scale RO system treating agricultural drainage water.

6. Provide data supporting potential marketing efforts for new water supplies created by desalting agricultural drainage water.
7. Provide data supporting development of cost opinions for full-scale treatment.
8. Determine an appropriate pretreatment filtration system necessary to facilitate maximum RO performance and RO membrane operation lifetime.
9. Demonstrate the effectiveness of shallow wells as a feedwater to an RO plant and determine impact on ground water levels.

Testing Protocol

The following demonstration test protocol was developed to provide evidence that the objectives listed above were attained.

- **Particle removal verification**: The feed water Silt Density Index (SDI) should be below 3.0. The performance of both pretreatment filtration systems indicated that this requirement could be met on a consistent basis.

- **Fouling constituent verification**: Analyses of the feed and filtrate stream samples were taken to show that potential RO membrane fouling constituent concentrations were at levels which do not negatively impact membrane life and performance. Based on the analytical data, RO membrane fouling will occur at acceptable rates as long as the proper amounts of scale inhibitor and acid are injected into the RO feed stream.

- **Product water quality verification**: Analyses of the permeate indicated that RO is capable of producing water that can be utilized for potable or agricultural use.

Analytical Sampling and Systems

Table 1 is an outline of the analyses that were performed on a daily, weekly and monthly basis. The onsite operator performed daily analyses and DWR's Bryte Laboratory performed the weekly and monthly analyses.

Table 1. Analytical Schedule

Analysis	Sample Location											
	Feed			Filtrate (2 units)			Permeate			Concentrate		
	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly
Turbidity	X	X	X	X	X	X		X	X		X	X
EC	X	X	X		X	X	X	X	X	X	X	X
Temp.				X			X					
TDS		X	X		X	X		X	X		X	X
Calcium		X	X		X	X		X	X			X
Magnesium		X	X		X	X		X	X			X
Sodium		X	X		X	X		X	X			X
Carbonate*		X	X		X	X		X	X			X
Bicarb.*		X	X		X	X		X	X			X
Chloride			X			X			X			X
Sulfate			X			X			X			X
Boron			X			X			X			X
SiO2			X			X			X			X
Barium			X			X			X			X
Strontium			X			X			X			X
Selenium			X						X			X
TSS			X			X						
TOC			X			X			X			X
UV254			X			X			X			X
SDI				X								
Other analyses as needed: pH, fluoride, iron, nitrate, nitrite, orthophosphate, potassium and DOC												

Schedule of Operation

Initially, the desalination demonstration project was to operate throughout the 2000 and 2001 irrigation seasons. However, due to the lack of water from the tile drain system, the project was not able to maintain sustained operation in 2001. The project was extended for a year, and modified by the inclusion of two shallow wells to provide a more reliable drainage water supply. These wells were completed in December 2001, and RO demonstration continued through the 2002 irrigation season.

The data in this report reflects the RO demonstration plant's operation from June 27 to September 13, 2000 and from April 1 to December 4, 2002. The data focuses mainly on the year 2002 irrigation season when sustained RO operations were maintained.

Operation during the previous years is described in the following reports:

- Pilot Design Report for Buena Vista Water Storage District, June 2000
- Desalination Pilot Report for Buena Vista Water Storage District, December 2000
- Phase 2 Demonstration Project Report for Buena Vista Water Storage District, January 2002

Plant Location and Layout

During the two irrigation seasons the demonstration plant operated, two sources supplied feed water to the demonstration plant. The first source, used during the year 2000,was from a tile drain system. David Bloemhof, the owner of Bloemhof Farms, where the demonstration plant was located, installed this tile drain system.

A location map is provided in **Figure 1, Demonstration Plant Location Map**.

Figure 2, Tile Drain Layout, shows the tile drain system and demonstration plant site in relation to the drainage problem areas of Bloemhof Farms.

The second source of feed water, used during 2002, was two shallow wells drilled in December of 2001. **Figure 3, Well Location Map**, shows the locations of the two wells and the shallow piezometer wells in reference to the RO demonstration plant. The differences in water quality of each source are discussed in the next section.

The demonstration plant was located adjacent to a Bloemhof Farms' drainage water sump. Water flowed into the sump from the tile drain system and was pumped to the RO prefiltration equipment. Following the RO desalting process, both the permeate and the concentrate were returned to the drainage sump.

In addition to the treatment equipment, an office trailer was situated at the site to serve as a facility for the operator to perform analytical tests, and to house the monitoring computer.

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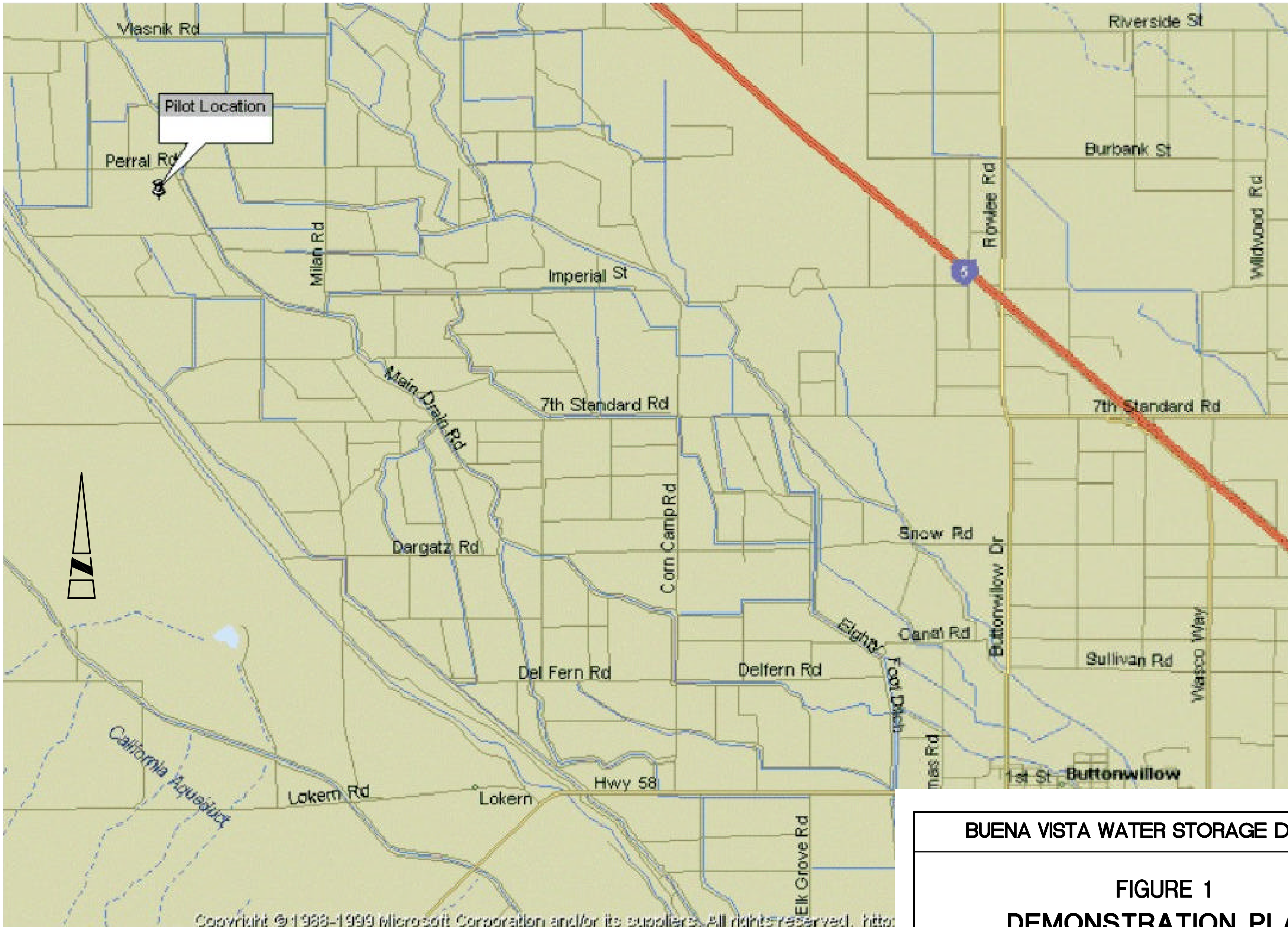

BUENA VISTA WATER STORAGE DISTRICT

FIGURE 1
DEMONSTRATION PLANT LOCATION MAP

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DWG: S:\B21\105-02\2002\Final Report Revisions\Figures\FIGURE2.dwg USER: dghilarducci
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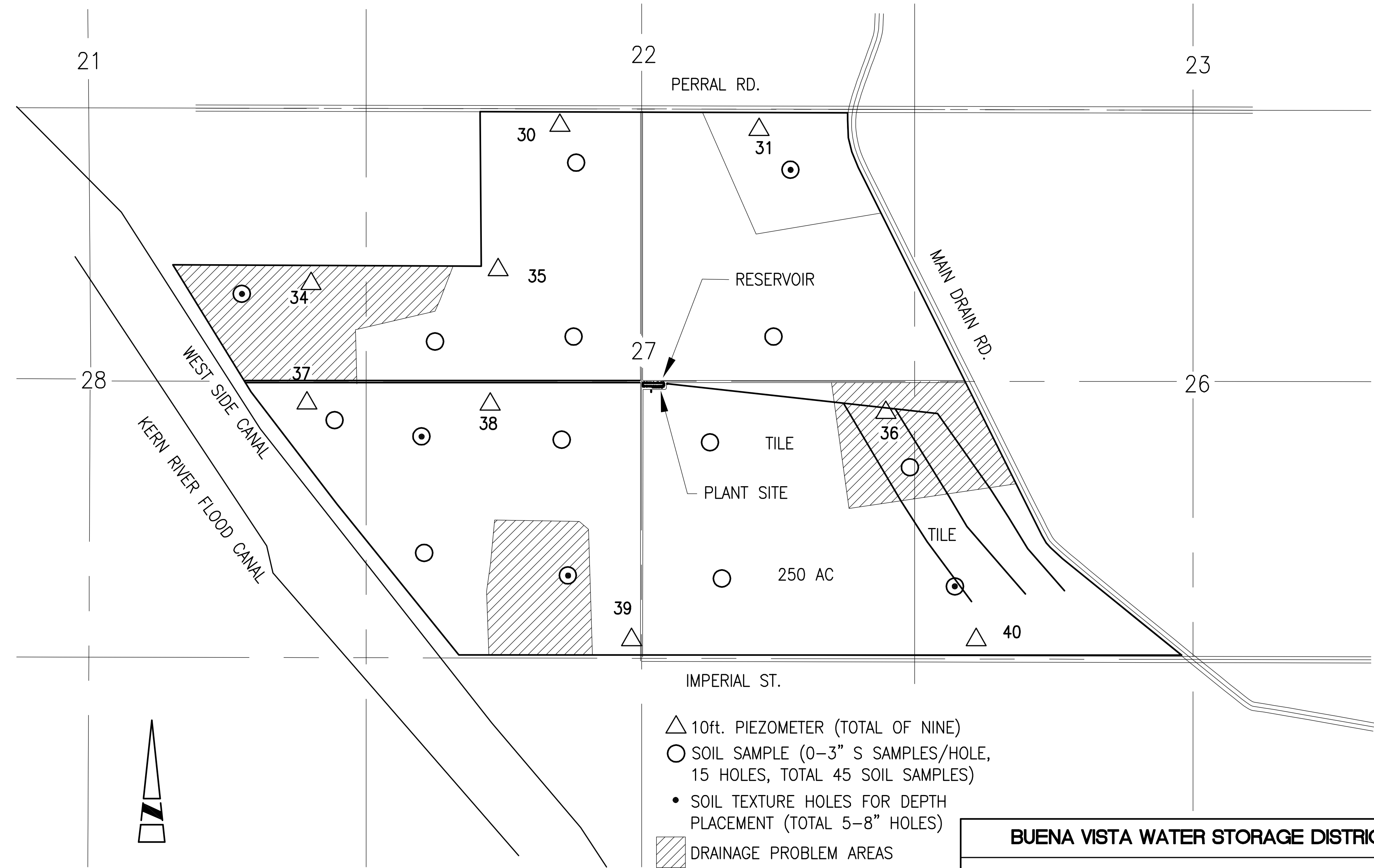

BUENA VISTA WATER STORAGE DISTRICT

FIGURE 2
TILE DRAIN LAYOUT

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DWG: S:\B21\105-02\2002\Final Report Revisions\Figures\FIGURE3.dwg USER: ccampbell
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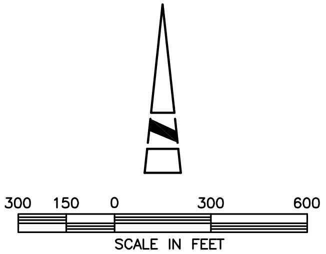

LEGEND

PEIZOMETER

BRACKISH WATER WELL

BUENA VISTA WATER STORAGE DISTRICT

FIGURE 3

WELL LOCATION MAP

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Feedwater Quality

Feedwater Sources

Two sources supplied feed water to the plant. The first source referred hereinafter as *tile drain water* was used during 2000. Tile drain water, as the name implies, came from a tile drain system constructed beneath the root zone of the crops. Water that percolates through the crop root zone is collected by the tile drain system and is emptied into a sump. A sump pump delivers the drainage water to the RO demonstration plant. Refer to **Figure 2** for the location of the tile drain system and the RO demonstration plant.

The second source, hereinafter referred to as *well water* was used in 2002. Well water was supplied by two wells drilled after flows too low to operate the demonstration plant were experienced in 2001 with tile drain water. These wells pump water from the same aquifer as the tile drain system but from a deeper depth so that fluctuations in groundwater depth have less impact than with a tile drain system. The depth of the two wells is about 80 feet. The two wells are referred to hereinafter as the North Well and the South Well (100 gpm each).

Piezometers

In 2002, five piezometers were installed to monitor the effects on the groundwater elevation resulting from operation of the North and South Wells. The piezometers are located as shown on **Figure 3:**

- #1, #2, and #3 (between the North Well and the South Well):
- #4 (north of the North Well); and,
- #5 (south of the South Well).

These five piezometers supplemented five existing piezometers:

- #30 (northwest of the North Well);
- #31 (northeast of the North Well);
- #35 (southwest of the South Well);
- #36 (southeast of the South Well); and,
- #38 (southeast of the South Well).

Figures G-1 through **G-4**, located in **Appendix G**, show surface and groundwater elevation contours for the September 2001, December 2001, September 2002, and December 2002. The North and South Wells were drilled in December 2001 and operated during 2002.

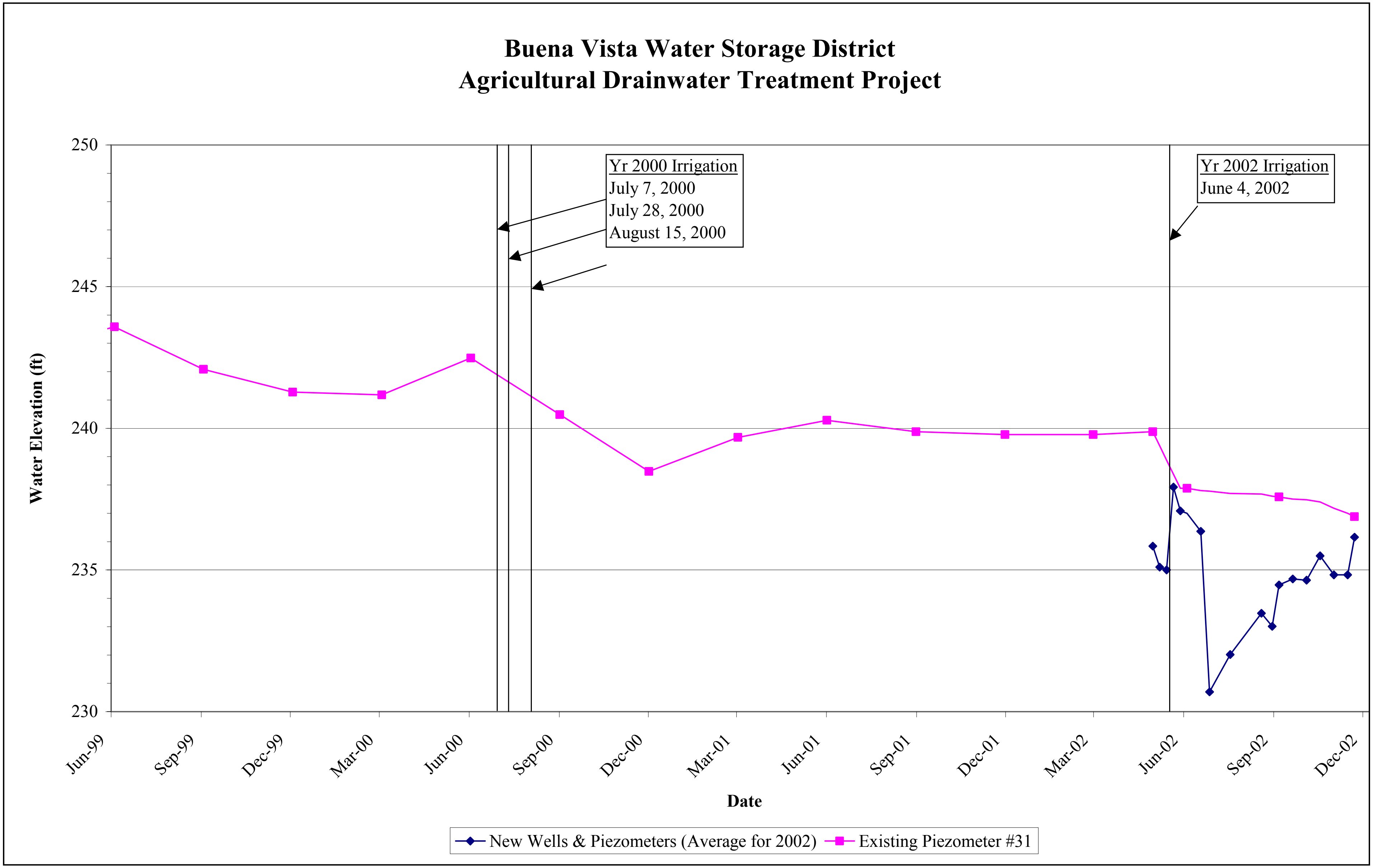
Table 2 shows the depths to groundwater for piezometers #30, #31, #35, and #36 and for the North and South Wells based on the information in **Figures G-1** through **G-4.**

Table 2

Depth to Groundwater (feet)					
	Piezometers				**North and South Wells**
Date	**#30**	**#31**	**#35**	**#36**	
9/01	**8**	**8**	**7**	**8**	**6**
12/01	**7**	**9**	**6**	**9**	**6-7**
9/02	**10**	**8**	**9**	**7**	**13-15**
12/-2	**10**	**10**	**11**	**10**	**12-13**

Figure 4 shows the water surface elevations recorded at piezometer #31 for the period June 1999 through December 2002. In addition, the figures shows the water surface elevations measured at the North and South Wells during the months in 2002 when the demonstration plant was operated.

Figure 4. Change in Groundwater Elevation Through 2002



Feedwater Quality

Feedwater quality affects the performance of any treatment process including RO. The more important quality parameters of RO feedwater include total dissolved solids, electrical conductivity, total suspended solids, silt density index, and pH.

- **Total Dissolved Solids (TDS) -** TDS is a measure of the dissolved substances in water such as calcium, magnesium, sodium, potassium, chloride, sulfate, bicarbonate, and nitrate. TDS removal is the primary objective of the RO process. Dissolved solids test results are reported in terms of milligrams per liter (mg/L).

- **Electrical Conductivity (EC)** - The electrical conductivity is a temperature dependent indication of the TDS of the water. EC is either expressed as milli-Siemens per centimeter or micro-Siemens per centimeter (mS/cm or µS/cm), and it can be used as an analogous measure of TDS. In this report, the values for EC are reported in both mS/cm and µS/cm. Values reported from the laboratory were taken at 25^{o}C while all values taken in the field were temperature compensated.

- **Total Suspended Solids (TSS)** - TSS is a measure of the undissolved suspended substances in water. TSS can be a wide variety of suspended organic and inorganic materials. Suspended solids test results are reported in terms of milligrams per liter (mg/L).

  - ***Turbidity*** – Turbidity is an indirect measurement of the suspended solids present in water. It measures the amount of light scattered by the particles suspended in the water. The presence of turbidity in the feedwater to the RO system above 0.5 nephelometric turbidity units (NTU) indicates material in the water that may foul the RO membranes and is a performance goal measure for filtration processes.

- **Silt Density Index (SDI)** – SDI measures the level of materials in the water that will plug a 0.45 μm[1] filter. It is an indicator of the fouling potential a particular water source has on RO membranes. Typical RO membrane warranties require that SDI remain below 4.

- **pH** - pH is a term used to express the intensity of the acid or alkaline condition of a solution. The pH scale ranges from 0 to 14. Acidity increases as pH declines from 7 to 0. Alkalinity increases as pH increases from 7 to 14. Acceptable pH range in household water lies between 6.5 and 8.5.

After switching the source of the RO plant feedwater from the tile drain to the new wells, the quality of the RO feedwater changed. The well water quality was better than the tile drain water quality. The only exception was TSS, where water from the tile drain system contained less TSS than water from the wells. This did not impact RO permeate (desalted water) quality as the plant's pretreatment filtration system produced water with acceptable SDI for both water sources.

Table 3 presents average water quality for the years shown. Complete water quality data is presented in **Table 5** for the feed and product streams and in **Table 9** for the concentrate stream.

Table 3. Comparisons of Source Water

Feed Water (Irrigation Period)	**Yr. 2000** (Tile Drain)	**Yr. 2002** (Wells)
TDS (mg/L)	7,010	3,980
Feed EC (mS/cm)	10.2	6.2
TSS (mg/L)	4.0	4.4
Turbidity (NTU)	12.4	17.4
SDI (after filtration)	2.77	1.94
Feed pH	7.3	7.1

[1] μm = micron = one millionth of a meter = 0.00004 inches.

Shallow Water Characteristics

The quality of the shallow water collected by the tile drain system varied throughout the 2000 irrigation season. As shown in **Figure 5,** the SDI and conductivity (EC) values were influenced by application of irrigation water. Note that all SDI values were taken after filtration.

During the irrigation periods, the EC values decline and the SDI values of the filtrate increase. This happens because fresh water flows into the zone from which the tile drain system collects water diluting the salty water. Dilution causes a decrease in the conductivity of the feed water.

Furthermore, as the fresh water percolates through the soil, it carries suspended solids into the tile drain system. The addition of these suspended solids causes the SDI of the filtrate during irrigation periods to increase.

The tile drain may be generally characterized as moderately saline with low turbidity. Data taken during the year 2000 showed that the average turbidity of the tile drain water was12. Filtration ahead of the RO equipment was required because RO requires feedwater turbidity of less than 1 NTU.

Appendix A, 2000 Demonstration Plant Data, contains information on the demonstration plant using tile drain water to supply the demonstration plant feedwater.

Figure 5: Filtrate SDI and EC History for 2000 (Tile Drain)

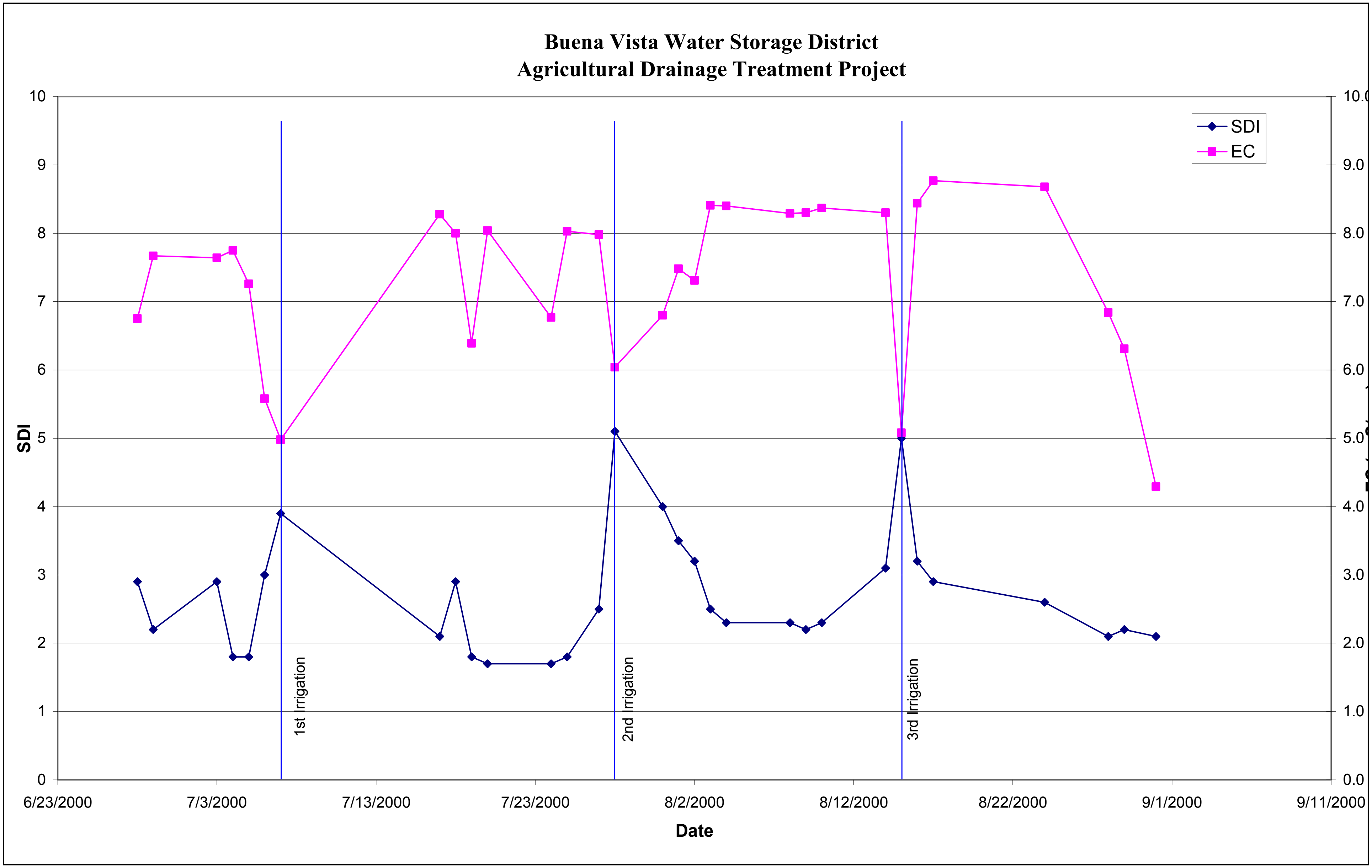
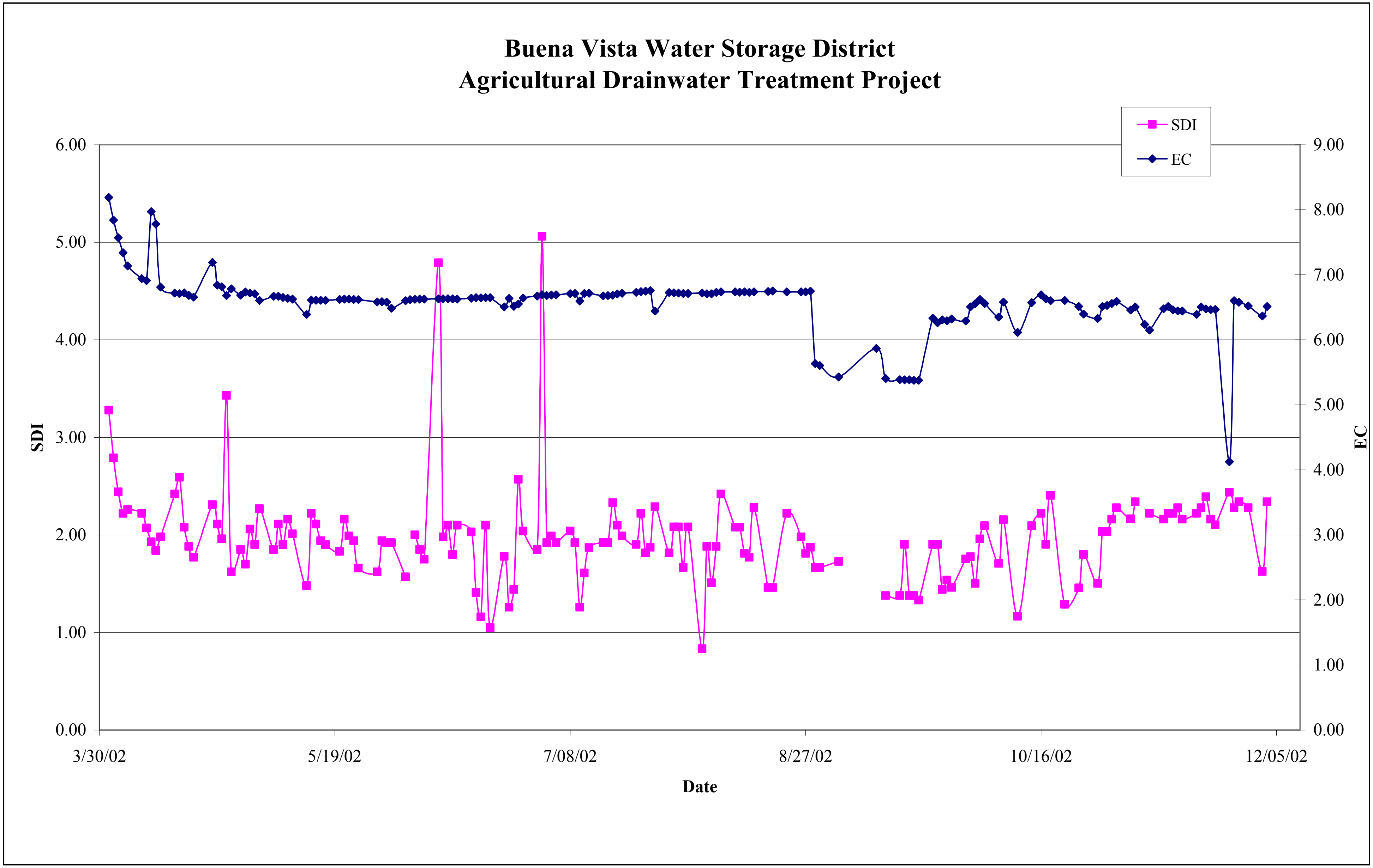


Figure 6: Filtrate SDI and EC History for 2002 (Well Water)



Well Water Characteristics

The water supplied to the RO demonstration plant during 2002 came from the two wells drilled during the winter of 2001. As shown in **Table 3**, the well water had lower TDS than the tile drain water.

Because the North and South Wells pump from deeper within the saline aquifer, there is less impact resulting from irrigation on EC and filtered water SDI as compared to the tile drain water (see **Figure 6**). Whereas the EC of the tile drain water varied from about 4.3 mS/cm to almost 9.0 mS/cm (see **Figure 5**), the EC of the well water was about 7.7 mS/cm during most of the time the demonstration plant was operated in 2002. And, whereas the SDI of the filtered tile drain water was widely variable (see **Figure 5**) and averaged about 2.8, the SDI of the filtered well water was reasonably consistent and averaged less than 2.0.

Water quality data for the well water is presented in **Appendix B**.

Treatment Process

Pretreatment Filtration System

The pretreatment filtration system was previously used in a DWR seawater-desalting project at William R. Hearst State Beach Park in San Simeon. The media filtration system consisted of four 36-inch diameter, 72- inch tall vertical fiberglass reinforced plastic (FRP) pressure vessels. An inlet baffle is provided inside the top opening of each vessel to deflect the water entering the tank. Slotted laterals are arranged around a central hub installed in the dished bottom of the vessel. The tops of the vessels are painted to decrease the effects of UV radiation. Each vessel weighs approximately 3,000 pounds when fully loaded with media.

Three of the four filters contain anthracite and garnet media and the fourth filter contains anthracite and sand media. The media for the garnet filters consists of:

- 14.5 inches (500 pounds) of anthracite coal (size 0.8 mm to 1.0 mm) on top;
- Of 12.5 inches (1100 pounds) of #50 mesh garnet;
- Supported by 3 inches (300 pounds) of #8 mesh garnet;
- On top of 11 inches (650 pounds) of pea gravel.

The anthracite/sand filter was arranged somewhat differently, with only three layers of media:

- 14.5 inches (500 pounds) of anthracite working media;
- On top of 15.5 inches (1400 pounds) of fine sand;
- Supported by 11 inches (650 pounds) of pea gravel.

Sketches of the filters are shown in **Figure 7, Garnet and Sand Filters**.

In order to obtain the desired RO feed water quality it was necessary to add coagulant (alum [aluminum sulfate]) to the filter feedwater. The addition of coagulant helped the suspended solids in the feed water to agglomerate, which makes them easier to filter out.

A chemical injection facility was provided to add coagulant to the feed water. Alum was chosen for the coagulant due to its widespread use and availability.

The alum was held in a 55-gallon drum prior to injection and fed into the influent water by a solenoid-operated chemical injection pump at a rate of 0.18 gallons per day (gpd). This provided an alum concentration of 4 mg/L in the influent water.

The four filters were operated in two separate trains consisting of two filters each. Each train was capable of supplying the necessary feed water flow to the RO plant. At 20 gpm (design feed water flow to the RO) filter surface loading was 2.8 gpm/ft^2 . With both filter trains running, filter loading would have been 1.4 gpm/ft^2. However, the system was never operated with both trains running.

Filter Train #1 consisted of two garnet filters connected in series, while Filter Train #2 consisted of one garnet filter followed by a sand filter connected in series.

The filters were installed in a manner to allow backwashing of either of the two filter trains without taking the other train offline. RO permeate was used to backwash the filters. The backwash water was stored in a 2250-gallon tank. The backwash flow rate was approximately 60 gpm.

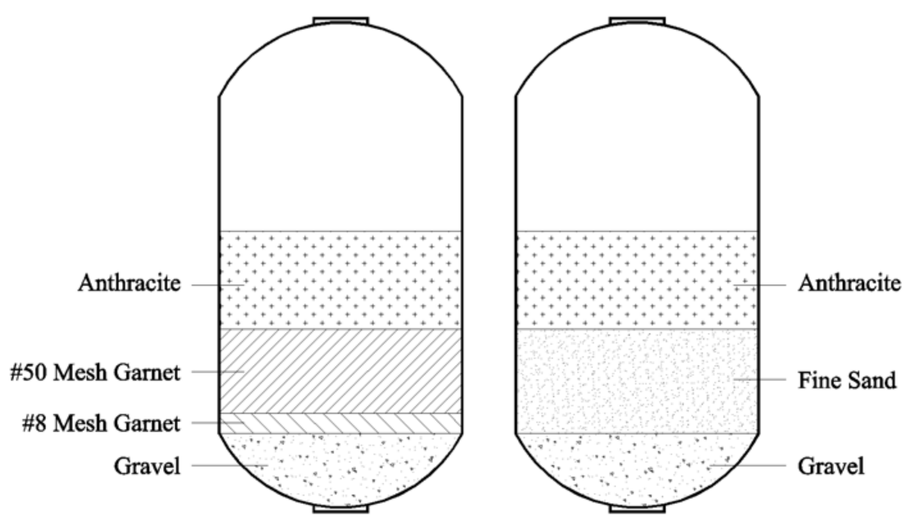


Figure 7: Garnet and Sand Filters

Reverse Osmosis System

The RO treatment system was trailer mounted and had a nominal permeate capacity of 16 gpm. It was equipped with a cartridge filter, boost and high-pressure pumps, monitoring instrumentation, and an automatic control system. The automatic control was connected to a computer that logged RO performance data. A flow diagram describing the demonstration unit is provided in **Figure 8**.

RO membranes were enclosed in six, three-element, four-inch diameter pressure vessels, arranged in a 2:2:1:1 array. **Table 4** lists the membranes used in the pilot.

Table 4. RO Membranes & Manufacturers

Membrane Type	Manufacture	Stage	Date Installed
TFC High Rejection	KOCH	First	8/15/00
TFC Ultra Low Pressure	KOCH	Second	8/30/00

The RO feed water was treated with muriatic acid (HCl) and scale inhibitor prior to entering the membranes. Target feed water pH and target scale inhibitor injection rates were 6.7 and 4.6 mg/L, respectively. In order to meet these injection rates using the chemical injection pumps, it was necessary to dilute the chemicals with RO permeate.

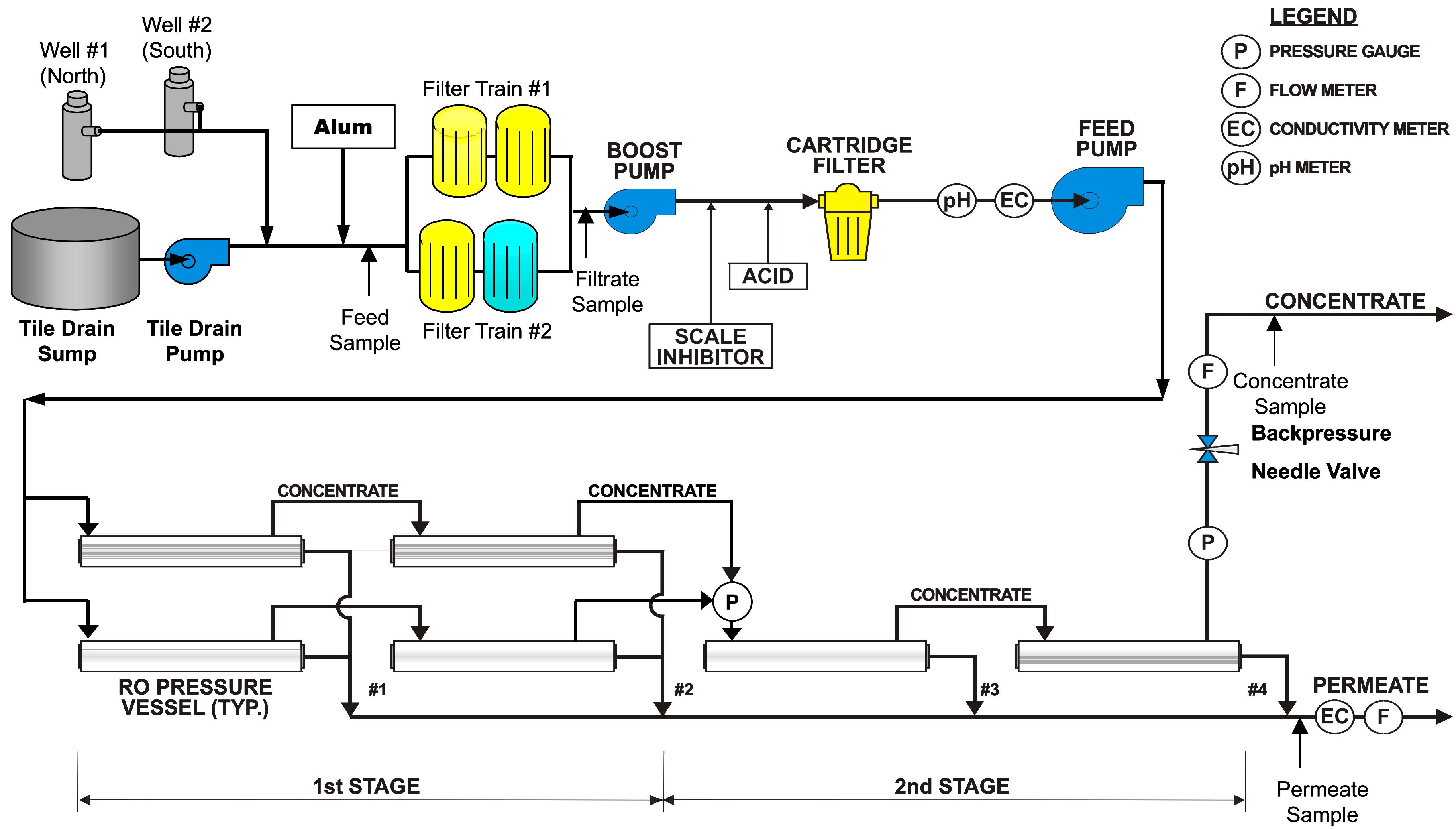
An initial projection of RO performance was made using water analyses sampled from nearby Well 38. The RO projection is provided in **Appendix C**. A mineral analysis of the water sampled from Well 38 is provided in **Table A.1** of **Appendix A** (under 1/6/00).

Daily Operator Tasks

The operators performed daily tasks as follows:

- Recorded and entered operating data into a computer spreadsheet. This data included the following: stream flowrates, system and stream pressures, temperatures, turbidities, the SDI, and the RO feed.

- Checked filter pressure drop and backwashed the filter when necessary.
- Adjusted the RO permeate to correct the flowrate.
- Checked the cartridge filter pressure drop. Replaced the cartridges when necessary.
- Checked the chemical tank levels and replenished as required.
- Checked the chemical feed rates by calculating the amount pumped from the tanks. Adjusted if necessary.
- Checked the mechanical equipment. Called for service if required.



#1, #2, #3, and #4 are permeate sample points.

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BUENA VISTA WATER STORAGE DISTRICT
FIGURE 8 DEMONSTRATION PLANT FLOW DIAGRAM
BOYLE ENGINEERING CORPORATION

RO Plant Performance Evaluation

Filter Performance Data

Throughout the 2000 and 2002 irrigation seasons, both filter trains were used interchangeably but not at the same time. During the year 2002 irrigation season, Filter Train #2 was used more often than Filter Train #1, however the two trains produced similar results.

Operating logs containing filter performance data are presented in **Table D.1** and **Figures D.2** and **D.3** of **Appendix D**.

RO Performance Data

Initially, the RO demonstration plant was designed to recover 70% of the feed water, while removing as much as 95% of the total dissolved solids. Because the quality of the feed water from the North and South Wells was better than that from the tile drain system, the recovery was increased to 75%. TDS removal averaged 97% throughout the life of the project. Tabulated performance data for the RO system can be found in **Appendix E**.

Normalized Flux Variations:

There are two primary standards of performance for RO systems: flux and salt rejection. Temperature and the salinity of the feed water affect flux and salt rejection. It is necessary to normalize the data to standard conditions in order to obtain a realistic evaluation of the performance of the system.

Flux is a measure of the amount of permeate (desalted water) produced per square foot of membrane surface per unit of time. It is typically reported in gallons per day per square foot of membrane area (gfd). When comparing different membranes, specific flux is typically reported[2]. This is the flux produced by 1 psi of net driving pressure. Specific flux typically increases by about 3 percent per degree Celsius. This is because as the temperature of the water increases, its viscosity decreases. Normalized permeate flux is reported as specific flux at 25 degrees C.

[2] A simplified definition of *net driving pressure* is the pressure available to drive water (permeate) through the RO membrane.

Salt rejection describes the amount of salt that the membranes prevent from passing into the permeate. Salt rejection is impacted by temperature, but to a lesser degree than flux.

Normalized flux and salt rejection were monitored throughout the operation of the demonstration plant to determine the condition of the RO membranes. As the membranes fouled, normalized flux dropped. A drop of about 15 percent indicated the need to clean the membranes.

Figure 9 presents the normalized flux and net driving pressure for the RO system for 2002. Ten days after 2002 startup, the demonstration plant experienced a drastic drop in normalized flux from greater than 0.10 gfd/psi to about 0.08 gfd/psi. Inspection revealed a green algae-like substance in a rotometer (flow measuring device). Bio fouling was suspected, and the membranes were cleaned using detergent and citric acid.

Shortly after startup, a well water quality analysis was received. The report indicated a better feed water quality than observed in 2000 when the feedwater for the plant was taken from the tile drain system. Subsequently, the RO recovery rate was increased from the 50% achieved in 2000 to 70%.

On day 30, the second new well was brought online. It appeared that that well initially produced a significant amount of sediment. Some of the materials got through the filters and entered the RO membranes, reducing the normalized flux. The membranes were chemically cleaned[3] on day 37, and the flux recovered.

On day 56, the pH/temperature analyzer probe was replaced. Prior to the replacement, the operator was reporting temperatures from the conductivity/temperature probe. Afterward, the operator reported temperature from the pH/temperature probe.

Based on field observations, the pH/temperature probe read in a range of 1.0 to 1.5 degrees Celsius higher than the conductivity/temperature probe. This led to an adjustment of the normalized flux value, reducing it to approximately 0.080 gfd/psi.

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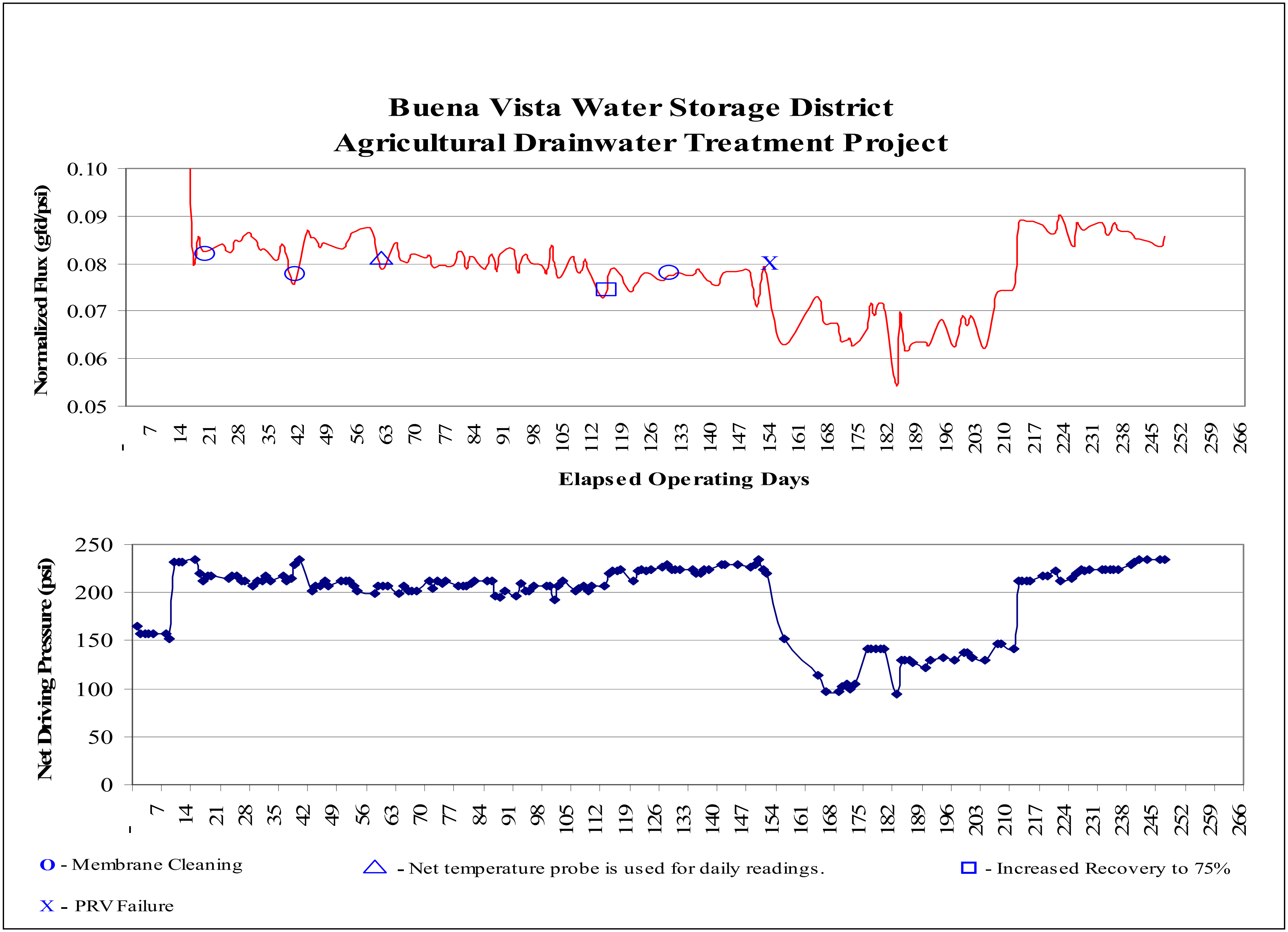
[3] Chemical cleaning consisted of a detergent cleaning and a low pH cleaning. The former includes cleaning with soap (in this case, Tide laundry detergent) to get rid of the organics, while the latter includes adding citric acid to get rid of the mineral scales.

On day 111, the recovery was increased from 70% to 75%. The normalized flux had slightly decreased by this point, but then remained steady at 0.077 gfd/psi. On day 124, due to a decreasing normalized flux, the membranes were chemically cleaned. The cleaning had no effect on normalized flux. However, the recovery rate remained at 75% (producing 15 gpm permeate).

On day 152, a sizeable RO pressure drop was noticed as both the flowrates and the recovery sharply declined. At this point, the normalized flux had dropped to below 0.070 gfd/psi. Initial thinking was that the feed pump had a mechanical failure, however, further probing proved that the pressure relief valve had failed to seat properly. The valve failure was causing the plant to recycle concentrate.

Figure 9: Normalized Flux 2002



On day 208, the pressure relief valve was replaced and the RO pressures as well as the flowrates and recovery rate returned to levels seen before the pressure drop. The normalized flux increased to an average of 0.087 gfd/psi and remained near this level through the end of the project.

Figures 10 through **14** present additional operating data for the plant.

Figure 10: Demonstration Plant Flowrates 2002

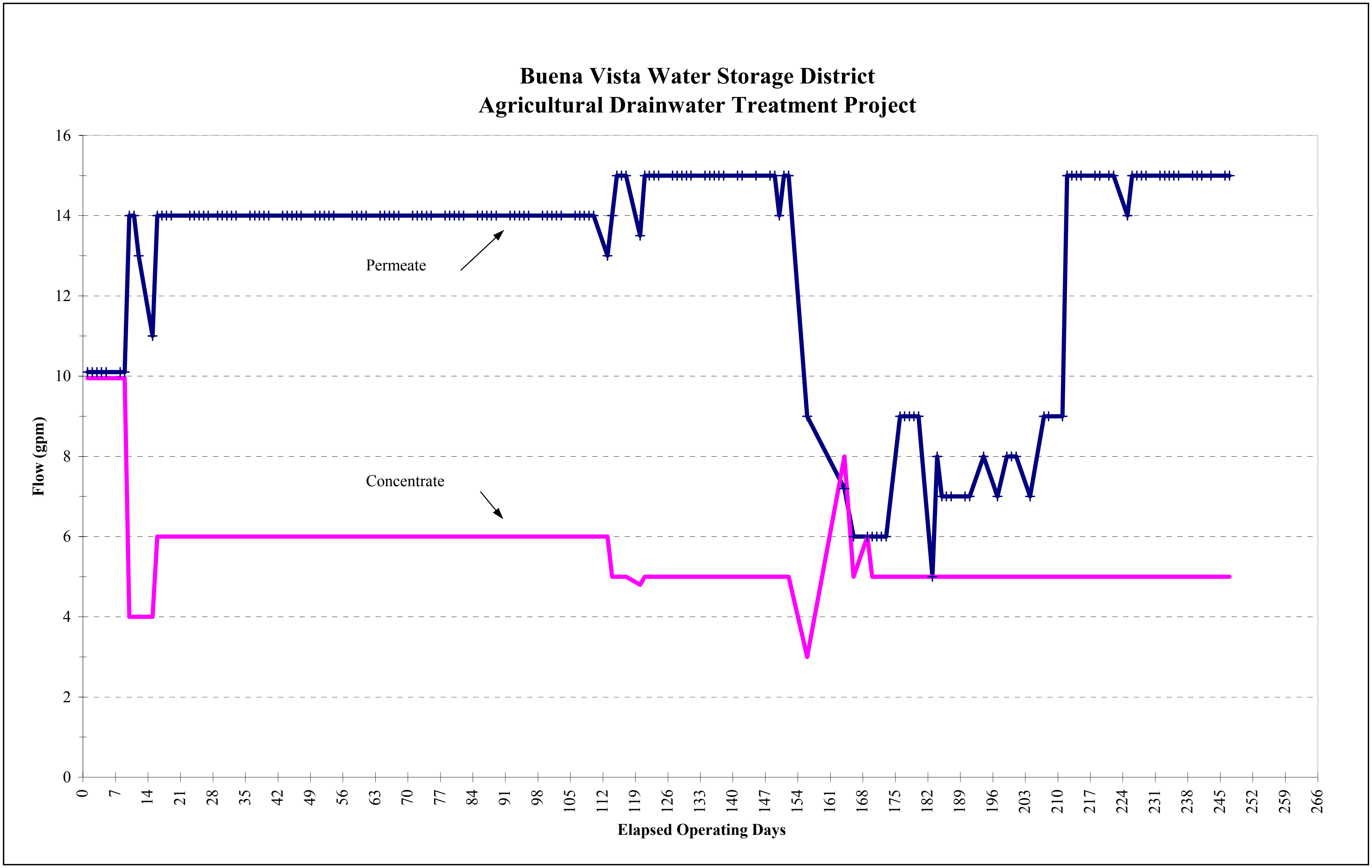


Figure 11: Demonstration Plant Pressures 2002

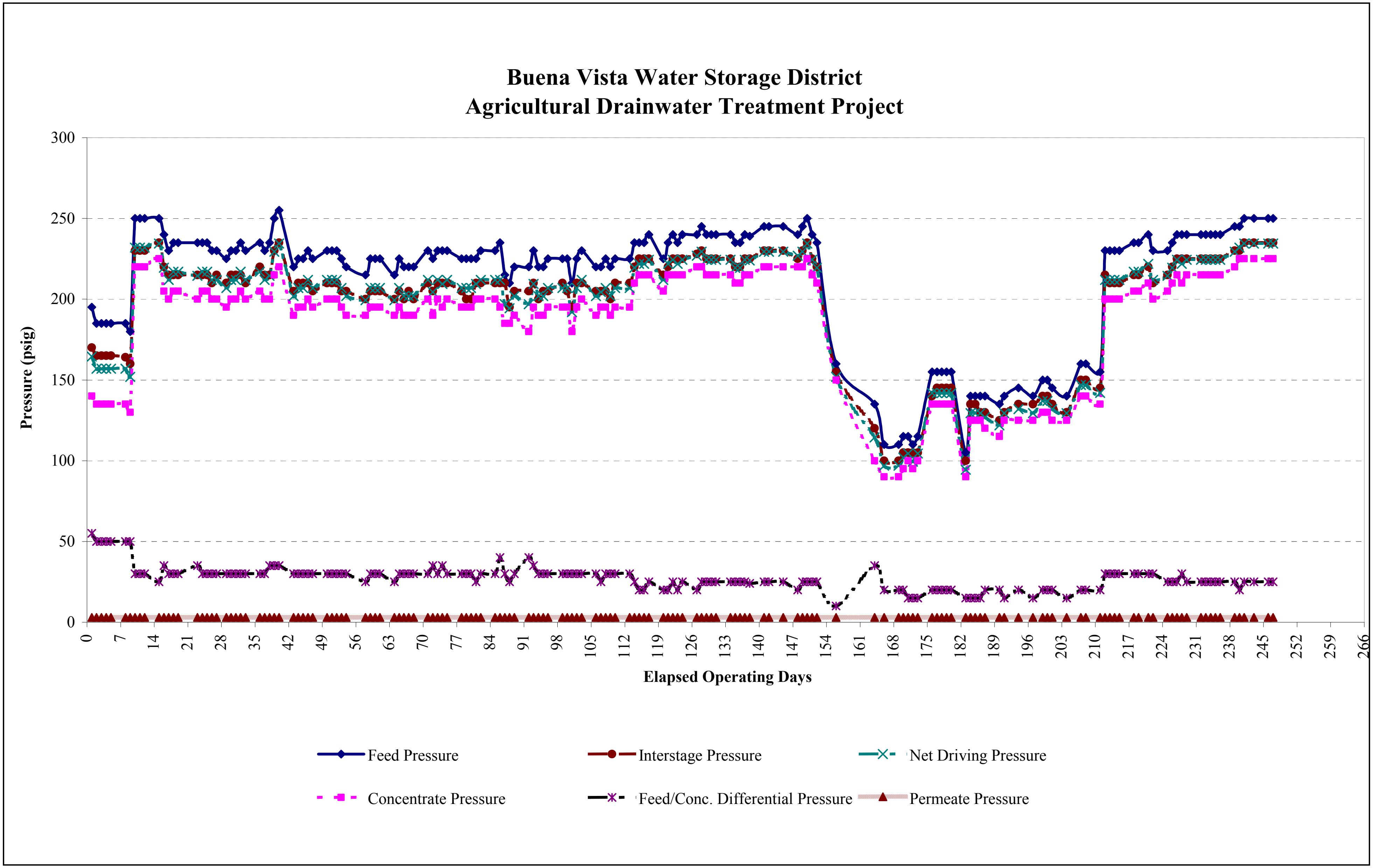


Figure 12: Electrical Conductivities 2002

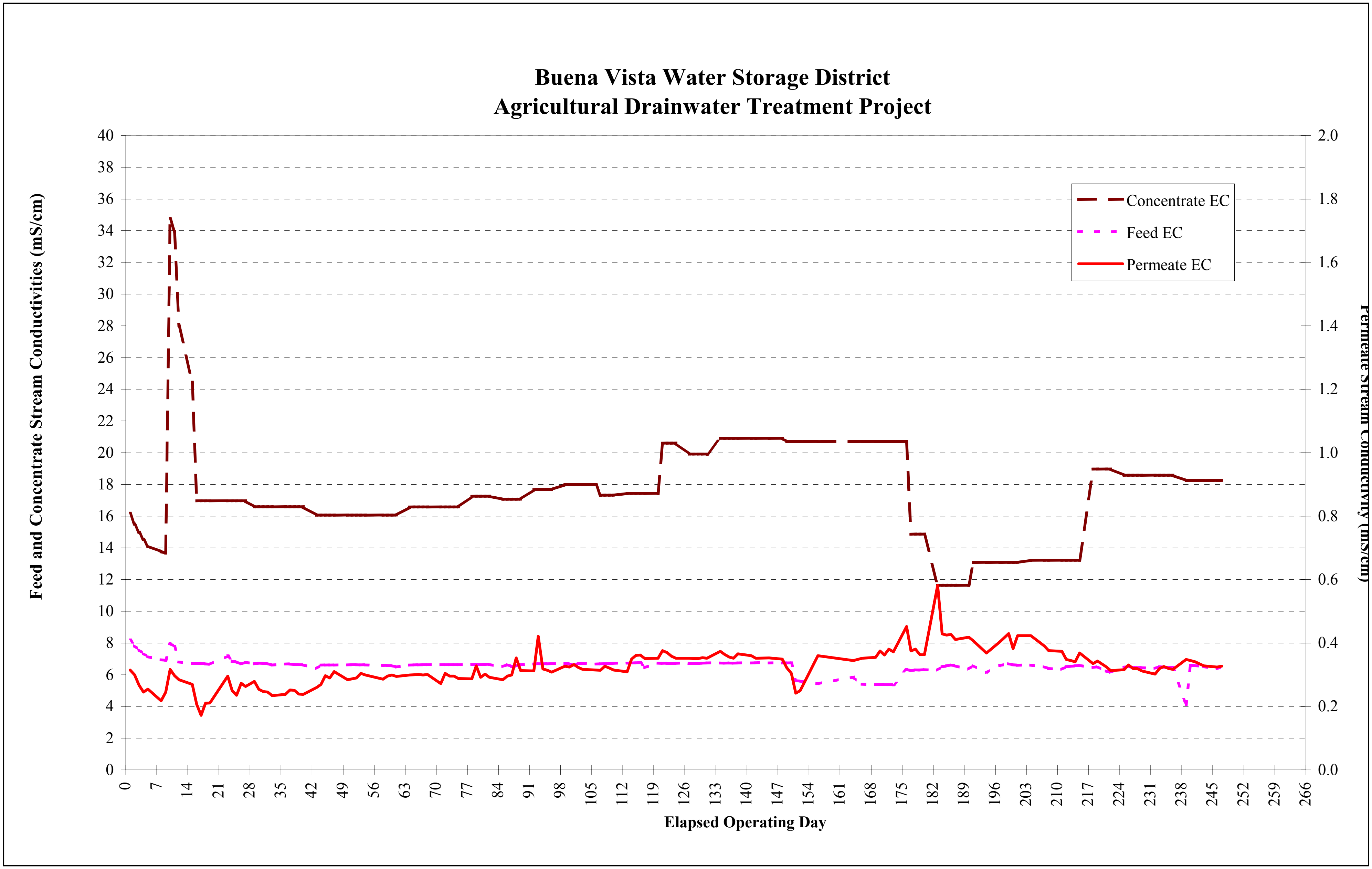


Figure 13: Permeate Electrical Conductivities 2002

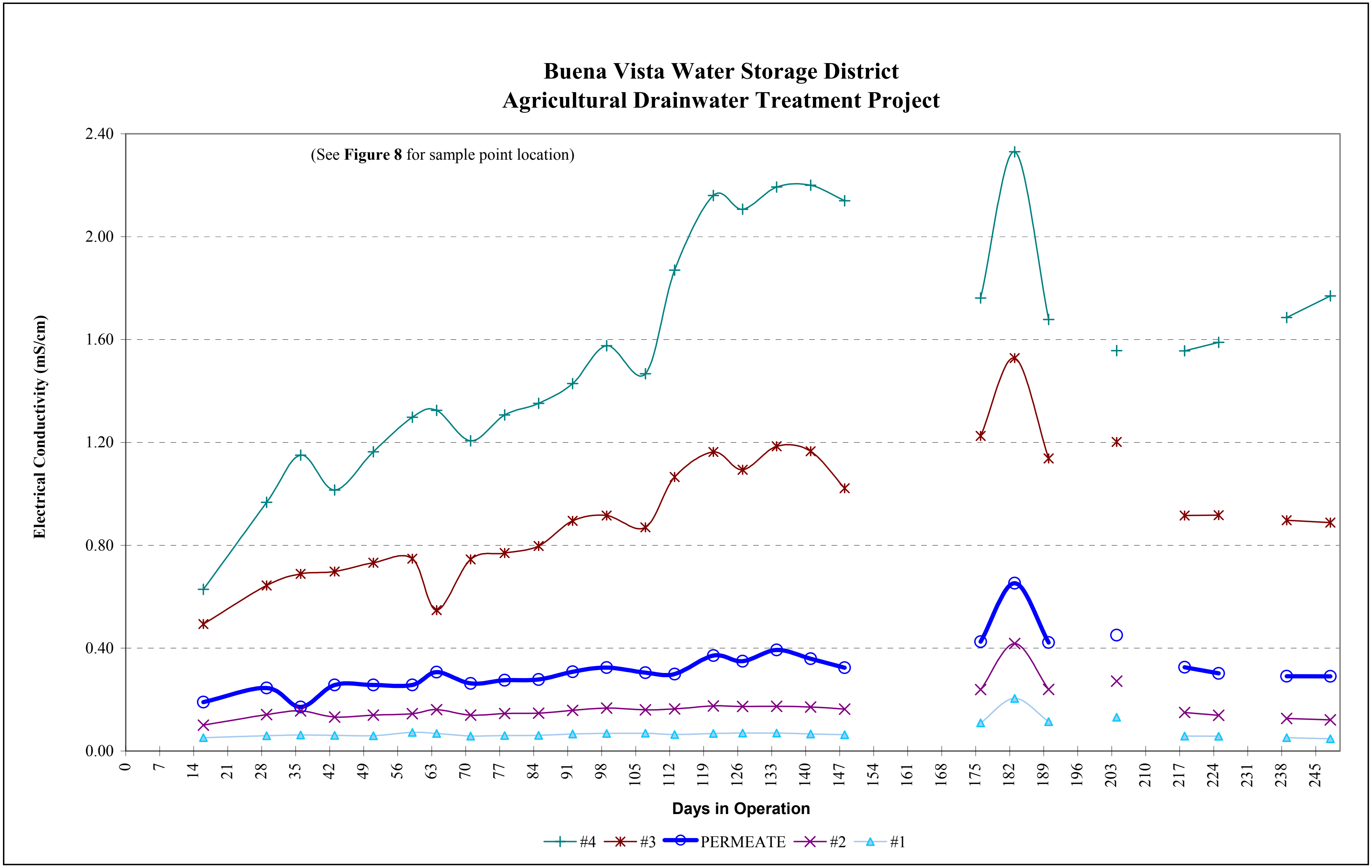
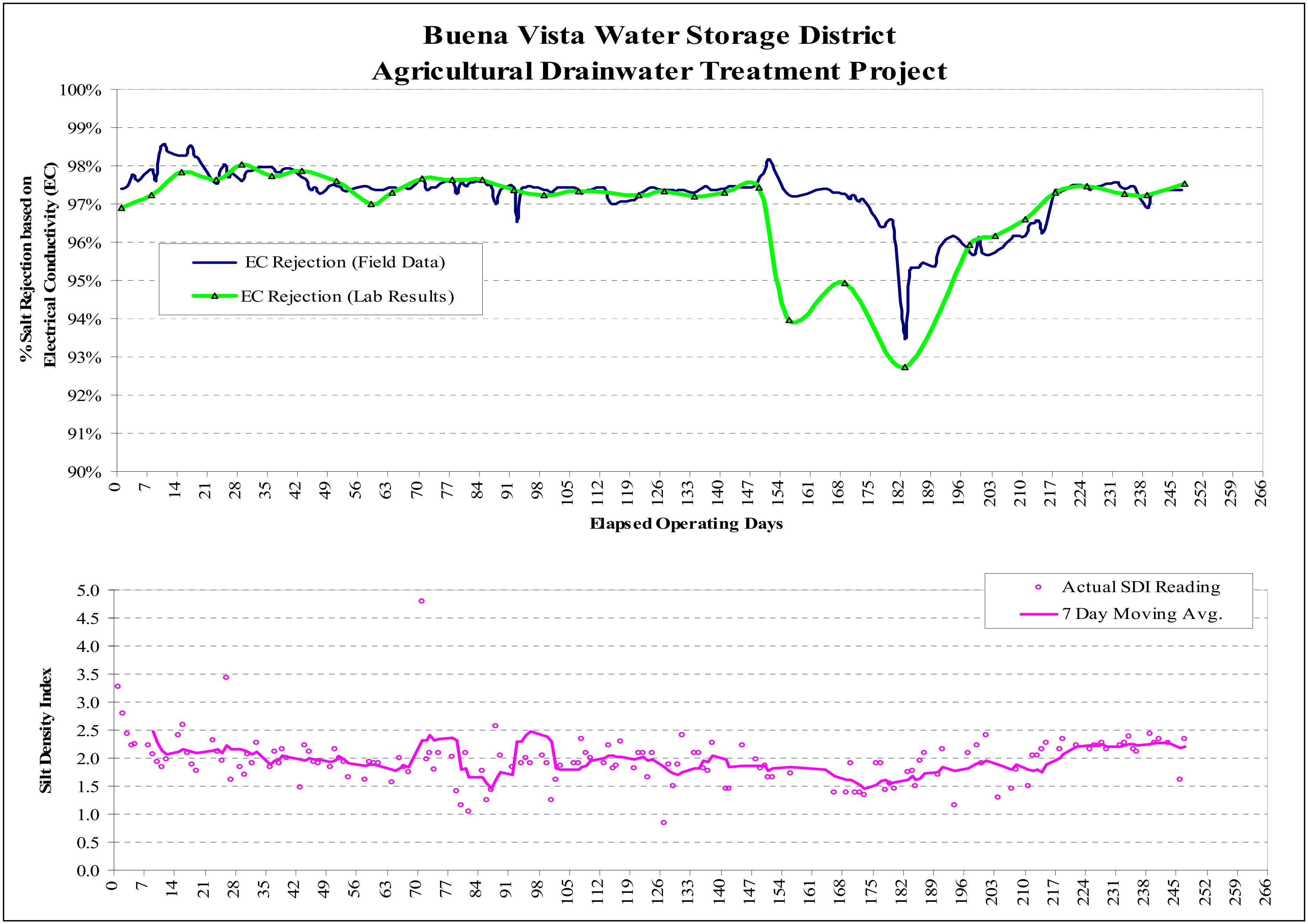


Figure 14: Demonstration Plant Salt Rejection 2002



Laboratory Water Quality Analysis

Figure 16 shows the TDS (salt) rejection rate consistently stayed between 97%-98%. In **Figure 16**, the rejection rates are differentiated by ionic species. As expected the RO membranes are more effective at rejecting divalent[4] ions such as calcium (2+), magnesium (2+), and sulfate (2-), versus the monovalent ions such as sodium (1+), chloride (1-), and bicarbonate (1-). The majority of the ions varied slightly in terms of their rejection; rejection rates were not dependent upon which filter train was used.

Evaluating RO Membrane Salt Rejection

Besides using operating data to formulate values such as normalized flux and process stream conductivities or driving pressures to characterize the health of the RO membranes, analytical lab data can also be used to measure the effectiveness of the RO membranes. The analytical recovery and rejection rates of TDS from the process streams were used in this study.

The TDS rejection rate is defined as the ratio of the permeate TDS concentration divided by the average of the filtrate and concentrate TDS concentrations. Likewise, rejection rate for each ionic species is also defined as the ratio of the permeate ionic species' concentration divided by the average of the filtrate and concentrate ionic species' concentrations. These are typically expressed as *percent rejection.*

TDS Analytical Recovery is a mass balance calculation. It is defined as the ratio of the mass (pounds) of material that exits the membranes over the mass of material that enters the membranes. In this case, it is the sum of the mass of the TDS found in the permeate and the

[4] TDS results from the dissolving of minerals such as calcium sulfate (gypsum) and salt (sodium chloride). When the minerals dissolve, they separate into the *ions* that compose them. For example, calcium sulfate consists of calcium ions and sulfate ions. Sodium chloride consists of sodium ions and chloride ions. Ions are electrically charged either positively or negatively. Ions can have a single charge (monovalent) or multiple charges (multivalent). Divalent ions have twice the electrical charge of monovalent ions. Sodium and chloride are examples of monovalent ions. Calcium and sulfate are examples of divalent ions.

concentrate divided by the mass of the TDS found in the filtrate. A value significantly different than 100% indicates an error in measurement. Error sources include incorrect flow rate measurement, improper sampling technique, and analytical errors (See **Figure 15** for values relating to the TDS Analytical Recovery).

Figure 15: TDS Rejection 2002

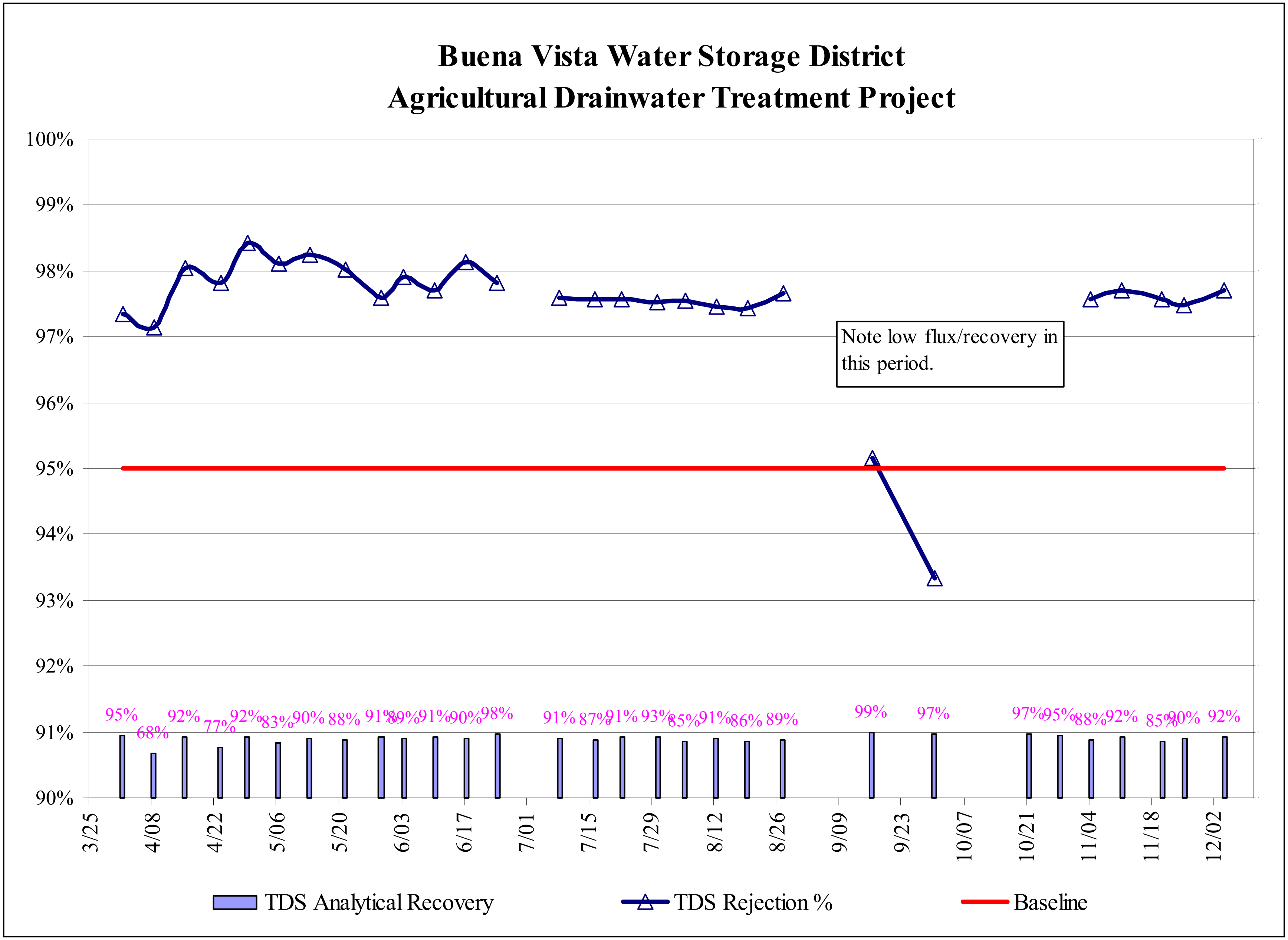
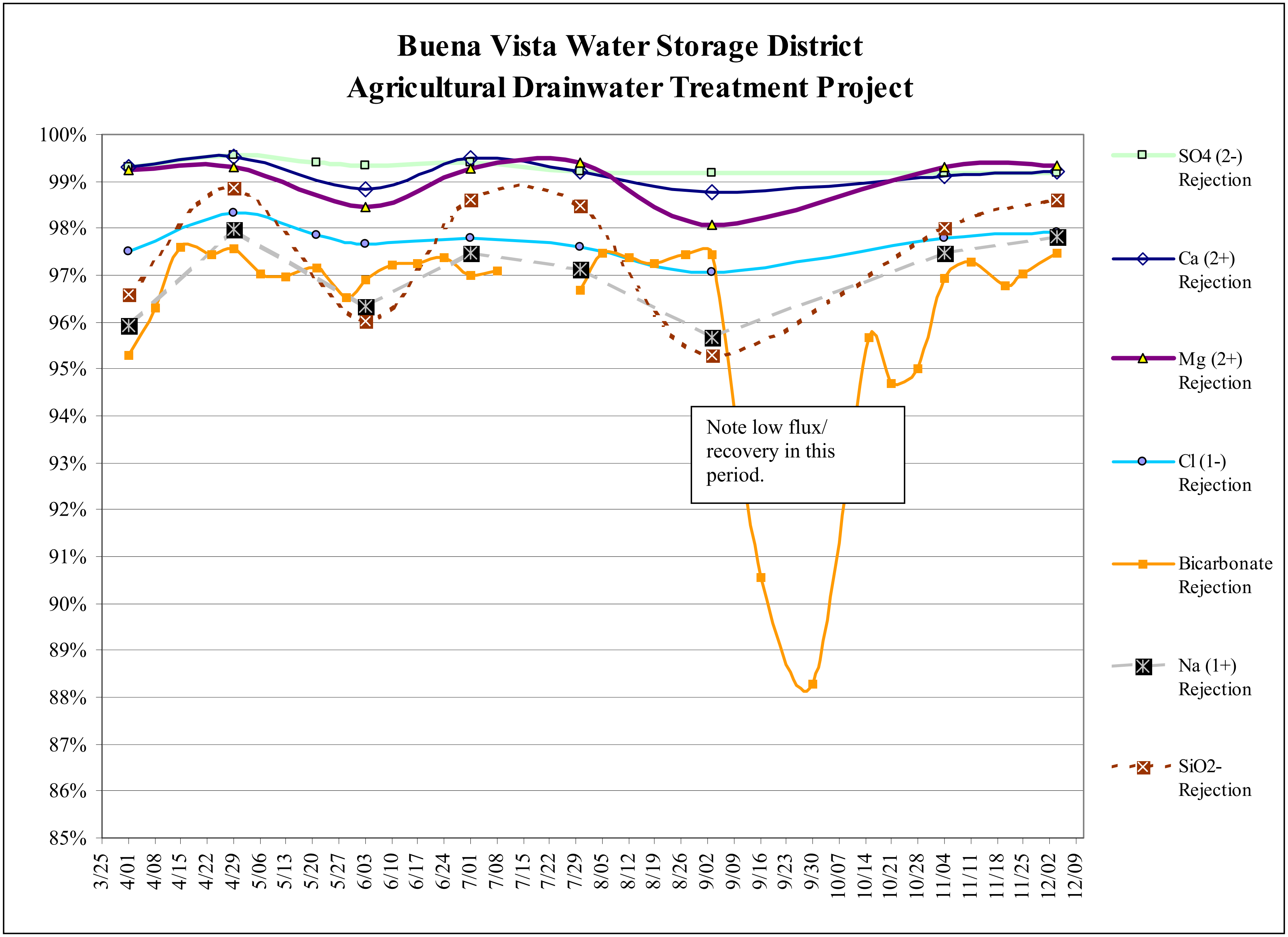


Figure 16: Ion Rejection 2002



Total Organic Carbon Results

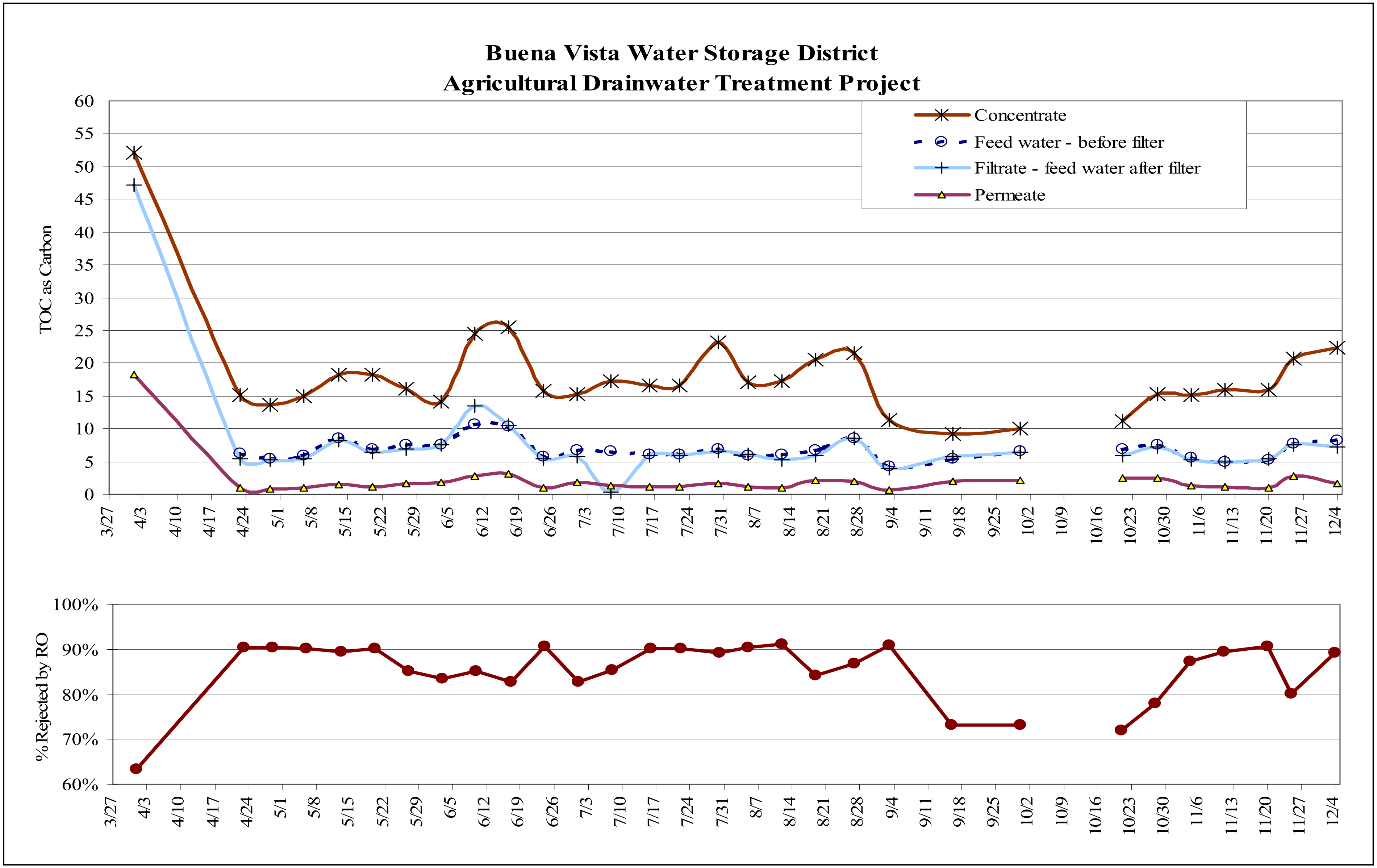
Total organic carbon (TOC)[5] concentration in the feed water varied throughout the testing period. The RO process typically provided over 80% rejection of organics.

Typical TOC concentration in the feed water ranged between 5.0 and 8.0 mg/L. During the start of the irrigation period on June 4th, 2002, a value of over 10.0 was observed, however, this high TOC concentration was not seen again. TOC in the feed water promotes bio fouling of the RO membranes. An increase in TOC will lead to more downtime, as the plant would have to be idled more often for membrane cleaning.

Alum coagulation was used as a supplement to the filter vessels. Injection began April 15th, 2002, two weeks after startup. By comparing the TOC values between the Feed and Filtrate Streams in **Figure 17**, it can be seen that filtration did not appreciably reduce TOC in the demonstration plant's feedwater.

[5] TOC is the sum of all forms of organic carbon found in the water. Organic carbons are combinations of carbon and hydrogen sometimes associated with other elements such as chlorine, oxygen, etc. Examples of substances that make up TOC include natural plant and animal materials, herbicides, fertilizers, insecticides, petroleum related substances, etc.

Figure 17: Total Organic Carbon Rejection 2002



Costs

Costs to construct a 1 MGD, 2 MGD, 5 MGD, and 10 MGD plant employing filtration and RO such as was demonstrated were estimated. The estimates are based on a 75% recovery rate and using the reclaimed water for irrigation. Because the TDS of the permeate exiting the RO system was less than 200 mg/L, the permeate could be blended with filtered raw water (bypass) to increase the final TDS concentration to 750 mg/L for irrigation supply (14% filtered but undesalted water/86% permeate or a ratio of 6.2:1 permeate to undesalted water).

Table 5 shows the feed and product water qualities.

Table 5. Feed and Product Water Qualities

Constituent	Bypass (mg/L)	Permeate (mg/L)	Blended Product (mg/L)
Calcium	344	6	60
Magnesium	62	1	11
Sodium	950	49	193
Barium	0.45	0.01	0.09
Strontium	2.96	0.05	0.5
Iron	2.34	0.04	0.4
Bicarbonate	264	18	57
Chloride	1455	68	290
Sulfate	873	14	151
Silica	28	1	5
pH	7.20	5.71	6.26
TDS	3,848	154	752

Estimates of capital and operating and maintenance costs for various production rates are presented in the following tables. Costs per acre of land drained are included in the cost tables. These costs were developed assuming that each acre of farmland produces 0.5 AF of drain water per year. The number of acres that could be served by each plant size is obtained by multiplying the feed AFY by two and assuming a Plant Usage Factor (PUF) of 95%. Plant Usage Factor is the hours per year that a plant is operated divided by the total number of hours in a year (8760 hours).

Capital Cost Basis

RO System - $1.00/gpd product

Electrical Cost – 10% of the total Equipment Cost

Building Cost - $70/sqft

Storage Tanks - $0.50/gallon capacity

Engineering & Contingencies – 60%

Conceptual layout designs are shown in **Appendix F**.

Operating and Maintenance Cost Basis

Membrane replacement cost was calculated using a membrane life of 5 years.

Electrical power cost was assumed to be $0.13/KWHr. The majority of the power cost is comprised of pumping power for the RO system, with 25% added for miscellaneous loads. Feed pressure is assumed to be 220 psig, as was seen in the demonstration plant.

Chemical costs are based upon consumption seen in the demonstration plant.

Maintenance cost is estimated to be 2 percent of the plant construction cost excluding engineering, administration, and contingencies.

Cost Per Acre Served

Since a desalination plant treating agricultural drainage water must support itself both by producing saleable water and by increasing crop yields, it is important to know both the cost of water produced, and the cost per acre of land out of production. These costs are provided in **Tables 6** and **7**.

Table 6 presents the capital cost both as a Grand Total and as a Capital Cost per Acre for each plant size and use. The cost per acre is calculated by dividing the total capital cost by the number of acres served by the plant. The number of acres served depends upon the feed flow to the plant and the amount of drainage water from each acre, which was assumed to be 0.5 acre-feet per year per acre. The feed flow varies for each plant size and use, depending upon the blending rate and the recovery in the RO system. Due to economies of scale, the capital cost per acre reduces from a little over $1,000 per acre to about $875/acre as plant size increases from 1 to 10 MGD.

Table 7 presents the O&M cost both on a total annual cost basis and on an annual per-acre basis. The per-acre O&M cost is calculated by dividing the total annual O&M cost by the acres served, as provided in **Table 6**. As with capital costs, O&M costs show the economies of scale as costs decrease from about $177/acre to $126/acre as plant size increases from 1 to 10 MGD.

The costs presented in **Tables 6** and **7** do not take into account the cost of gathering or delivering the water, sale of produced water or offset water rights, or concentrate disposal.

Water Cost Table 8 gives the cost of water in $/AF assuming:

- Capital costs (**Table 6**) are amortized over 30 years at 8% interest;
- O&M costs are as shown in **Table 7**; and,
- Annual plant product water production (blend of permeate and undesalted water) is as shown in the table.

As shown in **Table 8**, the cost of water is estimated to range from $459/AF (10 MGD plant) to $651/AF (1 MGD). It should be noted, however, that these costs do not include the cost of collecting and transporting the saline water to the desalter or the costs of disposing of the concentrate. However, the volume of saline drainage water would be reduced by 75%--that portion of the drainage water recovered as usable irrigation water. RO desalination costs would be reduced by the market value of the recovered usable water.

Table 6. Capital Costs for 1, 2, 5, and 10 MGD Plant

		1 MGD	2 MGD	5 MGD	10 MGD
		Irrigation			
Feed (gpm)		893	1788	4469	8940
Bypass (gpm)		96	193	481	964
RO Feed (gpm)		806	1579	3935	7882
Recovery		75%	75%	75%	75%
Product (gpm)		**694**	**1389**	**3472**	**6946**
Acres Served		2,438	4,882	12,201	24,410
RO Process Equipment & Installation		$1,000,000	$2,000,000	$5,000,000	$10,000,000
Filtration System		$90,000	$100,000	$150,000	$300,000
Electrical		$200,000	$300,000	$640,000	$1,300,000
Plant Control System		$200,000	$250,000	$290,000	$500,000
Chemical Systems		$150,000	$200,000	$200,000	$600,000
Building Cost		$175,000	$230,000	$300,000	$600,000
Site Civil		$10,000	$20,000	$20,000	$30,000
SUBTOTAL		**$1,825,000**	**$3,100,000**	**$6,600,000**	**$13,330,000**
Engineering & Administrative Fees	60%	$1,100,000	$1,900,000	$4,000,000	$8,000,000
GRAND TOTAL*		**$2,925,000**	**$5,000,000**	**$10,600,000**	**$21,330,000**
Capital Cost per Acre ($/acre)**		$1,200	$1,024	$869	$874

*Does not include concentrate disposal or cost to get product water to river.

**Based on 0.5 Ac ft per Acre of drain water.

Table 7. Annual O&M Costs for 1, 2, 5, and 10 MGD Plant

	1 MGD	2 MGD	5 MGD	10 MGD
	Irrigation			
Membrane Replacement Costs/Yr	$22,000	$41,000	$99,000	$200,000
Elec. Cost/Yr	$170,000	$330,000	$830,000	$1,700,000
Labor/Yr	$150,000	$150,000	$300,000	$450,000
CIP Chem Cost/Yr	$6,000	$12,000	$12,000	$24,000
Chemical Cost/Yr	$28,000	$55,000	$140,000	$280,000
Maintenance Cost/Yr	$56,000	$66,000	$210,000	$414,000
Total ($/Yr)	**$432,000**	**$654,000**	**$1,591,000**	**$3,068,000**
$/Ac-Ft	**$400**	**$302**	**$294**	**$284**
$/Kgal	$1.18	$0.90	$0.87	$0.84
$/acre	$177	$134	$130	$126

Table 8. Water Costs

	1 MGD	2 MGD	5 MGD	10 MGD
	Irrigation			
RO Permeate (AFY)	964	1,930	4,825	9,649
Bypass (AFY)	116	233	582	1,166
Product Water (AFY)	1,080	2,163	5,406	10,815
Capital Cost	$2,925,000	$5,000,000	$10,600,000	$21,330,000
Annual Capital ($/Yr)	$260,000	$445,000	$942,000	$1,900,000
Annual O&M ($/Yr)	$432,000	$654,000	$1,591,000	$3,068,000
Total Annual Cost ($/Yr)	$692,000	$1,099,000	$2,533,000	$4,968,000
Water Cost ($/AFY Production)	$641	$508	$469	$459

Summary

Using reverse osmosis, the saline groundwater from the shallow aquifer was desalted. The product water would be suitable for use as irrigation water.

The RO demonstration plant operated periodically throughout the 2000 and continuously throughout the 2002 irrigation seasons using two different feedwater sources to produce the permeate. During 2000 the water used in the RO demonstration plant came from the on-farm tile drain system that was installed by the farmers to keep the saline groundwater below the crop root zone and to transport the drainage water away from the crops. During 2002, two shallow wells were used to supply water to the RO demonstration plant. The water from the two wells was 57 % less salty than that of the tile drain system.

The RO demonstration plant recovered up to 75% of the feed water and rejected as much as 90% of the organics and 97% of the TDS. Alum was injected ahead of the filter system to promote coagulation and to increase solid settling to obtain RO feedwater with an acceptable SDI. The prefiltration did not reduce the TOC concentration in the raw water.

The RO Demonstration Project has shown that it is technically feasible to reclaim agricultural drainage water in the San Joaquin Valley using reverse osmosis. A suitable method for disposing of the concentrate must be determined before implementation is possible.

Future Study

Future studies should focus mainly on RO process brine disposal. **Table 9** shows the brine concentrate quality data captured during the pilot study.

Table 9. Concentrate Quality

Constituent (mg/L)	Field Data
Calcium	1,215
Magnesium	218
Sodium	3,200
Potassium	0
Ammonium	0
Barium	0
Strontium	9
Iron	5
Aluminum	0
Bicarbonate	725
Chloride	5,238
Sulfate	3,192
Fluoride	0
Nitrate	0
Phosphate	0
Silica	99
pH (pH units)	7.20
TDS	12,079

There are multiple ways to dispose of RO concentrate, including:

- Evaporation Ponds
- Deep Well Injection
- Disposal to a Body of Water (i.e. Ocean or River)
- Enhanced Recovery (Zero Liquid Discharge)

Evaporation Ponds

Disposal of wastewater (including desalting concentrate) via evaporation ponds has been used for many years. There are several design aspects of evaporation ponds that need to be considered:

- The net evaporation rate (gross evaporation less precipitation and decrease in evaporation rate as TDS increases)
- Land requirements—the area required depends on the volume of water requiring disposal, net evaporation rate, and topography (a level site would require the least land for a given evaporation surface need)
- Number and size of ponds
- Impermeable lining for minimizing leakage into underlying groundwater
- Impacts of trace elements (i.e. sodium) on water flow and biological resources

Assuming a net evaporation rate of 5 feet per year, **Table 10** shows the surface areas of evaporation ponds that would be needed for various treatment plant sizes.

Table 10. Needed Evaporation Pond Area for Varying Production Rates

Plant Productions (MGD)	**1**	**2**	**5**	**10**
Concentrate (AFY)	326	637	1,587	3,178
Evaporation Area (acres)	65	127	317	636
Number of Ponds	2	4	8	16
Size of Each Pond (acres)	35	35	40	40
Total Pond Area (acres)	70	140	320	640
Total Area Needed (acres)	75	150	345	690

A typical pond may have a total depth of 12 ft (including 2 ft of freeboard) and side slopes of 3 to 1.

Deep Well Injection

An alternative to evaporation ponds is deep well injection (DWI). DWI consists of drilling a well into an aquifer that does not contain usable water to dispose of the concentrate. The aquifer needs to be deep enough so as not to interfere with usable groundwater.

Disposal to a Body of Water

Another alternative is to dispose of concentrate to a body of water. Typical bodies of water used for disposal include the ocean or nearby rivers and streams. Since this project takes place inland from the ocean, a pipeline would have to be constructed to carry the concentrate from the treatment site.

In order to dispose to a body of water like a river or stream, state and local regulatory agencies insist that the water quality be nontoxic to whatever wildlife may inhabit the waterway. Typical RO waste streams are high in TDS concentration and are difficult to dispose of in a body of water.

Enhanced Recovery

By further treating the concentrate or enhancing the recovery, more useable water and less concentrate is produced. At this point, the brine becomes a highly concentrated waste that can be either disposed of or precipitated for salt recovery.

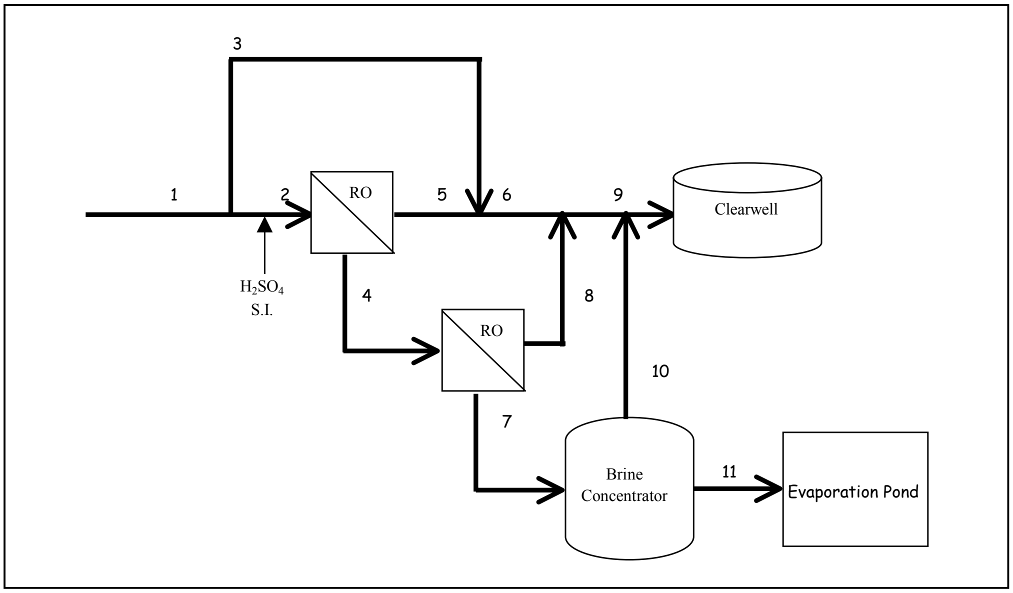
Secondary RO Treatment

Depending on the TDS concentration and the ionic makeup of the concentrate, more usable water can be recovered using a second RO unit. However, since the concentrate from the primary RO treatment is saturated in scaling minerals, it must first be treated to remove these minerals before secondary RO treatment.

Zero Liquid Discharge (ZLD)

ZLD is another form of enhanced recovery. This can be achieved by using equipment such as brine concentrators and/or crystallizers to remove essentially all of the water from the concentrate. The TDS that was dissolved in the original raw water are recovered as relatively dry salts. (see **Figure 18**).

Figure 18: Enhanced Recovery Block Flow Diagram



Stream	1	2	3	4	5	6	Y_1%*
gpm	782	707	75	177	530	605	75%
TDS	3,848	3,861	3,848	14,936	170	626	
Stream	**7**	**8**	**9**	**10**	**11**	**Y_2%***	**Y_O%***
gpm	88.4	88	**772**	78	10	50%	98.7%
TDS	28,340	1,532	**668**	20	240,000		

*Y = Percent recovery for each stage of production ("1" & "2") and overall production ("o").

Typically, what's left over after the enhanced recovery process is a highly concentrated sludge. This sludge can be disposed of in drying beds or evaporation ponds to remove what little liquid remains. Once dry, the solid can be hauled off for disposal. Assuming a sludge handling cost of $53/ton[6], the annual cost to remove the sludge would approximate $283,000 dollars for 5,300 tons of sludge waste.

[6] Waste disposal estimate provided by J Torres Company.

Appendix A – 2000 Demonstration Plant Data

Table A.1 – Water Quality Analysis - Feed

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Feed Stream		1/6/2000	8/8/2000	8/15/2000	8/24/2000	8/31/2000	9/8/2000
Dissolved Bicarbonate	as ion		370	206	373	346	366
Dissolved Carbonate	as ion		1	1	2	1	<1
Dissolved Chloride		3990	2610				2380
EC	μS/cm @ 25 C	13700	10200	4880	9890	9650	9880
Dissolved Barium		0.183	0.13				0.116
Dissolved Boron		5.8	5.24				4.89
Dissolved Calcium		1090	696	329	663	702	725
Dissolved Fluoride		0.8					
Dissolved Iron							
Dissolved Magnesium		180	121	49	108	113	130
Dissolved Nitrate	as N	7	53				
Dissolved Nitrite	as N		0.03				
DOC	as C		4.5				
Dissolved Phosphate	as P						
Dissolved Potassium		9.8					
Dissolved Selenium		0.033	0.04				0.04
Dissolved Silica		46	54				29
Dissolved Sodium		1960	1530	705	1460	1410	1550
Dissolved Strontium		8.03	6.99				6.62
Dissolved Sulfate		1540	1420				1390
Hardness	as CaCO3	3484	2237	1023	2101	2219	2346
Hydroxide	as CaCO3		<1	<1	<1	<1	<1
pH	pH units	7.8	7.27	7.45	7.61	7.18	7.3
Total Alkalinity	as CaCO3	425	371	207	374	346	366
TDS		9430	7010	3160	6750	6730	6840
UV254	absorb./cm	0.171	0.149				0.117
Total Barium							
Total Calcium							
Total Iron							
Total Magnesium							
TOC as C	as C	3.9					3.7
Total Potassium							
Total Selenium							
Total Silica							
Total Sodium							
Total Strontium							
TSS		6	4				2
Turbidity	NTU	1.7	1.4	45.4	10.3, 11	4.8	<1

Table A.2 – Water Quality Analysis - Filtrate

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Filtrate Stream		1/6/2000	8/8/2000	8/15/2000	8/24/2000	8/31/2000	9/8/2000
Dissolved Bicarbonate	as ion		370	203	372	345	366
Dissolved Carbonate	as ion		1	1	1	1	1
Dissolved Chloride			2610				2490
EC	µS/cm @ 25 C		10200	4650	9900	9650	9880
Dissolved Barium			0.13				0.108
Dissolved Boron			5.4				4.4
Dissolved Calcium			685	330	679	698	726
Dissolved Fluoride							
Dissolved Iron							
Dissolved Magnesium			124	50	110	113	97.3
Dissolved Nitrate	as N		52				
Dissolved Nitrite	as N		0.03				
DOC	as C		6.7				
Dissolved Phosphate	as P						
Dissolved Potassium							
Dissolved Selenium			0.039				
Dissolved Silica			53				41.9
Dissolved Sodium			1620	717		1420	1540
Dissolved Strontium			6.94				6.84
Dissolved Sulfate			1430				1400
Hardness	as CaCO3		2221	1030	2149	2209	2220
Hydroxide	as CaCO3		<1	<1	<1	<1	<1
pH	pH units		7.28	7.46	7.55	7.19	7.2
Total Alkalinity	as CaCO3		371	204	373	346	367
TDS			7000	3140			
UV254	absorb./cm		0.141				0.116
Total Barium							
Total Calcium							
Total Iron							
Total Magnesium							
TOC as C	as C						3.6
Total Potassium							
Total Selenium							
Total Silica							
Total Sodium							
Total Strontium							
TSS							1
Turbidity	NTU			<1	<1	<1	<1

Table A.3 – Water Quality Analysis - Permeate

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Permeate Stream		1/6/2000	8/8/2000	8/15/2000	8/24/2000	8/31/2000	9/8/2000
Dissolved Bicarbonate	as ion				18	10	10
Dissolved Carbonate	as ion				<1	<1	<1
Dissolved Chloride							93
EC	µS/cm @ 25 C				679	389	387
Dissolved Barium							<0.05
Dissolved Boron							5.2
Dissolved Calcium					6	6	8
Dissolved Fluoride							
Dissolved Iron							
Dissolved Magnesium					<1	2	<1
Dissolved Nitrate	as N						
Dissolved Nitrite	as N						
DOC	as C						
Dissolved Phosphate	as P						
Dissolved Potassium							
Dissolved Selenium							0.002
Dissolved Silica							0.4
Dissolved Sodium					125	68	80
Dissolved Strontium							0.055
Dissolved Sulfate							12
Hardness	as CaCO3				18	23	21
Hydroxide	as CaCO3				<1	<1	<1
pH	pH units				6.3	6.04	6.2
Total Alkalinity	as CaCO3				18	10	10
TDS					343	199	194
UV254	absorb./cm						0.002
Total Barium							
Total Calcium							
Total Iron							
Total Magnesium							
TOC as C	as C						0.2
Total Potassium							
Total Selenium							
Total Silica							
Total Sodium							
Total Strontium							
TSS							
Turbidity	NTU				<1	<1	<1

Table A.4 – Water Quality Analysis - Concentrate

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Concentrate Stream		1/6/2000	8/8/2000	8/15/2000	8/24/2000	8/31/2000	9/8/2000
Dissolved Bicarbonate	as ion						
Dissolved Carbonate	as ion						
Dissolved Chloride							6040
EC	µS/cm @ 25 C				17700		18000
Dissolved Barium							0.207
Dissolved Boron							8.7
Dissolved Calcium							
Dissolved Fluoride							
Dissolved Iron							
Dissolved Magnesium							
Dissolved Nitrate	as N						
Dissolved Nitrite	as N						
DOC	as C						
Dissolved Phosphate	as P						
Dissolved Potassium							
Dissolved Selenium							0.078
Dissolved Silica							9.6
Dissolved Sodium							
Dissolved Strontium							12.9
Dissolved Sulfate							2720
Hardness	as CaCO3						
Hydroxide	as CaCO3						
pH	pH units						7.2
Total Alkalinity	as CaCO3						
TDS					13100		13400
UV254	absorb./cm						0.235
Total Barium							
Total Calcium							
Total Iron							
Total Magnesium							
TOC as C	as C						8.6
Total Potassium							
Total Selenium							
Total Silica							
Total Sodium							
Total Strontium							
TSS							
Turbidity	NTU				10.2		<1

Table A.5 – Year 2000 Filter Performance Data

Date	Train	Operation	Op Time (min)	P_{in} (psi)	P_{IS} (psi)	P_{out} (psi)	SDI	EC (mS)	pH
6/27/2000	2	-	-	63	63	62.5	3.1	-	-
6/28/2000	2	-	-	62	62	60	2.9	6.75	-
6/29/2000	2	-	-	61	62	60	2.2	7.67	-
6/30/2000	2	-	-	-	-	-	-	7.28	7.35
7/3/2000	2	-	-	62	63	61	2.9	7.64	8.78
7/4/2000	2	-	-	68	55	52	1.8	7.75	8.29
7/5/2000	2	Backwash	20	73	38	34	1.8	7.26	8.35
7/5/2000	1	Online	-	62	62	62	2.7	-	-
7/6/2000	1	-	-	61	61	60	3	5.58	8.45
7/7/2000	1	-	-	62	58	58	3.9	4.98	8.57
7/10/2000	1	Backwash	20	66	42	42	NC	4.54	8.56
7/10/2000	2	Online	-	62	62	62	3.6	-	-
7/11/2000	2	Backwash	20	70	47	42	NC	-	-
7/11/2000	1	Online	-	60	60	60	3.4	-	-
7/12/2000	1	Backwash	20	66	30	30	3.4	-	-
7/12/2000	1	Online	-	60	60	60	-	-	-
7/13/2000	2	Online	-	60	60	60	-	-	-
7/14/2000	1	Online	-	60	60	60	-	-	-
7/17/2000	1	-	-	58	56	54	2.1	8.28	8.80
7/18/2000	1	-	-	58	54	54	2.9	8.00	8.58

Table A.5 – Year 2000 Filter Performance Data (cont.)

Date	Train	Operation	Op Time (min)	P_{in} (psi)	P_{IS} (psi)	P_{out} (psi)	SDI	EC (mS)	pH
7/18/2000	-	Took Sample/RO Online	-	-	-	-	-	-	-
7/19/2000	1	Backwash	20	58	50	50	1.8	6.39	8.51
7/19/2000	2	Online	-	56	52	52	-	-	-
7/20/2000	2	Backwash	20	50	46	30	1.7	8.04	5.51
7/20/2000	1	Online	-	58	58	58	-	-	-
7/24/2000	1	Backwash	20	58	48	46	1.7	6.77	8.50
7/24/2000	2	Online	-	58	58	56	-	-	-
7/25/2000	2	Took Sample	-	56	56	51	1.8	8.03	8.49
7/26/2000	2	Backwash	20	54	50	36	-	-	-
7/26/2000	1	Online	-	51	51	51	-	-	-
7/27/2000	1	-	-	52	50	48	2.5	7.98	8.36
7/28/2000	1	Backwash	20	51	41	40	5.1	6.04	8.48
7/28/2000	2	Online	-	-	-	-	-	-	-
7/31/2000	2	Backwash	20	50	50	18	4	6.80	8.46
7/31/2000	1	Online	-	-	-	-	-	-	-
8/1/2000	1	-	-	60	60	60	3.5	7.48	8.43
8/2/2000	1	Backwash	20	54	48	46	3.2	7.31	8.10
8/2/2000	2	Online		38	38	36	-	-	-
8/3/2000	2	Backwash	20	44	36	34	2.5	8.41	8.37
8/3/2000	1	Online		46	46	45	-	-	-

Table A.5 – Year 2000 Filter Performance Data (cont.)

Date	Train	Operation	Op Time (min)	P_{in} (psi)	P_{IS} (psi)	P_{out} (psi)	SDI	EC (mS)	pH
8/4/2000	1	-	-	42	40	38	2.3	8.40	8.69
8/7/2000	1	Backwash	20	44	28	26	-	8.43	9.38
8/8/2000	2	-	-	44	44	42	2.3	8.29	4.16
8/9/2000	2	-	-	44	42	40	2.2	8.30	9.00
8/10/2000	2	Backwash/Irrigation Began	20	46	38	32	2.3	8.37	9.00
8/14/2000	1	Backwash	20	46	43	42	3.1	8.30	8.86
8/15/2000	2			44	42	38	5.0	5.08	8.57
8/16/2000	2	Backwash	20	48	40	28	3.2	8.44	8.40
8/17/2000	1	Online		48	46	44	2.9	8.77	8.46
8/18/2000	1	-	-	48	44	42		8.65	7.51
8/22/2000	-	Load New Membranes	-	-	-	-	-	-	-
8/24/2000	1	Sampled	-	28	28	26	2.6	8.68	7.39
8/25/2000	2	Online	-	28	28	26		7.30	7.14
8/28/2000	2	-	-	26	26	24	2.1	6.84	-
8/29/2000	2	Backwash	20	26	24	20	2.2	6.31	-
8/30/2000	-	2nd Stage Membranes	-	-	-	-	-	-	-
8/31/2000	1	Sampled		26	24	22	2.1	4.29	-
9/6/2000	1	Backwash	20	-	-	-	-	-	-
9/6/2000	2	Online	-	26	26	22	-	0.93	-
9/7/2000	2	-	-	26	26	22	-	6.09	-

Table A.5 – Year 2000 Filter Performance Data (cont.)

Date	Train	Operation	Op Time (min)	P_{in} (psi)	P_{IS} (psi)	P_{out} (psi)	SDI	EC (mS)	pH
9/8/2000	2	-	-	26	26	24	-	3.48	-
9/11/2000	1	Online		26	26	24		6.73	
9/12/2000	1			26	26	24		5.13	
9/13/2000	1			26	26	24		5.57	

Table A.6 – RO Performance Data

Date	Conductivity (mS/s)					Pressure (psi)						Flow (gpm)	
	Overall	P1	P2	P3	P4	Permeate	Filter In	Filter Out	Feed	IS	Concentrate	Permeate	Concentrate
8/1/2000	1130	984	1426	1420	1810	3	67	63	206	160	154	10	10
8/2/2000	930	769	1357	1370	1842	3	75	70	215	160	155	10	10
8/3/2000	1354	1069	1874	1812	2390	3	41	37	145	105	95	9	12
8/4/2000	1533	1012	1806	1671	2240	3	38	34	205	165	145	11	10
8/7/2000	1705	1197	2080	1857	2500	3	44	39	225	185	170	12	9
8/8/2000	1743	1235	2130	1880	2530	3	42	38	225	160	165	8	10
8/9/2000	1766	1217	2080	1879	2500	3	40	36	235	185	160	10	10
8/10/2000	1679	1173	2020	1817	2420	3	34	30	225	180	165	10	10
8/14/2000	1651	-	-	-	-	3	-	-	226	176	166	10	10
8/15/2000	657	470	780	732	1009	3	39	37	200	150	145	9	12
8/16/2000	1460	1030	1670	1625	2120	3	30	30	215	170	155	10	9.5
8/17/2000	1768	1129	1774	1712	2330	3	45	45	225	180	165	10	9.8
8/18/2000	1485	1028	1552	1512	2130	-	-	-	-	-	-	-	-
8/22/2000	990	207	483	2060	2820	-	-	-	-	***New***	***Membranes***	-	-
8/24/2000	717	102	336	1933	2610	4	27	26	215	200	185	10	10
8/25/2000	682	95.6	321	1800	2460	4	25	25	215	195	185	10	10
8/28/2000	693	90	299	1009	2510	-	-	-	-	-	-	-	-
8/29/2000	623	90.4	291	1778	2460	4	24	23	215	195	185	10	10
8/30/2000						-	-	-	-	***New***	***Membranes***	-	-
8/31/2000	420	93.1	273	633	831	4	24	22	200	175	150	9.5	10.5
9/6/2000	430	275	410	781	1027	4	24	24	185	160	135	11	10
9/7/2000	394	100	303	765	1130	4	24	24	210	185	160	10	10
9/8/2000	350	76.9	178	570	763	4	25	24	205	175	160	10	10
9/11/2000	350	101	262	628	856	3	26	26	185	160	135	10	10
9/12/2000	436	95.3	295	689	973	4	62	60	220	195	170	10	10
9/13/2000	483	98.3	300	752	1150	4	61	61	220	195	170	10	10

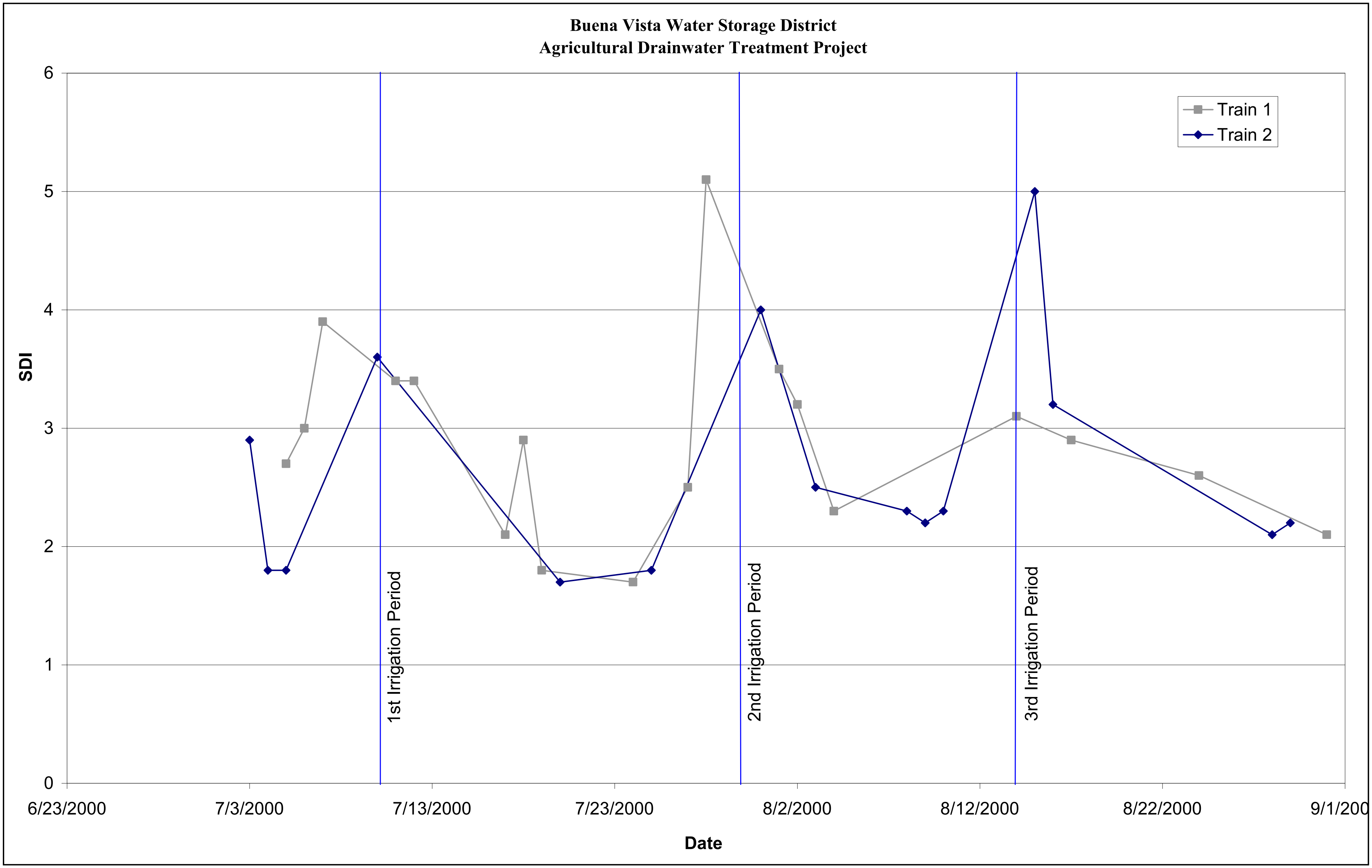
Table A.7 – Filter Train 1 SDI Data

Date	Train	Operation	Op Time (min)	P_{in} (psi)	P_{IS} (psi)	P_{out} (psi)	SDI	EC (mS)	pH
7/5/2000	1	Online	-	62	62	62	2.7	-	-
7/6/2000	1	-	-	61	61	60	3	5.58	8.45
7/7/2000	1	-	-	62	58	58	3.9	4.98	8.57
7/11/2000	1	Online	-	60	60	60	3.4	-	-
7/12/2000	1	Backwash	20	66	30	30	3.4	-	-
7/17/2000	1	-	-	58	56	54	2.1	8.28	8.80
7/18/2000	1	-	-	58	54	54	2.9	8.00	8.58
7/19/2000	1	Backwash	20	58	50	50	1.8	6.39	8.51
7/24/2000	1	Backwash	20	58	48	46	1.7	6.77	8.50
7/27/2000	1	-	-	52	50	48	2.5	7.98	8.36
7/28/2000	1	Backwash	20	51	41	40	5.1	6.04	8.48
8/1/2000	1	-	-	60	60	60	3.5	7.48	8.43
8/2/2000	1	Backwash	20	54	48	46	3.2	7.31	8.10
8/4/2000	1	-	-	42	40	38	2.3	8.40	8.69
8/14/2000	1	Backwash	20	46	43	42	3.1	8.30	8.86
8/17/2000	1	Online		48	46	44	2.9	8.77	8.46
8/24/2000	1	Sampled	-	28	28	26	2.6	8.68	7.39
8/31/2000	1	Sampled		26	24	22	2.1	4.29	-
Average	2.9								
SD	0.80								

Table A.8 – Filter Train 2 SDI Data

Date	Train	Operation	Op Time (min)	P_{in} (psi)	P_{IS} (psi)	P_{out} (psi)	SDI	EC (mS)	pH
7/3/2000	2	-	-	62	63	61	2.9	7.64	8.78
7/4/2000	2	-	-	68	55	52	1.8	7.75	8.29
7/5/2000	2	Backwash	20	73	38	34	1.8	7.26	8.35
7/10/2000	2	Online	-	62	62	62	3.6	-	-
7/20/2000	2	Backwash	20	50	46	30	1.7	8.04	5.51
7/25/2000	2	Took Sample	-	56	56	51	1.8	8.03	8.49
7/31/2000	2	Backwash	20	50	50	18	4	6.80	8.46
8/3/2000	2	Backwash	20	44	36	34	2.5	8.41	8.37
8/8/2000	2	-	-	44	44	42	2.3	8.29	4.16
8/9/2000	2	-	-	44	42	40	2.2	8.30	9.00
8/10/2000	2	Backwash/Irrigation Began	20	46	38	32	2.3	8.37	9.00
8/15/2000	2			44	42	38	5.0	5.08	8.57
8/16/2000	2	Backwash	20	48	40	28	3.2	8.44	8.40
8/28/2000	2	-	-	26	26	24	2.1	6.84	-
8/29/2000	2	Backwash	20	26	24	20	2.2	6.31	-
Average	2.6								
SD	0.92								

Figure A.9 – Filter Performance Data for Year 2000



Appendix B – Laboratory Analytical Data

Table B.1 - Water Quality Analysis - Feed

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Feed Stream		4/1/2002	4/8/2002	4/15/2002	4/23/2002	4/29/2002	5/6/2002	5/13/2002	5/21/2002	5/29/2002	6/3/2002	6/10/2002	6/17/2002	6/24/2002
Dissolved Bicarbonate	as ion					264								
Dissolved Carbonate	as ion					1								
Dissolved Chloride						1,530								
EC	uS/cm @ 25 C					6,550								
Dissolved Barium														
Dissolved Boron						3.6								
Dissolved Calcium						395								
Dissolved Fluoride														
Dissolved Iron														
Dissolved Magnesium						64								
Dissolved Nitrate	as N													
Dissolved Nitrite	as N													
DOC	as C					5.1								
Dissolved Phosphate	as P													
Dissolved Potassium														
Dissolved Selenium														
Dissolved Silica						27								
Dissolved Sodium						900								
Dissolved Strontium														
Dissolved Sulfate						908								
Hardness	as CaCO3					1,250								
Hydroxide	as CaCO3					<1								
pH	pH units					7.5								
Total Alkalinity	as CaCO3					265								
TDS						4,204								
UV254	absorb./cm					0.166								
Total Barium						<.05								
Total Calcium														
Total Iron												4.84	1.16	2.57
Total Magnesium														
TOC as C	as C				6.2	5.5	6	8.5	6.9	7.6	7.6	10.7	10.4	5.8
Total Potassium														
Total Selenium						0.019								
Total Silica														
Total Sodium														
Total Strontium						3.6								
TSS		<1	3	2	7	4	4	5	9	5	10	2	2	9
Turbidity	NTU	<1	16	13	7	17	13.8	11.2	11	6	30	8	21	22

Table B.1 - Water Quality Analysis - Feed (cont.)

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Feed Stream		7/1/2002	7/8/2002	7/16/2002	7/22/2002	7/30/2002	8/5/2002	8/12/2002	8/19/2002	8/27/2002	9/3/2002	9/16/2002	9/30/2002	10/15/2002	10/21/2002	10/28/2002	11/4/2002	11/11/2002	11/20/2002	11/25/2002	12/4/2002
Dissolved Bicarbonate	as ion	290									223						264				280
Dissolved Carbonate	as ion	<1									<1						<1				<1
Dissolved Chloride		1,534									1,190						1,490				1,530
EC	uS/cm @ 25 C	6,340									6,160						6,120				6,330
Dissolved Barium																					
Dissolved Boron		3.8									5						3.7				4
Dissolved Calcium		372									266						331				358
Dissolved Fluoride																					
Dissolved Iron																					
Dissolved Magnesium		70									49						61				66
Dissolved Nitrate	as N																				
Dissolved Nitrite	as N																				
DOC	as C	8									3.6						5.4				8
Dissolved Phosphate	as P																				
Dissolved Potassium																					
Dissolved Selenium																					
Dissolved Silica		29									28						28				30
Dissolved Sodium		956									781						883				990
Dissolved Strontium																					
Dissolved Sulfate		930									760						860				906
Hardness	as CaCO3	1,217									866						1,076				1,170
Hydroxide	as CaCO3	<1									<1						<1				<1
pH	pH units	7.2									7						7				7.2
Total Alkalinity	as CaCO3	290									223						264				280
TDS																					3,980
UV254	absorb./cm	0.144									0.191						0.137				0.113
Total Barium		<.5									<.5						<0.5				<.25
Total Calcium																					
Total Iron		1.22	1.32			1.68					4.65										1.3
Total Magnesium																					
TOC as C	as C	6.7	6.5	6.1	6.1	6.9	6	6.1	6.8	8.5	4.3	5.5	6.5	5.5	6.9	7.5	5.6	5	5.2	7.7	803
Total Potassium																					
Total Selenium		0.026									0.017						0.02				0.025
Total Silica																					
Total Sodium																					
Total Strontium		3.21									2.29						2.72				2.99
TSS		3	<1	4	4	4	1	4	3	2	11	6	9	4	3	2	3	4	4	9	4
Turbidity	NTU	14	13	10	10	10	10	20	11	7	26	38	34	11	12	15	13	17	18	36	16

Table B.1 - Water Quality Analysis - Filtrate

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Filtrate Stream		4/1/2002	4/8/2002	4/15/2002	4/23/2002	4/29/2002	5/6/2002	5/13/2002	5/21/2002	5/29/2002	6/3/2002	6/10/2002	6/17/2002	6/24/2002
Dissolved Bicarbonate	as ion	336	290	280	302	276	279	295	280	261	283	290	292	278
Dissolved Carbonate	as ion	1	1	1	2	1	1	2	1	<1	<1	1	1	<1
Dissolved Chloride		2,070				1,550			1,460		1560			
EC	uS/cm @ 25 C	8,130	6,910	6,560	7,220	6,320	6,580	6,400	6,600	6,150	6,350	6,510	6,480	6,220
Dissolved Barium														
Dissolved Boron		4				3.5			3.6		3.7			
Dissolved Calcium		597				390			364		364			
Dissolved Fluoride														
Dissolved Iron														
Dissolved Magnesium		92				63			62		64			
Dissolved Nitrate	as N													
Dissolved Nitrite	as N													
DOC	as C	44.5				5.3					7.5			
Dissolved Phosphate	as P													
Dissolved Potassium														
Dissolved Selenium														
Dissolved Silica		37.0	26.0	25.4	28.7	25.0	25	27.6	25.7	29	28	28.9	29.7	26.5
Dissolved Sodium		1,150				903			878		920			
Dissolved Strontium														
Dissolved Sulfate		1,090				919			897		911			
Hardness	as CaCO3	1,870				1,233			1,164		1173			
Hydroxide	as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
pH	pH units	7.5	7.5	7.5	7.7	7.5	7.3	7.8	7.4	7.1	7.2	7.3	7.3	6.9
Total Alkalinity	as CaCO3	337	291	281	303	277	280	297	281	261	283	291	293	278
TDS		5,368	4,404	4,192	4,600	4,224	4212	4,036	4,196	4,084	4132	4220	4,216	4,140
UV254	absorb./cm					0.135					0.1			
Total Barium		<.05				<.05					<0.5			
Total Calcium														
Total Iron												0.502	0.035	<.05
Total Magnesium														
TOC as C	as C	47.2			5.5	5.2	5.4	8.2	6.4	6.9	7.5	13.4	10.5	5.4
Total Potassium														
Total Selenium		0.036				0.021					0.025			
Total Silica														
Total Sodium														
Total Strontium		6.23				3.56					3.34			
TSS						1	4	<1	<1	<1	<1	<1	<1	<1
Turbidity	NTU	2	3	2	7	8	4.4	<1	<1	<1	<1	<1	<1	<1

Table B.1 - Water Quality Analysis - Filtrate (cont.)

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Filtrate Stream		7/1/2002	7/8/2002	7/16/2002	7/22/2002	7/30/2002	8/5/2002	8/12/2002	8/19/2002	8/27/2002	9/3/2002	9/16/2002	9/30/2002	10/15/2002	10/21/2002	10/28/2002	11/4/2002	11/11/2002	11/20/2002	11/25/2002	12/4/2002
Dissolved Bicarbonate	as ion	290	293	291	291	279	294	296	297	276	196	222	269	288	278	269	269	268	248	261	280
Dissolved Carbonate	as ion	<1	1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1
Dissolved Chloride		1,535				1,480					1,190						1,490				1,530
EC	uS/cm @ 25 C	6,340	6,440	6,580		6,570	6,800	6,590	6,640	6,310	5,300	5,170	6,190	6,510	6,340	6,140	6,130	6,110	6,000	6,320	6,360
Dissolved Barium																					
Dissolved Boron		3.7				3.8					4						3.7				3.9
Dissolved Calcium		359				375					265						330				346
Dissolved Fluoride																					
Dissolved Iron																					
Dissolved Magnesium		66				70					48						62				64
Dissolved Nitrate	as N																				
Dissolved Nitrite	as N																				
DOC	as C	5.1				3.4					3.5						4.7				7.2
Dissolved Phosphate	as P																				
Dissolved Potassium																					
Dissolved Selenium																					
Dissolved Silica		27	27	28.2	28.2	27.8	28.0	28.8	28.9	26.3	27		26.5		37.9	27	26	32.1	29.7	27.8	30
Dissolved Sodium		1,030				952					753						882				980
Dissolved Strontium																					
Dissolved Sulfate		930				850					763						856				902
Hardness	as CaCO3	1,168				1,225					860						1,087				1,130
Hydroxide	as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
pH	pH units	7.2	7.3	7.2	7.2	7.4	6.9	6.9	7	7.2	6.6	6.4	6.8	7.1	6.9	6.9	6.9	6.9	6.8	7.4	7.3
Total Alkalinity	as CaCO3	290	294	291	291	280	294	296	297	276	196	222	269	288	278	269	269	268	248	282	281
TDS			4,276	4,268	4,268	3,960	4,260	4,200	4,324	4,192		3,334	4,000	4,200	4,132	3,980	4,000	3,990	4,020	4,060	3,960
UV254	absorb./cm	0.099				0.089					0.123						0.095				0.095
Total Barium		<.05				<.05					<.05						<0.5				<1
Total Calcium																					
Total Iron		0.012	0.034			0.025					4.18										0.03
Total Magnesium																					
TOC as C	as C	5.7	0.4	6	6	6.5	6.1	5.2	6	8.6	4	5.7	6.4	5.5	6	7.3	5.3	5	5.5	7.6	7.3
Total Potassium																					
Total Selenium		0.027				0.003					0.018						0.02				0.028
Total Silica														32.1							
Total Sodium																					
Total Strontium		3.42				3.68					2.47						2.66				3.01
TSS		<1	<1	<1	<1	1	<1	<1	<1	<1	7	5	<1	<1	1	<1	<1	<1	<1	<1	<1
Turbidity	NTU	<1	<1	<1	<1	<1	<1	<1	<1	1	45	31	<1	<1	<1	<1	<1	<1	<1	<1	1

Table B.1 - Water Quality Analysis - Permeate

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Permeate Stream		4/1/2002	4/8/2002	4/15/2002	4/23/2002	4/29/2002	5/6/2002	5/13/2002	5/21/2002	5/29/2002	6/3/2002	6/10/2002	6/17/2002	6/24/2002
Dissolved Bicarbonate	as ion	19	15	14	15	13	15	16	15	17	16	15	15	14
Dissolved Carbonate	as ion	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Chloride		79				60			70		77			
EC	uS/cm @ 25 C	359	271	274	327	249	283	259	299	362	326	291	296	290
Dissolved Barium														
Dissolved Boron		2.5				2					2.4			
Dissolved Calcium		6				4					9			
Dissolved Fluoride														
Dissolved Iron														
Dissolved Magnesium		1				<1					2			
Dissolved Nitrate	as N													
Dissolved Nitrite	as N													
DOC	as C	12.8				0.9					1.4			
Dissolved Phosphate	as P													
Dissolved Potassium														
Dissolved Selenium														
Dissolved Silica		1.8				0.6					2.2			
Dissolved Sodium		67				38					69			
Dissolved Strontium														
Dissolved Sulfate		12				9			12		13			
Hardness	as CaCO3	19				12					31			
Hydroxide	as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
pH	pH units	6.1	6.1	6.1	6.2	6.6	5.9	6.2	6.1	5.9	7.1	6	6	5.7
Total Alkalinity	as CaCO3	19	15	14	15	13	15	15	15	17	16	15	15	14
TDS		204	147	163	175	133	146	139	160	193	168	191	153	182
UV254	absorb./cm	0.003				0.003					0.001			
Total Barium		<.05				<.05					<.05			
Total Calcium														
Total Iron														
Total Magnesium														
TOC as C	as C	18.2			1	0.9	1	1.4	1.2	1.7	1.8	2.8	3.1	1
Total Potassium														
Total Selenium		0.001				0.001					0.002			
Total Silica														
Total Sodium														
Total Strontium		0.049				0.031					0.042			
TSS									<1					
Turbidity	NTU	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table B.1 - Water Quality Analysis - Permeate (cont.)

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Permeate Stream		7/1/2002	7/8/2002	7/16/2002	7/22/2002	7/30/2002	8/5/2002	8/12/2002	8/19/2002	8/27/2002	9/3/2002	9/16/2002	9/30/2002	10/15/2002	10/21/2002	10/28/2002	11/4/2002	11/11/2002	11/20/2002	11/25/2002	12/4/2002
Dissolved Bicarbonate	as ion	16	16			17	15	16	17	15	20	24	36	21	20	17	15	15	17	17	15
Dissolved Carbonate	as ion	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Dissolved Chloride		72				89					75						80				76
EC	uS/cm @ 25 C	322	351	335		390	372	396	382	356	600	375	626	420	389	362	354	330	344	377	342
Dissolved Barium																					
Dissolved Boron		2.32				2.4					2.9						2.4				2.3
Dissolved Calcium		4				7					7						7				7
Dissolved Fluoride																					
Dissolved Iron																					
Dissolved Magnesium		<1				1					2						1				1
Dissolved Nitrate	as N																				
Dissolved Nitrite	as N																				
DOC	as C	0.8				0.2					0.5						1.1				1.7
Dissolved Phosphate	as P																				
Dissolved Potassium																					
Dissolved Selenium																					
Dissolved Silica		0.8				1					2.7						1.3				1
Dissolved Sodium		50				64					68						54				52
Dissolved Strontium																					
Dissolved Sulfate		12				18					14						17				18
Hardness	as CaCO3	10				22					26						22				22
Hydroxide	as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1
pH	pH units	6	6	5.8	5.8	5.9	5.7	5.6	5.7	5.6	6.7	5.7	5.7	6	5.9	5.6	5.8	5.8	5.7	6.1	6.2
Total Alkalinity	as CaCO3	16	16	16	16	17	16	16	17	15	20	24	36	21	20	17	15	15	17	17	15
TDS			202	196	196	239	222	239	239	216		234	379	260	237	222	213	199	207	228	206
UV254	absorb./cm	0.003				0.003					0.005						0.004				0.003
Total Barium		<.05				<.05					<.05						<0.05				<.05
Total Calcium																					
Total Iron		<.005				<.005					0.086										<.005
Total Magnesium																					
TOC as C	as C	1.8	1.3	1.1	1.1	1.6	1.1	1	2.1	2	0.7	2	2.2	0.8	2.4	2.5	1.3	1.1	1	2.8	1.6
Total Potassium																					
Total Selenium		0.001				0.001					0.001						0.001				0.001
Total Silica																					
Total Sodium																					
Total Strontium		0.042				0.071					0.037						0.05				0.059
TSS											<1				1						
Turbidity	NTU	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

Table B.1 - Water Quality Analysis - Concentrate

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Concentrate Stream		4/1/2002	4/8/2002	4/15/2002	4/23/2002	4/29/2002	5/6/2002	5/13/2002	5/21/2002	5/29/2002	6/3/2002	6/10/2002	6/17/2002	6/24/2002
Dissolved Bicarbonate	as ion	471	520	883	878	799	736	761	774	714	751	792	801	794
Dissolved Carbonate	as ion	1	2	4	6	4	3	6	3	2	2	3	3	2
Dissolved Chloride		4,270				5,350			5,080		5040			
EC	uS/cm @ 25 C	15,130	12,680	18,610	20,520	19,000	18,320	17,790	18,260	17,870	17,720	18,600	18,410	18,460
Dissolved Barium														
Dissolved Boron		5.6				6.6					6.4			
Dissolved Calcium		1130				1,270					1160			
Dissolved Fluoride														
Dissolved Iron														
Dissolved Magnesium		173				201					193			
Dissolved Nitrate	as N													
Dissolved Nitrite	as N													
DOC	as C	40.8				13					13.3			
Dissolved Phosphate	as P													
Dissolved Potassium														
Dissolved Selenium														
Dissolved Silica		69				82					83			
Dissolved Sodium		2,130				2,860					2860			
Dissolved Strontium														
Dissolved Sulfate		2,320				3,180			3,060		3070			
Hardness	as CaCO3	3,535				4,000					3711			
Hydroxide	as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
pH	pH units	7.4	7.6	7.7	7.8	7.7	7.6	7.9	7.6	7.5	7.5	7.6	7.6	7.3
Total Alkalinity	as CaCO3	472	522	887	883	803	739	767	777	716	753	795	804	798
TDS		9,980	8,570	12,410	11,410	12,670	11,290	11,790	11,900	11,990	11,870	12,400	12,250	12,570
UV254	absorb./cm	0.308				0.456					0.328			
Total Barium		0.093				0.128					<1			
Total Calcium														
Total Iron														
Total Magnesium														
TOC as C	as C	52.1			15.2	13.6	14.9	18.2	18.3	16.1	14.2	24.5	25.5	15.8
Total Potassium														
Total Selenium		0.052				0.057					0.068			
Total Silica														
Total Sodium														
Total Strontium		11				11.7					10.7			
TSS						3	6	2	<1		<1	<1	<1	3
Turbidity	NTU	3	3	<1	22	26	30.1	<1	<1	<1	<1	<1	1	<1

Table B.1 - Water Quality Analysis - Concentrate (cont.)

DWR Bryte Laboratory Analysis Results for Buena Vista Project

Note: all results are in mg/L unless otherwise stated

Concentrate Stream		7/1/2002	7/8/2002	7/16/2002	7/22/2002	7/30/2002	8/5/2002	8/12/2002	8/19/2002	8/27/2002	9/3/2002	9/16/2002	9/30/2002	10/15/2002	10/21/2002	10/28/2002	11/4/2002	11/11/2002	11/20/2002	11/25/2002	12/4/2002
Dissolved Bicarbonate	as ion	792	823	749	749	911	899	924	946	897	481	286	346	682	477	412	714	833	805	886	909
Dissolved Carbonate	as ion	3	3	1	1	3	1	1	2	1	<1	<1	<1	2	1	<1	1	1	2	6	2
Dissolved Chloride		4,910				5,800					3,930						5,780				5,770
EC	uS/cm @ 25 C	18,230	18,810	18,540		21,750	20,960	21,740	21,830	21,390	14,550	9,640	11,070	14,150	13,980	15,120	20,190	19,990	19,120	20,800	21,200
Dissolved Barium																					
Dissolved Boron		6.6				7.7					5.8						7.9				8.8
Dissolved Calcium		1,180				1,380					873						1240				1,400
Dissolved Fluoride																					
Dissolved Iron																					
Dissolved Magnesium		208				259					160						224				240
Dissolved Nitrate	as N																				
Dissolved Nitrite	as N																				
DOC	as C	14.4				9.2					10.7						15.7				22
Dissolved Phosphate	as P																				
Dissolved Potassium																					
Dissolved Selenium																					
Dissolved Silica		86				104					88						105				112
Dissolved Sodium		2,940				3,500					2,400						3,390				3,770
Dissolved Strontium																					
Dissolved Sulfate		3,070				3,400					2,620						3,360				3,510
Hardness	as CaCO3	3,802				4,513					2,839						4,111				4,480
Hydroxide	as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1
pH	pH units	7.5	7.5	7.3	7.3	7.5	7.1	7.1	7.2	7.2	6.6	6.4	6.8	7.4	7.1	6.8	6.8	7.2	7.4	7.8	7.4
Total Alkalinity	as CaCO3	794	825	750	750	914	900	925	947	898	481	286	346	684	478	412	715	834	807	891	911
TDS			12,500	11,920	11,920	14,010	13,750	14,550	14,220	14,200		6,336	7,352	9,380	9,330	10,170	13,510	13,330	13,000	13,950	14,000
UV254	absorb./cm	0.322				0.365					0.414						0.353				0.363
Total Barium		<.5				<.5					<.5						<1				<.25
Total Calcium																					
Total Iron		<.05				0.142					14.7										0.045
Total Magnesium																					
TOC as C	as C	15.3	17.3	16.6	16.6	23.2	17.1	17.2	20.6	21.6	11.3	9.2	10	12	11.1	15.3	15.2	15.9	16	20.7	22.3
Total Potassium																					
Total Selenium		0.07				<.01					0.05						0.1				0.105
Total Silica																					
Total Sodium																					
Total Strontium		10.3				1.36					7.51						10.3				12.8
TSS		<1	<1	<1	<1	1	<1	<1	<1	<1	31	14	<1	<1	2	<1	<1	1	<1	2	2
Turbidity	NTU	<1	<1	<1	<1	<1	<1	<1	<1	9	152	70.2	<1	<1	<1	<1	<1	<1	<1	<1	

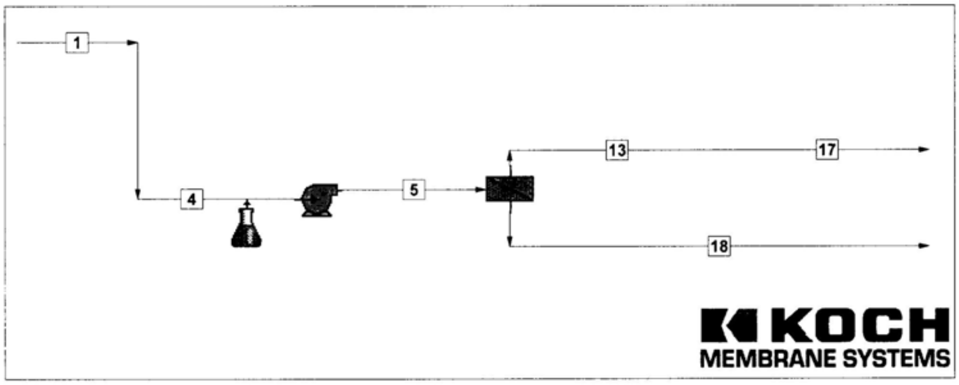
Appendix C – Initial RO Projection

Project: BVWSD
Prepared By: aeg

Description: Initial RO Projection
Type: Single Pass Design

PROJECT SUMMARY

PROCESS FLOW DIAGRAM



RO Recovery [13/4] = 70.0%
Overall System Rec [17/(4+15)] = 70.0%
Design Temperature = 77.0 Deg F

PASS 1
Array Recovery [13/4] = = 70.0%
Element Age = 0.00 Years
Fouling Allowance (FA) = 0.0%

Bank	Element Type	Tubes /Bank	Elems /Tube	Avg Flux (GFD)
1	TFC 4820HR	2	6	15.6
2	TFC 4821ULP	1	6	11.5
System/Pass Total				14.2

Stream	Pressure with FA (Psig)	Flow Rate (USGPM)	TDS 180C (mg/L)	Hardness (CaCO3)	Chloride (mg/L)
1	0.0	20.0	5947.65	2036.2	2364.0
4	0.0	20.0	5947.65	2036.2	2364.0
5	217.5	20.0	5969.09	2036.2	2364.0
13	0.0	14.0	228.51	33.5	110.6
17	0.0	14.0	228.51	33.5	110.6
18	186.2	6.0	19363.89	6709.1	7621.9

Project: BVWSD
Prepared By: aeg

Description: Initial RO Projection
Type: Single Pass Design

ARRAY SUMMARY - PASS 1

Permeate Flow	14.0 USGPM	Temp (Design/Avg)	77.0/ 77.0 Deg F
Pass Recovery	70.0 %	Fouling Allowance (FA)	0.0 %
Inlet Pres w/o FA	217.5 Psig	Conc. Pres w/o FA	186.2 Psig
Inlet Pres w/FA	217.5 Psig		

Bank	Element Type	Tubes /Bank (#)	Elems /Tube (#)	Elems /Bank (#)	Elem Age (Yr)	Boost Pressure (Psig)	Manifold Loss (Psig)	Perm Back Pressure (Psig)
1	TFC 4820HR	2	6	12	0.00	0.0	0.0	10.0
2	TFC 4821ULP	1	6	6	0.00	0.0	0.0	0.0

Bank	Total Feed (GPM)	Tube Feed (GPM)	Total Conc. (GPM)	Tube Conc. (GPM)	Avg Flux (GFD)	Inlet Pres (Psig)	Avg NDP (Psig)	Bank DP (Psig)	Final Element Beta
1	20.0	10.0	9.9	4.9	15.6	217.5	121.5	13.4	1.080
2	9.9	9.9	6.0	6.0	11.5	204.0	62.9	17.8	1.039
System					14.2				

	Net Feed	RO Inlet	Conc.	Permeate
Stream Number	4	5	18	13
Concentration	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Ca++	675.00	675.00	2224.06	11.12
Mg++	85.13	85.13	280.50	1.40
Na+	1327.00	1327.00	4252.88	73.05
K+	4.07	4.07	12.92	0.28
NH4+	0.10	0.10	0.30	0.01
Sr++	6.22	6.22	20.49	0.10
Ba++	0.15	0.15	0.49	0.00
Fe++	0.45	0.45	1.48	0.01
Mn++	1.00	1.00	3.29	0.02
CO3--	0.00	0.13	0.42	0.00
HCO3-	292.00	220.02	691.59	18.04
SO4--	1303.00	1359.66	4484.91	20.27
Cl-	2364.00	2364.00	7621.86	110.63
NO3-	7.68	7.68	22.61	1.28
F-	1.53	1.53	5.00	0.04
SiO2	28.90	28.90	92.98	1.44
CO2	4.74	56.60	56.60	56.52
Sum of Ions	6096.23	6081.04	19715.79	237.69
TDS (180 C)	5947.65	5969.09	19363.89	228.51
pH	8.00	6.80	7.30	5.71
Hardness (as CaCO3)	2036.22	2036.22	6709.15	33.54
Osm Pressure (Psig)	51.62	51.35	165.68	2.35
Langlier Index	1.76	0.43	1.94	-3.65
Stiff-Davis Index	1.32	0.00	1.02	---

Membrane data file version: Jul-27-2001
Please review the Design Notes & Warnings page attached.
Concentrate exceeds solubility limit - see warnings sheet.

Project: BVWSD Description: Initial RO Projection
Prepared By: aeg Type: Single Pass Design

CHEMICAL ADDITION

14.9 lb/day of 93.2% Sulfuric Acid (H2SO4) is required to achieve the target pH in stream [5].

CONCENTRATE SATURATION DATA - STREAM 18

Langlier Index	=	1.937	<== Warning: Scaling Potential
Stiff-Davis Index	=	1.017	<== Warning: Scaling Potential
Ratio [Ca][SO4] to Ksp(CaSO4)	=	2.69	<== Warning!
Ratio [Ca][F]^2 to Ksp(CaF2)	=	1.69	<== Warning!
Ratio [Ba][SO4] to Ksp(BaSO4)	=	41.88	<== Warning!
Ratio [Sr][SO4] to Ksp(SrSO4)	=	1.10	<== Warning!

DESIGN WARNINGS - PASS 1: None

APPROXIMATE PUMPING POWER REQUIREMENTS (kW)

Feed pumping power (w/FA) @65.0% efficiency	2.91
Interbank pumping power @65.0% efficiency	0.00

NOTE

This projection is the anticipated performance and is based on nominal properties of the elements, with manifold losses as included.

The fouling allowance option (if included) increases the required 'clean water' net driving pressure by the stated percentage. Program default values are estimates only, and may not be representative of the actual fouling potential of the water source.

Project: BVWSD
Prepared By: aeg

Description: Initial RO Projection
Type: Single Pass Design

FEED STREAM SUMMARY

Stream	Name	Type	Percent of Total	Stream Flow Rate (USGPM)	Temperature Design (Deg F)	Temperature Average (Deg F)
1	Feed 1	Brackish Wel	100.0	20	77.0	77.0
2	Feed 2	Other	0.0	0	77.0	77.0
3	Feed 3	Other	0.0	0	77.0	77.0
4	Net Feed	Other	100.0	20	77.0	77.0
5	Treated Feed	Other	100.0	20	77.0	77.0

CHEMICAL ADDITION

To achieve the target pH in stream [5], 14.9 lb/day of 93.2% Sulfuric Acid (H2SO4) is required.

FEED STREAM COMPOSITIONS

Stream Number Concentration	1 (mg/L)	2 (mg/L)	3 (mg/L)	4 (mg/L)	5 (mg/L)
Ca++	675.00	0.00	0.00	675.00	675.00
Mg++	85.13	0.00	0.00	85.13	85.13
Na+	1327.00	0.00	0.00	1327.00	1327.00
K+	4.07	0.00	0.00	4.07	4.07
NH4+	0.10	0.00	0.00	0.10	0.10
Sr++	6.22	0.00	0.00	6.22	6.22
Ba++	0.15	0.00	0.00	0.15	0.15
Fe++	0.45	0.00	0.00	0.45	0.45
Mn++	1.00	0.00	0.00	1.00	1.00
CO3--	0.00	0.00	0.00	0.00	0.13
HCO3-	292.00	0.00	0.00	292.00	220.02
SO4--	1303.00	0.00	0.00	1303.00	1359.66
Cl-	2364.00	0.00	0.00	2364.00	2364.00
NO3-	7.68	0.00	0.00	7.68	7.68
F-	1.53	0.00	0.00	1.53	1.53
SiO2	28.90	0.00	0.00	28.90	28.90
CO2	4.74	0.00	0.00	4.74	56.60
Sum of Ions	6096.23	0.00	0.00	6096.23	6081.04
TDS (180 C)	5947.65	0.00	0.00	5947.65	5969.09
pH	8.00	7.00	7.00	8.00	6.80
Hardness (as CaCO3)	2036.22	0.00	0.00	2036.22	2036.22
Osm Pressure (Psig)	51.62	0.00	0.00	51.62	51.35
Langlier Index	1.76	-7.00	-7.00	1.76	0.43
Stiff-Davis Index	1.32	---	---	1.32	0.00

Project: BVWSD
Prepared By: aeg

Description: Initial RO Projection
Type: Single Pass Design

BYPASS STREAM SUMMARY

Stream	Name	Type	Percent of Total	Stream Flow Rate (USGPM)	Temperature Design (Deg F)	Temperature Average (Deg F)
1A	Feed 1 Bypass	Brackish Wel	---	0	77.0	77.0
2A	Feed 2 Bypass	Other	---	0	77.0	77.0
3A	Feed 3 Bypass	Other	---	0	77.0	77.0
15	Feed Bypass	Other	---	0	77.0	77.0

BYPASS STREAM COMPOSITIONS

Stream Number Concentration	1A (mg/L)	2A (mg/L)	3A (mg/L)	15 (mg/L)
Ca++	675.00	0.00	0.00	0.00
Mg++	85.13	0.00	0.00	0.00
Na+	1327.00	0.00	0.00	0.00
K+	4.07	0.00	0.00	0.00
NH4+	0.10	0.00	0.00	0.00
Sr++	6.22	0.00	0.00	0.00
Ba++	0.15	0.00	0.00	0.00
Fe++	0.45	0.00	0.00	0.00
Mn++	1.00	0.00	0.00	0.00
CO3--	0.00	0.00	0.00	0.00
HCO3-	292.00	0.00	0.00	0.00
SO4--	1303.00	0.00	0.00	0.00
Cl-	2364.00	0.00	0.00	0.00
NO3-	7.68	0.00	0.00	0.00
F-	1.53	0.00	0.00	0.00
SiO2	28.90	0.00	0.00	0.00
CO2	4.74	0.00	0.00	0.00
Sum of Ions	6096.23	0.00	0.00	0.00
TDS (180 C)	5947.65	0.00	0.00	0.00
pH	8.00	7.00	7.00	7.00
Hardness (as CaCO3)	2036.22	0.00	0.00	0.00
Osm Pressure (Psig)	51.62	0.00	0.00	0.00
Langlier Index	1.76	-7.00	-7.00	-7.00
Stiff-Davis Index	1.32	---	---	---

Project: BVWSD
Prepared By: aeg

Description: Initial RO Projection
Type: Single Pass Design

PRODUCT STREAM SUMMARY

Stream	Name	Stream Flow Rate (USGPM)	Temperature Design (Deg F)	Temperature Average (Deg F)
13	Permeate	14	77.0	77.0
14	Stripped Permeat	14	77.0	77.0
15	Feed Bypass	0	77.0	77.0
16	Blended Product	14	77.0	77.0
17	Treated Product	14	77.0	77.0

CHEMICAL ADDITION

No Chemical Treating

PRODUCT STREAM COMPOSITIONS

Stream Number Concentration	13 (mg/L)	14 (mg/L)	15 (mg/L)	16 (mg/L)	17 (mg/L)
Ca++	11.12	11.12	0.00	11.12	11.12
Mg++	1.40	1.40	0.00	1.40	1.40
Na+	73.05	73.05	0.00	73.05	73.05
K+	0.28	0.28	0.00	0.28	0.28
NH4+	0.01	0.01	0.00	0.01	0.01
Sr++	0.10	0.10	0.00	0.10	0.10
Ba++	0.00	0.00	0.00	0.00	0.00
Fe++	0.01	0.01	0.00	0.01	0.01
Mn++	0.02	0.02	0.00	0.02	0.02
CO3--	0.00	0.00	0.00	0.00	0.00
HCO3-	18.04	18.04	0.00	18.04	18.04
SO4--	20.27	20.27	0.00	20.27	20.27
Cl-	110.63	110.63	0.00	110.63	110.63
NO3-	1.28	1.28	0.00	1.28	1.28
F-	0.04	0.04	0.00	0.04	0.04
SiO2	1.44	1.44	0.00	1.44	1.44
CO2	56.52	56.52	0.00	56.52	56.52
Sum of Ions	237.69	237.69	0.00	237.69	237.69
TDS (180 C)	228.51	228.51	0.00	228.51	228.51
pH	5.71	5.71	7.00	5.71	5.71
Hardness (as CaCO3)	33.54	33.54	0.00	33.54	33.54
Osm Pressure (Psig)	2.35	2.35	0.00	2.35	2.35
Langlier Index	-3.65	-3.65	-7.00	-3.65	-3.65
Stiff-Davis Index	---	---	---	---	---

KOCH Membrane Systems, Inc.   ROPRO Ver. 7.0-CP   Date: Dec-17-2003

Project: BVWSD   Description: Initial RO Projection
Prepared By: aeg   Type: Single Pass Design

ELEMENT BY ELEMENT DATA - PASS 1

Bank	Element	Inlet Pressure (Psig)	Diff Pressure (Psig)	NDP (Psig)	Element Flux GFD	m Value	Beta	Permeate TDS (mg/L)
1	1	217.5	3.3	148.5	19.5	-0.022	1.075	44.2
1	2	214.1	2.8	138.5	18.0	-0.022	1.078	54.3
1	3	211.3	2.4	128.0	16.5	-0.022	1.080	67.7
1	4	209.0	2.0	116.8	14.9	-0.022	1.082	86.1
1	5	207.0	1.6	104.9	13.2	-0.022	1.082	111.8
1	6	205.4	1.4	92.4	11.4	-0.022	1.080	148.3
	Avg			121.5	15.6	-0.022	1.079	85.4
2	1	204.0	4.1	90.9	17.9	-0.022	1.072	316.4
2	2	200.0	3.5	77.4	14.8	-0.022	1.066	433.2
2	3	196.5	3.0	65.4	12.1	-0.022	1.059	594.1
2	4	193.4	2.7	55.3	9.8	-0.021	1.052	808.6
2	5	190.8	2.4	47.2	7.9	-0.021	1.045	1085.2
2	6	188.4	2.2	41.3	6.4	-0.021	1.039	1424.1
	Avg			62.9	11.5	-0.022	1.056	776.9

Appendix D – Year 2002 Filter Performance Data

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
3/25/2002	-	2	68	-	-	5.55	6.34	-	CIP
3/28/2002	-	2	40	-	39	-	-	-	Backwash
4/1/2002	1	2	20	-	19	3.28	8.19	-	Adjusted Chem feed rates
4/2/2002	2	2	20	-	19	2.79	7.84	-	-
4/3/2002	3	2	21	-	19	2.44	7.57	-	-
4/4/2002	4	2	21	-	19	2.22	7.34	-	-
4/5/2002	5	2	20	-	19	2.26	7.14	-	-
4/6/2002	6	2	-	-	-	-	-	-	-
4/7/2002	7	2	-	-	-	-	-	-	-
4/08/02	8	2	20	-	18	2.22	6.94	-	-
4/9/2002	9	2	20	-	18	2.07	6.91	-	-
4/10/2002	10	1	20	-	18	1.93	7.97	-	Increased RO Recovery rate to 70%
4/11/2002	11	1	20	-	18	1.84	7.78	-	-
4/12/2002	12	1	20	-	18	1.98	6.81	-	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
4/14/2002	14	1	20	-	17	-	-	-	-
4/15/02	15	2	20	-	19	2.42	6.72	-	Backwash
4/16/02	16	2	20	-	18	2.59	6.71	-	RO Membrane Cleaning
4/17/2002	17	2	20	16	18	2.08	6.72	-	Initiated Alum Injection
4/18/2002	18	2	20	16	17	1.88	6.68	-	-
4/19/2002	19	2	15	14	11	1.77	6.66	-	-
4/20/2002	20	2	-	-	-				Plant Idled due to the lack of feed water - Electrical Problem w/ Well Pump
4/21/2002	21	2	-	-	-				Plant Idled due to the lack of feed water - Electrical Problem w/ Well Pump
4/22/2002	22	2	-	-	-				Plant Idled due to the lack of feed water - Electrical Problem w/ Well Pump

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
4/23/2002	23	2	*35*	*36*	*34*	*2.75*	*7.21*	-	*Prior to backwashing*
4/23/02	23	2	35	34	35	2.31	7.19	-	Backwash
4/24/2002	24	2	34	35	33	2.11	6.84	-	-
4/25/2002	25	2	34	33	32	1.96	6.82	-	-
4/26/2002	26	2	25	27	24	3.43	6.68	-	Added Well #2 as a Feedwater source
4/27/2002	27	2	26	24	22	1.62	6.78	-	-
4/28/2002	28	2	-	-	-	-	-	-	-
4/29/2002	29	*2*	*26*	*15*	*12*	*1.78*	*6.74*	-	*Prior to backwashing*
4/29/02	29	2	26	27	26	1.85	6.69	-	Backwash waste fluid turned red
4/30/2002	30	2	26	28	25	1.70	6.74	-	-
5/1/2002	31	2	26	26	24	2.06	6.72	-	-
5/2/2002	32	2	26	24	22	1.90	6.71	-	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
5/3/2002	33	2	27	28	25	2.27	6.60	-	-
5/4/2002	34	2	-	-	-	-	-	-	-
5/5/2002	35	2	-	-	-	-	-	-	-
5/6/2002	*36*	*2*	*26*	*16*	*13*		*6.67*	-	*Prior to backwashing*
5/06/02	36	2	28	28	27	1.85	6.67	-	Backwash
5/7/2002	37	2	27	28	26	2.11	6.67	-	Switch from Alum to FeCl3
5/8/2002	*38*	*2*	*27*	*28*	*24*	*5.70*	*6.65*	-	*Prior to backwashing*
5/8/2002	38	2	27	28	27	1.90	6.65	-	Backwash
5/9/2002	39	2	27	28	27	2.16	6.64	-	Stopped using FeCl3
5/10/2002	40	2	27	28	27	2.01	6.63	-	No Coagulant
5/11/2002	41	2	-	-	-	-	-	-	No Coagulant
5/12/2002	42	2	-	-	-	-	-	-	No Coagulant
5/13/2002	43	*2*	*27*	*28*	*26*	*1.89*	*6.61*	-	*Prior to Membrane cleaning*
5/13/02	43	2	27	28	26	1.48	6.39	-	Membrane Cleaning & Backwash

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
5/14/02	44	2	27	27	24	2.22	6.61	-	Reinitiated Alum Injection
5/15/02	45	2	27	24	22	2.11	6.61	-	-
5/16/02	46	2	27	22	20	1.94	6.61	-	-
5/17/02	47	2	27	17	15	1.90	6.61	-	-
5/18/02	48	2	-	-	-	-	-	-	-
5/19/02	49	2	-	-	-	-	-	-	-
5/20/02	50	2	27	23	22	1.83	6.62	6.21	Backwash
5/21/02	51	2	27	20	21	2.16	6.63	2.16	-
5/22/02	52	2	27	17	15	1.99	6.63	8.42	-
5/23/02	53	2	27	27	24	1.94	6.62	7.23	-
5/24/02	54	2	27	25	23	1.66	6.62	6.48	-
5/25/02	55	2	-	-	-	-	-	-	-
5/26/02	56	2	-	-	-	-	-	-	-
5/27/02	57	2	-	-	-	-	-	-	Memorial day

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
5/28/02	58	2	27	13	12	1.62	6.58	7.23	Backwash
5/29/02	59	2	27	27	24	1.94	6.59	6.48	-
5/30/02	60	2	27	25	21	1.92	6.58	8.54	-
5/31/02	61	2	27	22	22	1.92	6.49	8.95	-
6/01/02	62	2	-	-	-	-	-	-	-
6/02/02	63	2	-	-	-	-	-	-	-
6/03/02	64	2	27	9	3	1.57	6.60	6.33	Installed new pH & Temp probe
6/04/02	65	2	27	26	25		6.62	7.15	Backwash filters; Irrigation season
6/05/02	66	2	27	23	22	2.00	6.62	9.09	-
6/06/02	67	2	26	20	19	1.85	6.63	8.52	-
6/07/02	68	2	26	18	16	1.75	6.63	6.83	Backwash filters
6/08/02	69	2	-	-	-	-	-	-	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
6/09/02	70	2	-	-	-	-	-	-	-
6/10/02	71	2	26	17	16	4.79	6.63	6.60	Replace and calibrated pH probe; Backwash filters
6/11/02	72	2	26	26	23	1.98	6.63	6.38	-
6/12/02	73	2	26	23	21	2.10	6.63	6.41	-
6/13/02	74	2	26	20	19	1.80	6.63	6.39	-
6/14/02	75	2	26	20	19	2.10	6.63	6.45	-
6/15/2002	76								-
6/16/2002	77								-
6/17/2002	78	2	26	17	16	2.03	6.639	6.41	Backwash
6/18/2002	79	2	26	26	22	1.41	6.649	6.40	-
6/19/2002	80	2	26	25	22	1.16	6.646	6.40	-
6/20/2002	81	2	26	24	22	2.10	6.648	6.41	-
6/21/2002	82	2	26	24	22	1.05	6.648	6.41	-
6/22/2002	83								-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
6/23/2002	84								-
6/24/2002	85	2	26	22	21	1.78	6.507	6.43	-
6/25/2002	86	2	26	20	19	1.26	6.637	6.43	-
6/26/2002	87	2	15	7	4	1.44	6.516	6.46	Backwash
6/27/2002	88	2	26	25	24	2.57	6.550	6.43	-
6/28/2002	89	2	26	25	23	2.04	6.643	6.08	-
6/29/2002	90	2							-
6/30/2002	91	2							-
7/1/2002	92	2	26	24	22	1.85	6.671	5.78	Alum pump lost prime, reprimed and place in service
7/2/2002	93	2	26	26	25	5.06	6.695	6.66	Plant was found idled; placed in service @ 11:30am
7/3/2002	94	2	27	21	20	1.92	6.681	6.08	-
7/4/2002	95	2	27	20	19	1.99	6.688	5.92	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
7/5/2002	96	2	27	19	18	1.92	6.691	5.81	Backwashed filters after these readings: 35 min for vessel C, 20 min for vessel D; dark orange
7/6/2002	97	2							-
7/7/2002	98	2							-
7/8/2002	99	2	26	21	22	2.04	6.710	5.72	Alum pump failed over the weekend
7/9/2002	100	2	26	23	22	1.92	6.712	5.72	-
7/10/2002	101	2	15	10	8	1.26	6.597	5.70	-
7/11/2002	102	2	27	19	18	1.61	6.713	5.78	-
7/12/2002	103	2	27	17	15	1.87	6.716	5.79	Backwashed filters after these readings: 15 min for vessel C, 20 min for vessel D; dark orange
7/13/2002	104	2							-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
7/14/2002	105	2							-
7/15/2002	106	2	27	24	23	1.92	6.676	5.86	-
7/16/2002	107	2	27	22	22	1.92	6.680	5.86	Replace Alum Pump; recalibrated pH probe
7/17/2002	108	2	27	17	15	2.33	6.685	6.63	-
7/18/2002	109	2	26	13	12	2.10	6.704	6.62	-
7/19/2002	110	2	26	7	2	1.99	6.715	6.63	Backwashed filters after these readings: 20 min for vessel C, 20 min for vessel D; dark orange
7/20/2002	111								-
7/21/2002	112								-
7/22/2002	113	2	26	13	16	1.90	6.729	6.62	Increase Recovery
7/23/2002	114	2	26	10	8	2.22	6.741	6.61	Backwash
7/24/2002	115	2	26	25	24	1.82	6.748	6.63	-
7/25/2002	116	2	26	23	22	1.87	6.755	6.63	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
7/26/2002	117	2	27	21	20	2.29	6.441	6.63	-
7/27/2002	118								-
7/28/2002	119								-
7/29/2002	120	2	26	14	12	1.82	6.726	6.60	Backwashed filters after these readings: 20 min for vessel C - dark orange, 10 min for vessel D - light orange
7/30/2002	121	2	27	20	19	2.08	6.720	6.71	-
7/31/2002	122	2	27	19	16	2.08	6.719	6.69	-
8/1/2002	123	2	27	17	14	1.67	6.713	6.70	-
8/2/2002	124	2	27	11	10	2.08	6.714	6.70	Backwash
8/3/2002	125								-
8/4/2002	126								-
8/5/2002	127	2	27	18	16	0.83	6.718	6.71	Before CIP
8/5/2002	127	2	27	28	25		6.660	7.17	After Backwash & CIP

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
8/5/2002	127	2	27	28	25		6.670	7.16	After CIP
8/6/2002	128	2	27	26	23	1.88	6.707	6.51	-
8/7/2002	129	2	27	22	20	1.51	6.707	6.44	-
8/8/2002	130	2	27	19	18	1.88	6.730	6.40	-
8/9/2002	131	2	27	16	15	2.42	6.736	6.40	Power shut off for a day due to nearby construction; data logger off for the entire weekend
8/10/2002	132	2							-
8/11/2002	133	2							-
8/12/2002	134	2	27	21	20	2.08	6.737	6.66	Irrigation Season ends this week
8/13/2002	135	2	27	15	12	2.08	6.731	6.54	-
8/14/2002	136	2	27	14	12	1.81	6.736	6.53	Backwash; 20 min/20 min
8/15/2002	137	2	27	25	24	1.77	6.729	6.51	-
8/16/2002	138	2	27	23	22	2.28	6.736	6.49	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
8/17/2002	139								-
8/18/2002	140								-
8/19/2002	141	2	26	17	15	1.46	6.743	6.46	-
8/20/2002	142	2	26	16	14	1.46	6.750	6.48	Backwashed 30 min on the first, 14 min on the second (water ran out on the second)
8/21/2002	143	2							-
8/22/2002	144	2							-
8/23/2002	145	2	27	21	20	2.22	6.736	6.55	-
8/24/2002	146								-
8/25/2002	147								-
8/26/2002	148	1	27	17	14	1.98	6.738	6.50	-
8/27/2002	149	1	27	28	26	1.81	6.738	6.52	-
8/28/2002	150	1	27	27	25	1.87	6.749	6.50	-
8/29/2002	151	1	38	36	34	1.67	5.634	6.45	Increased Inflow

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
8/30/2002	152	1/2	38	33	29	1.67	5.605	6.45	Switched from Train 1 to Train 2; backwashed Train 1
9/3/2002	154	2	39	33	33	1.73	5.427	6.40	Backwashed Train 2 C and D and then shut plant down due to low RO pressures
9/11/2002	162	2	38	38.5	38		5.867	6.76	Train 1 was left in recycle; top washed Train 2 and left Train 2 in operation
9/13/2002	164	2	39	39	39	1.38	5.405	6.41	-
9/16/2002	167	2	39	39	39	1.38	5.387	6.42	-
9/17/2002	168	2	39	39	39	1.90	5.384	6.38	-
9/18/2002	169	2	39	39	40	1.38	5.386	6.38	-
9/19/2002	170	2	39	39	40	1.38	5.378	6.41	-
9/20/2002	171	2	39	39	40	1.33	5.376	6.40	Backwashed Train 2 C and D and turned on booster pump.

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
9/23/2002	174	2	38	37	36	1.90	6.332	6.59	Found unit off
9/24/2002	175	2	38	36	35	1.90	6.262	6.64	-
9/25/2002	176	2	38	35	34	1.44	6.305	6.63	-
9/26/2002	177	2	38	33	33	1.54	6.294	6.62	-
9/27/2002	178	2	38	32	33	1.46	6.319	6.60	-
9/30/2002	181	2	38	30	29	1.75	6.290	6.79	Found unit off/Operator backwashed Train 2 vessels C & D
10/1/2002	182	2	38	39	38	1.78	6.508	6.57	-
10/2/2002	183	2	38	39	38	1.50	6.555	6.57	-
10/3/2002	184	2	38	37	37	1.96	6.620	6.55	-
10/4/2002	185	2	38	36	35	2.09	6.559	6.92	-
10/7/2002	188	2	38	29	29	1.71	6.349	6.94	Backwashed Train 2 and did a top wash.
10/8/2002	189	2	38	39	39	2.15	6.580	6.93	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
10/10/2002	191								found plant off -- no power
10/11/2002	192	2	38	35	34	1.17	6.115	6.91	-
10/14/2002	195	2	38	28	27	2.09	6.573	6.95	Operator backwashed Train 2 vessels C & D
10/16/2002	197	2	38	37	37	2.22	6.692	6.12	had to use booster pump to get 30 psi for SDI test
10/17/2002	198	2	38	35	34	1.90	6.630	6.06	lowered acid injection to 50/50
10/18/2002	199	2	38	34	33	2.41	6.601	6.52	found plant off -- restarted
10/21/2002	202	2	38	28	27	1.29	6.603	6.56	Backwashed and top washed Train 2. Vessel D had light brown water and vessel C had dark red brown water

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
10/22/2002	203								2" pipe on the recycle line broke - plant shut down for repair
10/23/2002	204								Plant repaired (check valve and PRV removed and replaced with temporary PVC parts); acid rate set at 60%
10/24/2002	205	1	38	33	32	1.46	6.512	7.64	-
10/25/2002	206	1	38	32	31	1.80	6.396	6.67	Changed acid rate back to 50%
10/28/2002	209	1	38	25	23	1.50	6.328	7.78	Stopped plant to install new check valve and refurbished PRV; acid pump set at 50/60; backwashed Train 1 vessels A and B

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
10/29/2002	210	1	37	37	36	2.04	6.512	7.76	Changed acid rate from 60% to 75%
10/30/2002	211	1	37	37	36	2.04	6.528	7.58	Changed acid from 75% to 90% in an attempt to lower pH to 7.00
10/31/2002	212	1	37	37	35	2.16	6.558	7.35	Changed acid from 90% to 50%
11/1/2002	213	1	37	36	34	2.28	6.591	7.90	Found plant off - restarted
11/4/2002	216	1	37	34	32	2.16	6.457	7.36	Recalibrated pH probe
11/5/2002	217	1	37	37	36	2.34	6.505	5.84	-
11/6/2002	218								Plant shut down - no power (PG&E problem)
11/7/2002	219	1	37	37	36		6.237	5.95	Plant shut down in middle of SDI test
11/8/2002	220	1	37	37	36	2.22	6.150	6.13	-

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
11/11/2002	223	1	37	35	34	2.16	6.478	5.77	Recalibrated pH probe; operators backwashed Train #1 Vessel A & B
11/12/2002	224	1	37	37	37	2.22	6.513	6.51	-
11/13/2002	225	1	37	37	36	2.22	6.460	6.17	-
11/14/2002	226	1	37	37	35	2.28	6.444	6.19	Changed acid from 50/50 to 40/40
11/15/2002	227	1	37	37	35	2.16	6.443	6.16	Changed acid back to 50/50
11/18/2002	230	1	37	35	34	2.22	6.391	6.21	Backwashed Train 1, Vessels A & B
11/19/2002	231	1	37	37	36	2.28	6.504	6.60	-
11/20/2002	232	1	37	37	36	2.39	6.475	6.50	-
11/21/2002	233	1	37	37	35	2.16	6.463	6.28	-
11/22/2002	234	1	37	36	35	2.10	6.466	6.54	-
11/25/2002	237	1	37	35	34	2.44	4.124	6.06	Backwashed Train #1

Date	Runtime (days)	Train	Filter Inlet Pressure (psi)	Filter Interstage Pressure (psi)	Filter Outlet Pressure (psi)	Filtrate SDI	Feed EC (mS/cm)	pH	Operational Notes
11/26/2002	238	1	37	37	36	2.28	6.601	6.35	-
11/27/2002	239	1	37	37	36	2.34	6.578	6.12	-
11/29/2002	241	1	37	36	35	2.28	6.521	6.25	-
12/2/2002	242	1	37	35	33	1.62	6.367	6.30	Backwashed Train #1
12/3/2002	243	1	37	37	36	2.34	6.512	6.08	-

Appendix E – RO System Operating Data

Buena Vista Water Storage District
Agricultural Drainwater Treatment Project

DATE / TIME	Runtime (days)	FLOWS (gpm)			Feed Temp. (°C)	PRESSURES							CONDUCTIVITIES (mS/cm)				Temp. Comp. Factor	Normalized Flux (gfd/psi)
		Permeate	Recycle	Conc.		Feed Pressure	Interstage Pressure	Concentrate Pressure	Permeate Pressure	Osmotic Pressure	Net Driving Pressure	Feed to Conc. ΔP	Feed EC	Permeate EC	Concentrate EC	EC Rejection (Field Data)		
4/01/02	1	10	0	10		195	170	140	3.0	0.1	164.4	55	8.19	0.32	16.18	97.4%	2.09	0.143
4/02/02	2	10	0	10		185	165	135	3.0	0.1	156.9	50	7.84	0.30	15.49	97.4%	2.09	0.150
4/03/02	3	10	0	10		185	165	135	3.0	0.1	156.9	50	7.57	0.27	14.98	97.6%	2.09	0.150
4/04/02	4	10	0	10		185	165	135	3.0	0.1	156.9	50	7.34	0.25	14.54	97.8%	2.09	0.150
4/05/02	5	10	0	10		185	165	135	3.0	0.1	156.9	50	7.14	0.26	14.12	97.6%	2.09	0.150
4/08/02	8	10	0	10		185	164	135	3.0	0.1	156.9	50	6.94	0.22	13.76	97.9%	2.09	0.150
4/09/02	9	10	0	10		180	160	130	3.0	0.1	151.9	50	6.91	0.25	13.68	97.6%	2.09	0.155
4/10/02	10	14	0	4		250	230	220	3.0	0.1	231.9	30	7.97	0.32	34.76	98.5%	2.09	0.140
4/11/02	11	14	0	4		250	230	220	3.0	0.1	231.9	30	7.78	0.30	33.97	98.6%	2.09	0.140
4/12/02	12	13	0	4		250	230	220	3.0	0.1	231.9	30	6.81	0.28	28.02	98.4%	2.09	0.130
4/15/02	15	11	0	4		250	235	225	3.0	0.1	234.4	25	6.72	0.27	24.45	98.3%	2.09	0.109
4/16/02	16	14	0	6	20.8	240	220	205	3.0	0.1	219.4	35	6.71	0.21	16.96	98.3%	1.13	0.080
4/17/02	17	14	0	6	19.8	230	215	200	3.0	0.1	211.9	30	6.72	0.17	16.96	98.5%	1.17	0.086
4/18/02	18	14	0	6	20.0	235	215	205	3.0	0.1	216.9	30	6.68	0.21	16.96	98.2%	1.16	0.083
4/19/02	19	14	0	6	20.2	235	215	205	3.0	0.1	216.9	30	6.66	0.21	16.96	98.2%	1.15	0.083
4/23/02	23	14	0	6	20.0	235	215	200	3.0	0.1	214.4	35	7.19	0.30	16.96	97.5%	1.16	0.084
4/24/02	24	14	0	6	20.2	235	215	205	3.0	0.1	216.9	30	6.84	0.25	16.96	97.9%	1.15	0.083
4/25/02	25	14	0	6	20.2	235	215	205	3.0	0.1	216.9	30	6.82	0.24	16.96	98.0%	1.15	0.083
4/26/02	26	14	0	6	20.1	230	210	200	3.0	0.1	211.9	30	6.68	0.27	16.96	97.7%	1.16	0.085
4/27/02	27	14	0	6	20.2	230	215	200	3.0	0.1	211.9	30	6.78	0.26	16.96	97.8%	1.15	0.085
4/29/02	29	14	0	6	20.3	225	210	195	3.0	0.1	206.9	30	6.69	0.28	16.59	97.6%	1.15	0.086
4/30/02	30	14	0	6	19.9	230	215	200	3.0	0.1	211.9	30	6.74	0.25	16.59	97.8%	1.16	0.085
5/01/02	31	14	0	6	20.1	230	215	200	3.0	0.1	211.9	30	6.72	0.25	16.59	97.9%	1.16	0.085
5/02/02	32	14	0	6	20.1	235	215	205	3.0	0.1	216.9	30	6.71	0.25	16.59	97.9%	1.16	0.083
5/03/02	33	14	0	6	20.8	230	210	200	3.0	0.1	211.9	30	6.60	0.23	16.59	98.0%	1.13	0.083
5/06/02	36	14	0	6	21.0	235	220	205	3.0	0.1	216.9	30	6.67	0.24	16.59	98.0%	1.13	0.081
5/07/02	37	14	0	6	20.4	230	215	200	3.0	0.1	211.9	30	6.67	0.25	16.59	97.8%	1.15	0.084
5/08/02	38	14	0	6	21.0	235	215	200	3.0	0.1	214.4	35	6.65	0.25	16.59	97.8%	1.13	0.082
5/09/02	39	14	0	6	20.4	250	230	215	3.0	0.1	229.4	35	6.64	0.24	16.59	97.9%	1.15	0.078
5/10/02	40	14	0	6	20.4	255	235	220	3.0	0.1	234.4	35	6.63	0.24	16.59	97.9%	1.15	0.076
5/13/02	43	14	0	6	21.0	220	205	190	3.0	0.1	201.9	30	6.39	0.26	16.06	97.7%	1.13	0.087
5/14/02	44	14	0	6	20.7	225	210	195	3.0	0.1	206.9	30	6.61	0.27	16.06	97.6%	1.14	0.085
5/15/02	45	14	0	6	20.8	225	210	195	3.0	0.1	206.9	30	6.61	0.30	16.06	97.4%	1.13	0.085
5/16/02	46	14	0	6	20.7	230	210	200	3.0	0.1	211.9	30	6.61	0.29	16.06	97.4%	1.14	0.083
5/17/02	47	14	0	6	21.1	225	205	195	3.0	0.1	206.9	30	6.61	0.31	16.06	97.3%	1.12	0.084
5/20/02	50	14	0	6	20.7	230	210	200	3.0	0.1	211.9	30	6.62	0.28	16.06	97.5%	1.14	0.083
5/21/02	51	14	0	6	20.8	230	210	200	3.0	0.1	211.9	30	6.63	0.29	16.06	97.5%	1.13	0.083
5/22/02	52	14	0	6	20.7	230	210	200	3.0	0.1	211.9	30	6.63	0.29	16.06	97.4%	1.14	0.083
5/23/02	53	14	0	6	20.8	225	205	195	3.0	0.1	206.9	30	6.62	0.30	16.06	97.3%	1.13	0.085
5/24/02	54	14	0	6	21.1	220	205	190	3.0	0.1	201.9	30	6.62	0.30	16.06	97.4%	1.12	0.086
5/28/02	58	14	0	6	21.1	215	200	190	3.0	0.1	199.4	25	6.58	0.29	16.06	97.5%	1.12	0.088
5/29/02	59	14	0	6	21.1	225	205	195	3.0	0.1	206.9	30	6.59	0.30	16.06	97.4%	1.12	0.084
5/30/02	60	14	0	6	22.5	225	205	195	3.0	0.1	206.9	30	6.58	0.30	16.06	97.4%	1.08	0.081
5/31/02	61	14	0	6	23.4	225	205	195	3.0	0.1	206.9	30	6.49	0.30	16.06	97.4%	1.05	0.079
6/03/02	64	14	0	6	22.3	215	200	190	3.0	0.1	199.4	25	6.60	0.30	16.57	97.4%	1.08	0.084
6/04/02	65	14	0	6	22.3	225	205	195	3.0	0.1	206.9	30	6.62	0.30	16.57	97.4%	1.08	0.081
6/05/02	66	14	0	6	23.6	220	200	190	3.0	0.1	201.9	30	6.62	0.30	16.57	97.4%	1.04	0.080
6/06/02	67	14	0	6	23.6	220	205	190	3.0	0.1	201.9	30	6.63	0.30	16.57	97.4%	1.04	0.080
6/07/02	68	14	0	6	22.9	220	200	190	3.0	0.1	201.9	30	6.63	0.30	16.57	97.4%	1.06	0.082
6/10/02	71	14	0	6	21.6	230	210	200	3.0	0.1	211.9	30	6.63	0.27	16.57	97.7%	1.11	0.081
6/11/02	72	14	0	6	22.6	225	205	190	3.0	0.1	204.4	35	6.63	0.30	16.57	97.4%	1.07	0.082
6/12/02	73	14	0	6	22.4	230	210	200	3.0	0.1	211.9	30	6.63	0.30	16.57	97.4%	1.08	0.079
6/13/02	74	14	0	6	22.8	230	210	195	3.0	0.1	209.4	35	6.63	0.30	16.57	97.4%	1.07	0.079
6/14/02	75	14	0	6	22.3	230	210	200	3.0	0.1	211.9	30	6.63	0.29	16.57	97.5%	1.08	0.080
6/17/02	78	14	0	6	23.0	225	205	195	3.0	0.1	206.9	30	6.64	0.29	17.25	97.6%	1.06	0.080
6/18/02	79	14	0	6	21.8	225	200	195	3.0	0.1	206.9	30	6.65	0.33	17.25	97.3%	1.10	0.083
6/19/02	80	14	0	6	22.1	225	200	195	3.0	0.1	206.9	30	6.65	0.29	17.25	97.6%	1.09	0.082
6/20/02	81	14	0	6	23.0	225	210	200	3.0	0.1	209.4	25	6.65	0.30	17.25	97.5%	1.06	0.079
6/21/02	82	14	0	6	21.5	230	210	200	3.0	0.1	211.9	30	6.65	0.29	17.25	97.6%	1.11	0.081

The osmotic pressure was calculated using the feed, permeate, and concentrate EC values.

Buena Vista Water Storage District
Agricultural Drainwater Treatment Project

		FLOWS (gpm)				PRESSURES							CONDUCTIVITIES (mS/cm)					
DATE / TIME	Runtime (days)	Permeate	Recycle	Conc.	Feed Temp. (°C)	Feed Pressure	Interstage Pressure	Concentrate Pressure	Permeate Pressure	Osmotic Pressure	Net Driving Pressure	Feed to Conc. ΔP	Feed EC	Permeate EC	Concentrate EC	EC Rejection (Field Data)	Temp. Comp. Factor	Normalized Flux (gfd/psi)
6/24/02	85	14	0	6	22.6	230	210	200	3.0	0.1	211.9	30	6.51	0.28	17.06	97.6%	1.07	0.079
6/25/02	86	14	0	6	22.2	235	210	195	3.0	0.1	211.9	40	6.64	0.30	17.06	97.5%	1.09	0.080
6/26/02	87	14	0	6	23.7	215	210	185	3.0	0.1	196.9	30	6.52	0.30	17.06	97.5%	1.04	0.082
6/27/02	88	14	0	6	25.7	210	195	185	3.0	0.1	194.4	25	6.55	0.35	17.06	97.0%	0.98	0.078
6/28/02	89	14	0	6	22.9	220	205	190	3.0	0.1	201.9	30	6.64	0.31	17.06	97.4%	1.06	0.082
7/01/02	92	14	0	6	23.3	220	205	180	3.0	0.1	196.9	40	6.67	0.31	17.67	97.4%	1.05	0.083
7/02/02	93	14	0	6	23.3	230	210	195	3.0	0.1	209.4	35	6.70	0.42	17.67	96.5%	1.05	0.078
7/03/02	94	14	0	6	23.6	220	200	190	3.0	0.1	201.9	30	6.68	0.32	17.67	97.4%	1.04	0.080
7/04/02	95	14	0	6	22.9	220	205	190	3.0	0.1	201.9	30	6.69	0.31	17.67	97.4%	1.06	0.082
7/05/02	96	14	0	6	22.8	225	205	195	3.0	0.1	206.9	30	6.69	0.31	17.67	97.5%	1.07	0.080
7/08/02	99	14	0	6	23	225	210	195	3.0	0.1	206.9	30	6.71	0.33	17.99	97.4%	1.06	0.080
7/9/2002	100	14	0	6	23.7	225	205	195	3.0	0.1	206.9	30	6.71	0.32	17.99	97.4%	1.04	0.078
7/10/2002	101	14	0	6	23.9	210	195	180	3.0	0.1	191.9	30	6.60	0.33	17.99	97.3%	1.03	0.084
7/11/2002	102	14	0	6	23.1	225	210	195	3.0	0.1	206.9	30	6.71	0.32	17.99	97.4%	1.06	0.080
7/12/2002	103	14	0	6	23.4	230	210	200	3.0	0.1	211.9	30	6.72	0.32	17.99	97.4%	1.05	0.077
7/15/2002	106	14	0	6	23.1	220	205	190	3.0	0.1	201.9	30	6.68	0.32	17.99	97.4%	1.06	0.081
7/16/2002	107	14	0	6	23.6	220	205	195	3.0	0.1	204.4	25	6.68	0.31	17.32	97.4%	1.04	0.079
7/17/2002	108	14	0	6	23.7	225	205	195	3.0	0.1	206.9	30	6.69	0.33	17.32	97.3%	1.04	0.078
7/18/2002	109	14	0	6	23.3	220	200	190	3.0	0.1	201.9	30	6.70	0.32	17.32	97.3%	1.05	0.081
7/19/2002	110	14	0	6	23.5	225	210	195	3.0	0.1	206.9	30	6.72	0.32	17.32	97.4%	1.05	0.079
7/22/2002	113	13	0	6	23.5	225	210	195	3.0	0.1	206.9	30	6.73	0.31	17.43	97.4%	1.05	0.073
7/23/2002	114	14	0	5	23.6	235	220	210	3.0	0.1	219.4	25	6.74	0.35	17.43	97.1%	1.04	0.074
7/24/2002	115	15	0	5	23.7	235	225	215	3.0	0.1	221.9	20	6.75	0.36	17.43	97.0%	1.04	0.078
7/25/2002	116	15	0	5	23.3	235	225	215	3.0	0.1	221.9	20	6.76	0.36	17.43	97.0%	1.05	0.079
7/26/2002	117	15	0	5	23.3	240	225	215	3.0	0.1	224.4	25	6.44	0.35	17.43	97.1%	1.05	0.078
7/29/2002	120	13.5	0	4.8	23.5	225	215	205	3.0	0.1	211.9	20	6.73	0.35	17.43	97.1%	1.05	0.074
7/30/2002	121	15	0	5	24.9	235	220	215	3.0	0.1	221.9	20	6.72	0.38	20.60	97.2%	1.00	0.075
7/31/2002	122	15	0	5	23.8	240	225	215	3.0	0.1	224.4	25	6.72	0.37	20.60	97.3%	1.04	0.077
8/1/2002	123	15	0	5	23.8	235	225	215	3.0	0.1	221.9	20	6.71	0.36	20.60	97.4%	1.04	0.078
8/2/2002	124	15	0	5	23.3	240	225	215	3.0	0.1	224.4	25	6.71	0.35	20.60	97.4%	1.05	0.078
8/5/2002	127	15	0	5	23.6	240	228	220	3.0	0.1	226.9	20	6.72	0.35	19.91	97.4%	1.04	0.077
8/6/2002	128	15	0	5	23.3	245	230	220	3.0	0.1	229.4	25	6.71	0.35	19.91	97.4%	1.05	0.076
8/7/2002	129	15	0	5	23.5	240	225	215	3.0	0.1	224.4	25	6.71	0.35	19.91	97.4%	1.05	0.078
8/8/2002	130	15	0	5	23.5	240	225	215	3.0	0.1	224.4	25	6.73	0.35	19.91	97.3%	1.05	0.078
8/9/2002	131	15	0	5	23.3	240	225	215	3.0	0.1	224.4	25	6.74	0.35	19.91	97.4%	1.05	0.078
8/12/2002	134	15	0	5	23.5	240	225	215	3.0	0.1	224.4	25	6.74	0.37	20.90	97.3%	1.05	0.078
8/13/2002	135	15	0	5	24.2	235	220	210	3.0	0.1	219.4	25	6.73	0.36	20.90	97.4%	1.02	0.078
8/14/2002	136	15	0	5	23.8	235	220	210	3.0	0.1	219.4	25	6.74	0.36	20.90	97.4%	1.04	0.079
8/15/2002	137	15	0	5	23.4	240	225	215	3.0	0.1	224.4	25	6.73	0.35	20.90	97.5%	1.05	0.078
8/16/2002	138	15	0	5	24.1	239	225	215	3.0	0.1	223.9	24	6.74	0.37	20.90	97.4%	1.03	0.076
8/19/2002	141	15	0	5	23.7	245	230	220	3.0	0.1	229.4	25	6.743	0.360	20.90	97.4%	1.04	0.075
8/20/2002	142	15	0	5	22.6	245	230	220	3.0	0.1	229.4	25	6.750	0.352	20.90	97.5%	1.07	0.078
8/23/2002	145	15	0	5	22.5	245	230	220	3.0	0.1	229.4	25	6.736	0.353	20.90	97.4%	1.08	0.078
8/26/2002	148	15	0	5	22.7	240	225	220	3.0	0.1	226.9	20	6.738	0.349	20.90	97.5%	1.07	0.079
8/27/2002	149	15	0	5	23.5	245	230	220	3.0	0.1	229.4	25	6.738	0.322	20.70	97.7%	1.05	0.076
8/28/2002	150	14	0	5	22.7	250	235	225	3.0	0.1	234.4	25	6.749	0.304	20.70	97.8%	1.07	0.071
8/29/2002	151	15	0	5	23.7	240	225	215	3.0	0.1	224.4	25	5.634	0.242	20.70	98.2%	1.04	0.077
8/30/2002	152	15	0	5	23.6	235	220	210	3.0	0.1	219.4	25	5.605	0.250	20.70	98.1%	1.04	0.079
9/3/2002	156	9	0	3	26.5	160	155	150	3.0	0.1	151.9	10	5.427	0.360	20.70	97.2%	0.96	0.063
9/11/2002	164	7.2	0	8	23.5	135	120	100	3.0	0.1	114.4	35	5.867	0.345	20.70	97.4%	1.05	0.073
9/13/2002	166	6	0	5	25.6	110	100	90	3.0	0.1	96.9	20	5.405	0.352	20.70	97.3%	0.98	0.068
9/16/2002	169	6	0	6	25.7	110	100	90	3.0	0.1	96.9	20	5.387	0.355	20.70	97.3%	0.98	0.067
9/17/2002	170	6	0	5	25.8	115	105	95	3.0	0.1	101.9	20	5.384	0.375	20.70	97.1%	0.98	0.064
9/18/2002	171	6	0	5	25.1	115	105	100	3.0	0.1	104.4	15	5.386	0.362	20.70	97.2%	1.00	0.064
9/19/2002	172	6	0	5	26.5	110	105	95	3.0	0.1	99.4	15	5.378	0.381	20.70	97.1%	0.96	0.064
9/20/2002	173	6	0	5	25.6	115	105	100	3.0	0.1	104.4	15	5.376	0.372	20.70	97.1%	0.98	0.063
9/23/2002	176	9	0	5	27.3	155	140	135	3.0	0.1	141.9	20	6.332	0.452	20.70	96.7%	0.93	0.066
9/24/2002	177	9	0	5	24.4	155	145	135	3.0	0.1	141.9	20	6.262	0.375	14.86	96.4%	1.02	0.072
9/25/2002	178	9	0	5	25.7	155	145	135	3.0	0.1	141.9	20	6.305	0.381	14.86	96.4%	0.98	0.069

The osmotic pressure was calculated using the feed, permeate, and concentrate EC values.

Buena Vista Water Storage District
Agricultural Drainwater Treatment Project

		FLOWS (gpm)				PRESSURES							CONDUCTIVITIES (mS/cm)					
DATE / TIME	Runtime (days)	Permeate	Recycle	Conc.	Feed Temp. (°C)	Feed Pressure	Interstage Pressure	Concentrate Pressure	Permeate Pressure	Osmotic Pressure	Net Driving Pressure	Feed to Conc. ΔP	Feed EC	Permeate EC	Concentrate EC	EC Rejection (Field Data)	Temp. Comp. Factor	Normalized Flux (gfd/psi)
9/26/2002	179	9	0	5	24.4	155	145	135	3.0	0.1	141.9	20	6.294	0.363	14.86	96.6%	1.02	0.072
9/27/2002	180	9	0	5	24.5	155	145	135	3.0	0.1	141.9	20	6.319	0.363	14.86	96.6%	1.01	0.072
9/30/2002	183	5	0	5	27.7	105	100	90	3.0	0.1	94.4	15	6.290	0.582	11.63	93.5%	0.92	0.054
10/1/2002	184	8	0	5	24.4	140	135	125	3.0	0.1	129.4	15	6.508	0.429	11.63	95.3%	1.02	0.070
10/2/2002	185	7	0	5	24.2	140	135	125	3.0	0.1	129.4	15	6.555	0.425	11.63	95.3%	1.02	0.062
10/3/2002	186	7	0	5	24.2	140	130	125	3.0	0.1	129.4	15	6.620	0.427	11.63	95.3%	1.02	0.062
10/4/2002	187	7	0	5	23.9	140	130	120	3.0	0.1	126.9	20	6.559	0.411	11.63	95.5%	1.03	0.063
10/7/2002	190	7	0	5	25.2	135	125	115	3.0	0.1	121.9	20	6.349	0.418	11.63	95.4%	0.99	0.063
10/8/2002	191	7	0	5	23.5	140	130	125	3.0	0.1	129.4	15	6.580	0.407	13.09	95.9%	1.05	0.063
10/11/2002	194	8	0	5	24.6	145	135	125	3.0	0.1	131.9	20	6.115	0.368	13.09	96.2%	1.01	0.068
10/14/2002	197	7	0	5	23.7	140	135	125	3.0	0.1	129.4	15	6.573	0.404	13.09	95.9%	1.04	0.062
10/16/2002	199	8	0	5	23.08	150	140	130	3.0	0.1	136.9	20	6.692	0.430	13.09	95.7%	1.06	0.069
10/17/2002	200	8	0	5	23.9	150	140	130	3.0	0.1	136.9	20	6.630	0.382	13.09	96.1%	1.03	0.067
10/18/2002	201	8	0	5	24.3	145	135	125	3.0	0.1	131.9	20	6.601	0.423	13.09	95.7%	1.02	0.069
10/21/2002	204	7	0	5	23.8	140	130	125	3.0	0.1	129.4	15	6.603	0.423	13.22	95.7%	1.04	0.062
10/24/2002	207	9	0	5	22.4	160	150	140	3.0	0.1	146.9	20	6.512	0.391	13.22	96.0%	1.08	0.073
10/25/2002	208	9	0	5	22	160	150	140	3.0	0.1	146.9	20	6.396	0.376	13.22	96.2%	1.09	0.074
10/28/2002	211	9	0	5	23	155	145	135	3.0	0.1	141.9	20	6.328	0.374	13.22	96.2%	1.06	0.075
10/29/2002	212	15	0	5	21	230	215	200	3.0	0.1	211.9	30	6.512	0.348	13.22	96.5%	1.13	0.089
10/30/2002	213	15	0	5	20.8	230	210	200	3.0	0.1	211.9	30	6.528	0.345	13.22	96.5%	1.13	0.089
10/31/2002	214	15	0	5	20.9	230	210	200	3.0	0.1	211.9	30	6.558	0.341	13.22	96.6%	1.13	0.089
11/1/2002	215	15	0	5	20.9	230	210	200	3.0	0.1	211.9	30	6.591	0.369	13.22	96.3%	1.13	0.089
11/4/2002	218	15	0	5	20.4	235	215	205	3.0	0.1	216.9	30	6.457	0.335	18.96	97.4%	1.15	0.088
11/5/2002	219	15	0	5	20.9	235	215	205	3.0	0.1	216.9	30	6.505	0.343	18.96	97.3%	1.13	0.087
11/7/2002	221	15	0	5	20.2	240	220	210	3.0	0.1	221.9	30	6.237	0.325	18.96	97.4%	1.15	0.087
11/8/2002	222	15	0	5	20.4	230	210	200	3.0	0.1	211.9	30	6.150	0.313	18.96	97.5%	1.15	0.090
11/11/2002	225	14	0	5	20.2	230	215	205	3.0	0.1	214.4	25	6.478	0.316	18.58	97.5%	1.15	0.084
11/12/2002	226	15	0	5	19.8	235	220	210	3.0	0.1	219.4	25	6.513	0.331	18.58	97.4%	1.17	0.089
11/13/2002	227	15	0	5	19.5	240	225	215	3.0	0.1	224.4	25	6.460	0.320	18.58	97.4%	1.18	0.087
11/14/2002	228	15	0	5	20	240	225	210	3.0	0.1	221.9	30	6.444	0.319	18.58	97.5%	1.16	0.087
11/15/2002	229	15	0	5	19.3	240	225	215	3.0	0.1	224.4	25	6.443	0.312	18.58	97.5%	1.18	0.088
11/18/2002	232	15	0	5	19	240	225	215	3.0	0.1	224.4	25	6.391	0.302	18.58	97.6%	1.19	0.089
11/19/2002	233	15	0	5	20	240	225	215	3.0	0.1	224.4	25	6.504	0.319	18.58	97.5%	1.16	0.086
11/20/2002	234	15	0	5	19.8	240	225	215	3.0	0.1	224.4	25	6.475	0.326	18.58	97.4%	1.17	0.087
11/21/2002	235	15	0	5	19	240	225	215	3.0	0.1	224.4	25	6.463	0.320	18.58	97.4%	1.19	0.089
11/22/2002	236	15	0	5	19.6	240	225	215	3.0	0.1	224.4	25	6.466	0.317	18.58	97.5%	1.17	0.087
11/25/2002	239	15	0	5	19.1	245	230	220	3.0	0.1	229.4	25	4.124	0.348	18.24	96.9%	1.19	0.086
11/26/2002	240	15	0	5	19.3	245	230	225	3.0	0.1	231.9	20	6.601	0.345	18.24	97.2%	1.18	0.085
11/27/2002	241	15	0	5	18.9	250	235	225	3.0	0.1	234.4	25	6.578	0.341	18.24	97.3%	1.20	0.085
11/29/2002	243	15	0	5	19.1	250	235	225	3.0	0.1	234.4	25	6.521	0.328	18.24	97.4%	1.19	0.085
12/2/2002	246	15	0	5	19.5	250	235	225	3.0	0.1	234.4	25	6.367	0.324	18.24	97.4%	1.18	0.084
12/3/2002	247	15	0	5	18.7	250	235	225	3.0	0.1	234.4	25	6.512	0.327	18.24	97.4%	1.20	0.086

The osmotic pressure was calculated using the feed, permeate, and concentrate EC values.

Appendix F – Conceptual Layout Designs for Various Production Flow Rates

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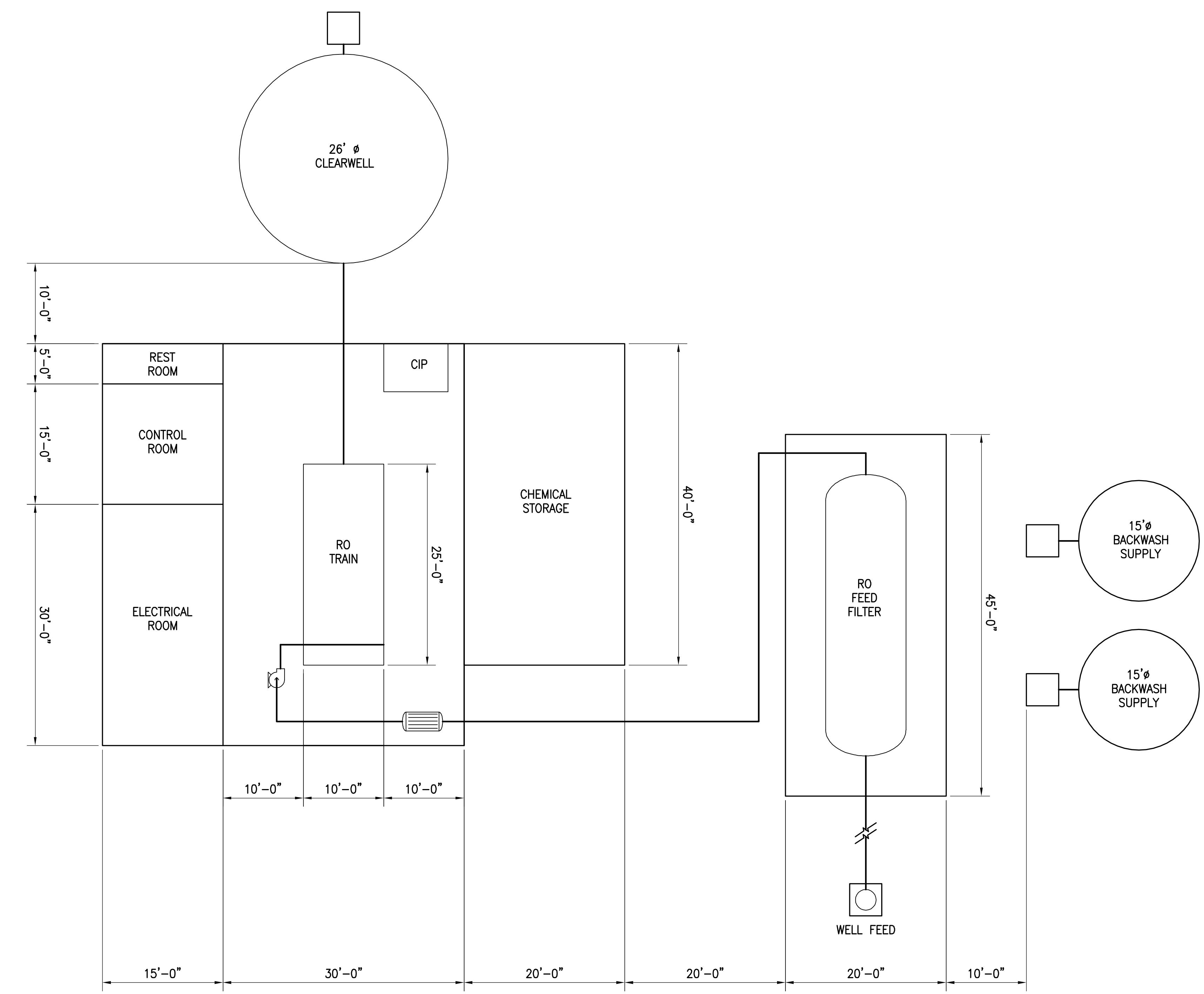

BUENA VISTA WATER STORAGE DISTRICT

FIGURE F-1
1 MGD WTP

BOYLE ENGINEERING CORPORATION

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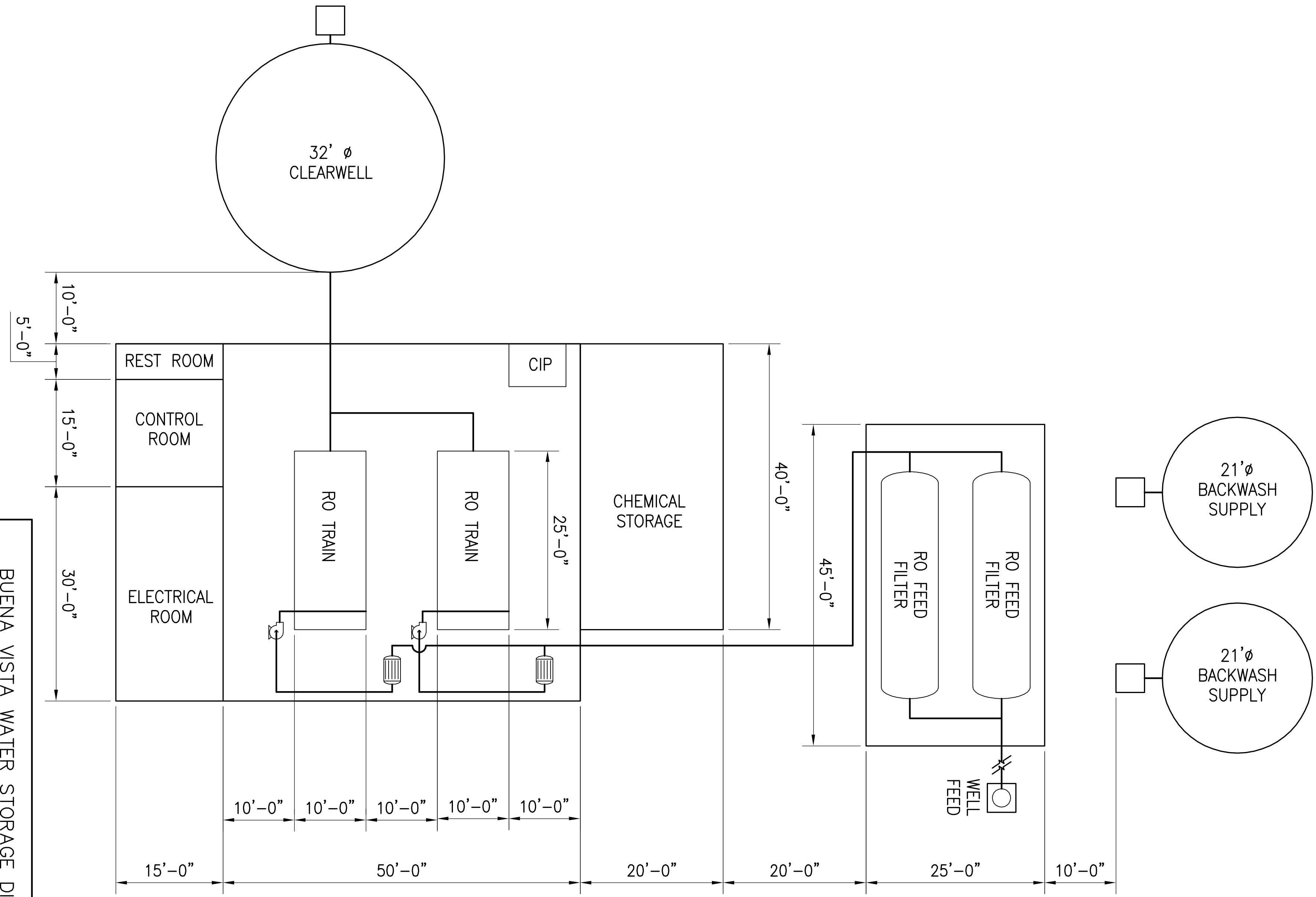
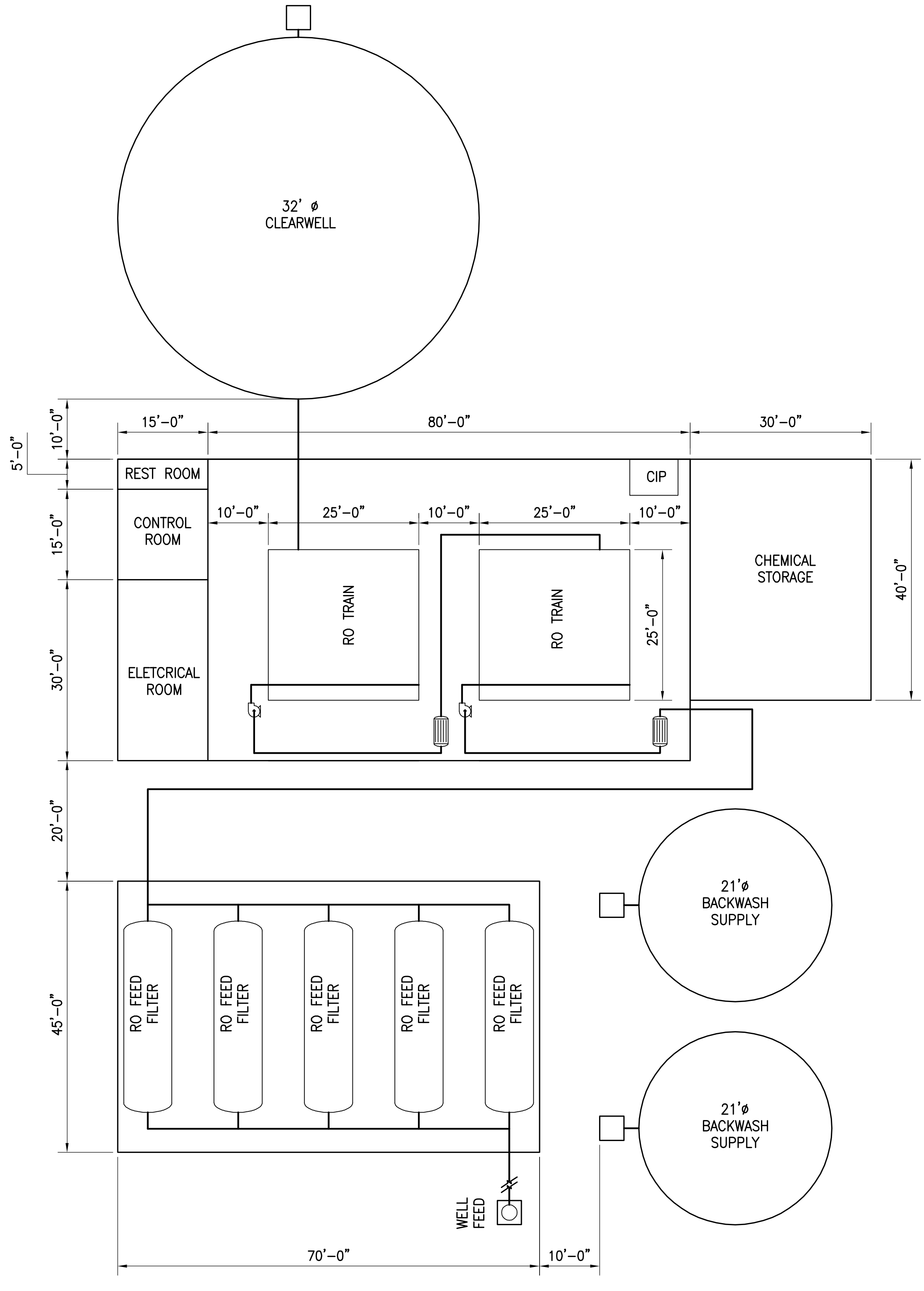


FIGURE F-2
2 MGD WTP

BUENA VISTA WATER STORAGE DISTRICT

BOYLE ENGINEERING CORPORATION



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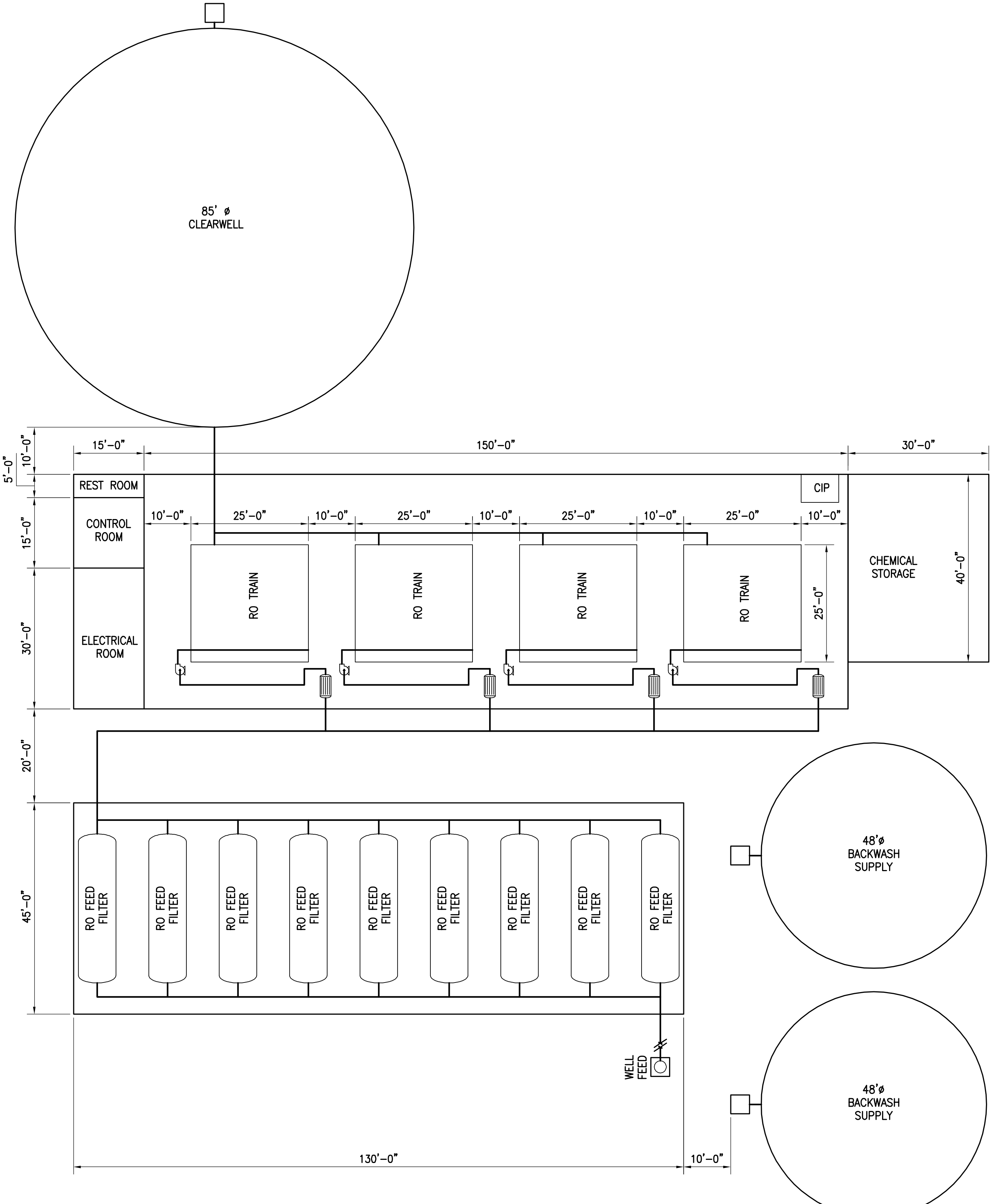
BUENA VISTA WATER STORAGE DISTRICT

FIGURE F-3

5 MGD WTP

BOYLE ENGINEERING CORPORATION



BUENA VISTA WATER STORAGE DISTRICT

FIGURE F-4

10 MGD WTP

BOYLE ENGINEERING CORPORATION

DWG: S:\B21\105-02\2002\Final Report Revisions\Figures\L1676-4.dwg USER: ccampbell
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Appendix G – Piezometer Data: Contour Maps

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LEGEND

- PEIZOMETER
- BRACKISH WATER WELL
- GROUND WATER LEVEL
- GROUND COUNTOURS

BUENA VISTA WATER STORAGE DISTRICT

FIGURE G-1

DEPTH TO GROUNDWATER

9-17-01

BOYLE ENGINEERING CORPORATION

DWG: S:\B21\105-02\2002\Final Report Revisions\Figures\FIGURE-G2.dwg USER: ccampbell
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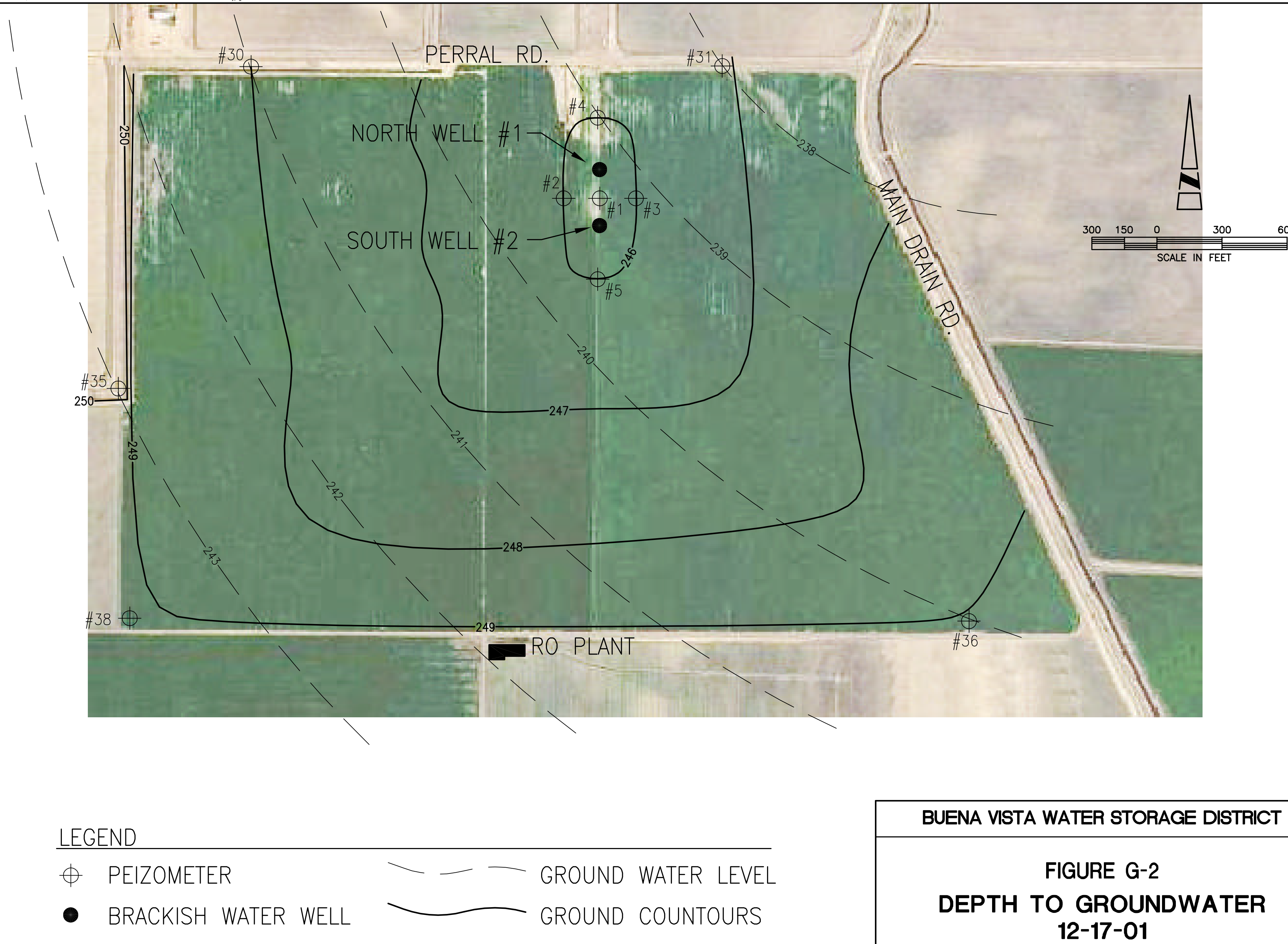

BUENA VISTA WATER STORAGE DISTRICT

FIGURE G-2

DEPTH TO GROUNDWATER

12-17-01

BOYLE ENGINEERING CORPORATION

DWG: S:\B21\105-02\2002\Final Report Revisions\Figures\FIGURE-G3.dwg USER: ccampbell
DATE: Nov 14, 2003 10:42am XREFS: IMAGES: bloemhofwells.jpg

LEGEND

PEIZOMETER	GROUND WATER LEVEL
BRACKISH WATER WELL	GROUND COUNTOURS

BUENA VISTA WATER STORAGE DISTRICT

FIGURE G-3

DEPTH TO GROUNDWATER
9-23-02

BOYLE ENGINEERING CORPORATION

DWG: S:\B21\105-02\2002\Final Report Revisions\Figures\FIGURE-G4.dwg USER: ccampbell
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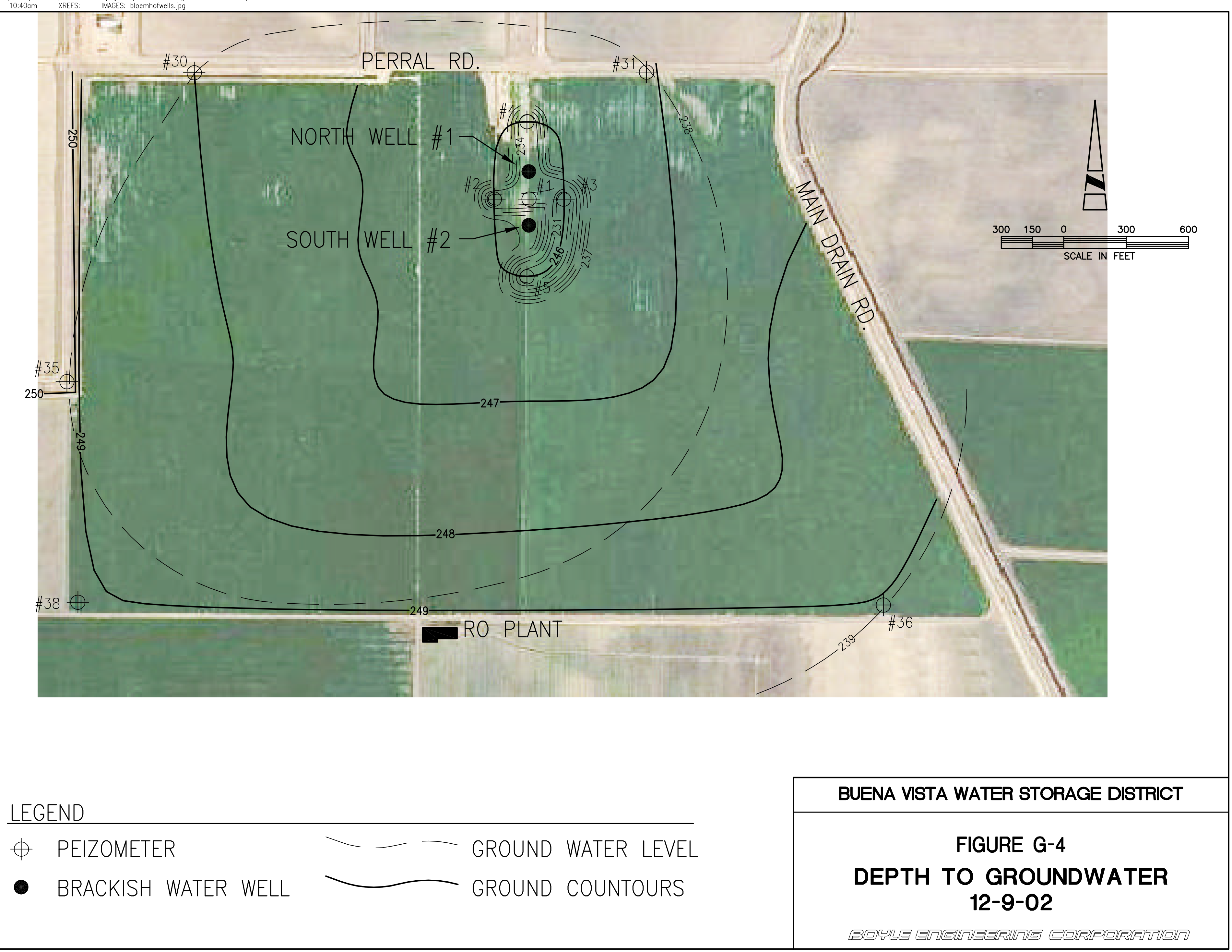


BUENA VISTA WATER STORAGE DISTRICT

FIGURE G-4

DEPTH TO GROUNDWATER

12-9-02

BOYLE ENGINEERING CORPORATION

Appendix H – KOCH Membrane Specifications

KOCH MEMBRANE SYSTEMS

FLUID SYSTEMS TFC® - ULP 4”

Ultra-Low Pressure, RO Elements

PRODUCT DESCRIPTION

Membrane Chemistry:	Proprietary TFC® polyamide
Membrane Type:	TFC®-ULP
Construction:	Spiral-wound with fiberglass outerwrap
Applications:	Ultra-low pressure application for light industrial & potable water production

SPECIFICATIONS

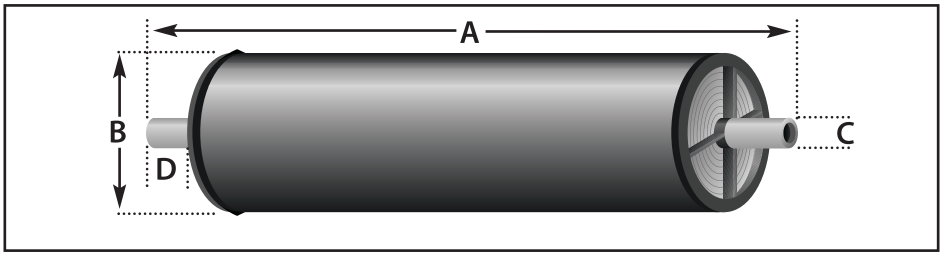
Model	Permeate Flow		Chloride Rejection	Membrane Area	
	gpd	(m^3/d)	percent	ft^2	(m^2)
TFC® 4820 ULP	1,750	(6.6)	98.5	78	(7.2)

Test Conditions: 2,000 mg/l NaCl solution at 125 psi (860 kPa) applied pressure, 15% recovery, 77°F (25°C) and pH 7.5.

OPERATING & DESIGN INFORMATION

Typical operating pressure:	50 - 175 psi (345 - 1,200 kPa)
Maximum operating pressure:	350 psi (2,400 kPa)
Maximum operating temperature:	113°F (45°C)
Maximum cleaning temperature:	113°F (45°C)
Maximum continuous free chlorine:	<0.1 mg/l
Allowable pH - continuous operation:	4 - 11
Allowable pH - short term cleaning:	2.5 - 11
Maximum differential pressure per element:	10 psi (69 kPa)
Maximum differential pressure per vessel:	60 psi (414 kPa)
Maximum feed turbidity:	1 NTU
Maximum feed SDI (15 minute):	5
Feed spacer thickness:	31 mil (0.8 mm)

PRODUCT DIMENSIONS AND WEIGHT



Model	A	B	C	D	Weight	Part Numbers		
	inches (mm)	inches (mm)	inches (mm)	inches (mm)	lbs (kg)	Interconnector	O-ring	Brine Seal
TFC® 4820 ULP	40 (1,016)	4 (101.6)	0.75 (19.0)	1.0 (25.4)	10 (4.5)	0035267	0035458	0035702

TFC® - ULP 4"

Performance:

Performance specifications shown on the front side of this document are nominal values. Individual element permeate flows may vary +20/-15% from the values shown. Minimum chloride ion rejection is 97.5% at the conditions shown.

System performance should be predicted using KMS' ROPRO® design software. Element performance within ROPRO® is based on the nominal values shown.

System operating data should be normalized and key performance parameters tracked using KMS' NORMPRO® software.

Operating Limits:

- **Operating Pressure:** Maximum operating pressure is 350 psi (2,400 kPa). Typical operating pressure for TFC®-ULP systems is in the range of 50 psi (345 kPa) to 175 psi (1,200 kPa). Actual operating pressure is dependent upon system flux rate (appropriate for feed source) as well as feed salinity, recovery and temperature conditions.
- **Permeate Pressure:** Permeate pressure should not exceed feed-concentrate pressure by more than 5 psi (34 kPa) at any time (on-line, off-line and during transition).
- **Differential Pressure:** Maximum differential pressure is 10 psi (69 kPa) for a 40" (1,016 mm) long element. Maximum differential pressure for any length pressure vessel is 60 psi (414 kPa).
- **Temperature:** Maximum operating temperature is 113°F (45°C). Maximum cleaning temperature is 113°F (45°C).
- **pH:** Allowable range for continuous operation is pH 4 - 11. Allowable range for short term cleaning is pH 2.5 - 11.
- **Turbidity and SDI:** Maximum feed turbidity is 1 NTU. Maximum feed Silt Density Index (SDI) is 5.0 (15 minute test). Experience has shown that feedwater with turbidity greater than 0.2 NTU generally results in excessive cleanings.
- **Recovery:** Maximum recovery is site and application specific. In general, single element recovery is approximately 15%. Recovery limits should be determined using KMS' ROPRO® program.

Chemical Tolerance:

- **Chlorine:** Intentional exposure of TFC®-ULP membrane to free chlorine or other oxidizing agents such as permanganate, ozone, bromine and iodine is not recommended. TFC®-ULP membrane has a free chlorine tolerance of approximately 1,000 ppm-hours based on testing at 77°F (25°C), pH 8. This tolerance may be significantly reduced if catalyzing metals such as iron are present or if the pH and/or temperature are different. Sodium metabisulfite (without catalysts such as cobalt) is the preferred reducing agent. TFC®-ULP membrane has a chloramine tolerance of approximately 60,000 ppm-hours in the absence of free chlorine based on testing at 77°F (25°C), pH 8.
- **Cationic (Positively Charged) Polymers and Surfactants:** TFC®-ULP membrane may be irreversibly fouled if exposed to cationic (positively charged) polymers or surfactants. Exposure to these chemicals during operation or cleaning is not recommended.

Lubricants:

For element loading, use only the supplied silicone lubricant (or approved equivalent), water or glycerin to lubricate O-rings and brine seals. The use of petroleum based lubricants or vegetable based oils may damage the element and void the warranty.

Service and Ongoing Technical Support:

KMS has an experienced staff of professionals available to assist endusers and OEM's for optimization of existing systems and support with the development of new applications. Along with the availability of supplemental technical bulletins, KMS also offers a complete line of KochTREAT™ and KochKLEEN® RO pretreatment and maintenance chemicals.

 # WD TS 19100A, 10/02

Koch Membrane Systems, Inc., www.kochmembrane.com

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USA: 10054 Old Grove Road, San Diego, CA 92131, USA, Telephone: 800-525-4369, Telephone: 858-695-3840, Fax 858-695-2176
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KOCH MEMBRANE SYSTEMS

FLUID SYSTEMS TFC® - HR 4"

High Rejection, Low Pressure, Brackish Water, RO Element

PRODUCT DESCRIPTION

Membrane Chemistry:	Proprietary TFC® polyamide
Membrane Type:	TFC-HR®
Construction:	Spiral-wound with fiberglass outerwrap
Applications:	High rejection for brackish water treatment

SPECIFICATIONS

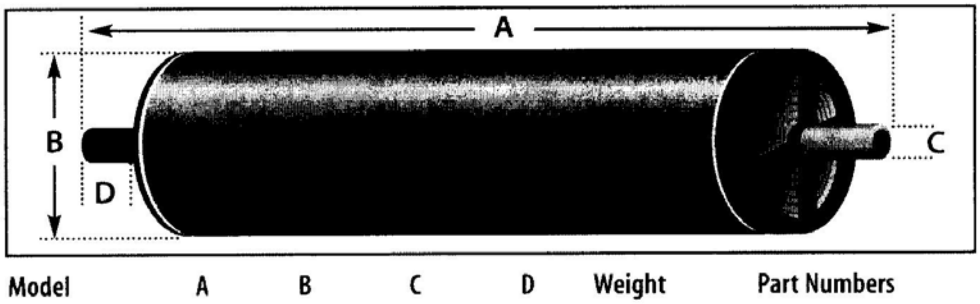
Model	Permeate Flow		Chloride Rejection	Membrane Area	
	gpd	(m^3/d)	NaCl	ft^2	(m^2)
TFC® 4820 HR	2,100	(7.9)	99.5	78	(7.2)

Test Conditions: 2,000 mg/l NaCl solution at 225 psi (1,550 kPa) applied pressure, 15% recovery, 77°F (25°C) and pH 7.5.

OPERATING & DESIGN INFORMATION

Typical operating pressure:	225 - 450 psi (1,550 - 3,100 kPa)
Maximum operating pressure:	600 psi (4,140 kPa)
Maximum operating temperature:	113°F (45°C)
Maximum cleaning temperature:	113°F (45°C)
Maximum continuous free chlorine:	<0.1 mg/l
Allowable pH - continuous operation:	4 - 11
Allowable pH - short term cleaning:	2.5 - 11
Maximum differential pressure per element:	10 psi (69 kPa)
Maximum differential pressure per vessel:	60 psi (414 kPa)
Maximum feed turbidity:	1 NTU
Maximum feed SDI (15 minute):	5
Feed spacer thickness :	31 mil (0.8 mm)

PRODUCT DIMENSIONS AND WEIGHT



Model	A	B	C	D	Weight	Part Numbers		
	inches (mm)	inches (mm)	inches (mm)	inches (mm)	lbs (kg)	Interconnector	O-ring	Brine Seal
TFC® 4820 HR	40 (1,016)	4 (101.6)	0.75 (19.0)	1.0 (25.4)	10(4.5)	0035267	0035458	0035702

TFC® - HR 4"

Performance:

Performance specifications shown on the front side of this document are nominal values. Individual element permeate flows may vary +20/-15% from the values shown. Minimum chloride ion rejection is 99.2% at the conditions shown.

System performance should be predicted using KMS' ROPRO® design software. Element performance within ROPRO® is based on the nominal values shown.

System operating data should be normalized and key performance parameters tracked using KMS' NORMPRO® software.

Operating Limits:

- **Operating Pressure:** Maximum operating pressure is 600 psi (4,140 kPa). Typical operating pressure for TFC®-HR systems is in the range of 225 psi (1,550 kPa) to 450 psi (3,100 kPa). Actual operating pressure is dependent upon system flux rate (appropriate for feed source) as well as feed salinity, recovery and temperature conditions.
- **Permeate Pressure:** Permeate pressure should not exceed feed-concentrate pressure by more than 5 psi (34 kPa) at any time (on-line, off-line and during transition).
- **Differential Pressure:** Maximum differential pressure is 10 psi (69 kPa) for a 40" (1,016 mm) long element. Maximum differential pressure for any length pressure vessel is 60 psi (414 kPa).
- **Temperature:** Maximum operating temperature is 113°F (45°C). Maximum cleaning temperature is 113°F (45°C).
- **pH:** Allowable range for continuous operation is pH 4 - 11. Allowable range for short term cleaning is pH 2.5 - 11.
- **Turbidity and SDI:** Maximum feed turbidity is 1 NTU. Maximum feed Silt Density Index (SDI) is 5.0 (15 minute test). Experience has shown that feedwater with turbidity greater than 0.2 NTU generally results in frequent cleanings.
- **Recovery:** Maximum recovery is site and application specific. In general, single element recovery is approximately 15%. Recovery limits should be determined using KMS' ROPRO® program.

Chemical Tolerance:

- **Chlorine:** Intentional exposure of TFC®-HR membrane to free chlorine or other oxidizing agents such as permanganate, ozone, bromine and iodine is not recommended. TFC®-HR membrane has a free chlorine tolerance of approximately 1,000 ppm-hours based on testing at 77°F (25°C), pH 8. This tolerance may be significantly reduced if catalyzing metals such as iron are present or if the pH and/or temperature are different. Sodium metabisulfite (without catalysts such as cobalt) is the preferred reducing agent. TFC®-HR membrane has a chloramine tolerance of approximately 60,000 ppm-hours in the absence of free chlorine based on testing at 77°F (25°C), pH 8.
- **Cationic (Positively Charged) Polymers and Surfactants:** TFC®-HR membrane may be irreversibly fouled if exposed to cationic (positively charged) polymers or surfactants. Exposure to these chemicals during operation or cleaning is not recommended.

Lubricants:

For element loading, use only the recommended silicone lubricant (or approved equivalent), water or glycerin to lubricate O-rings and brine seals. The use of petroleum based lubricants or vegetable based oils may damage the element and void the warranty.

Service and Ongoing Technical Support:

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WD TS 19102A, 11/02

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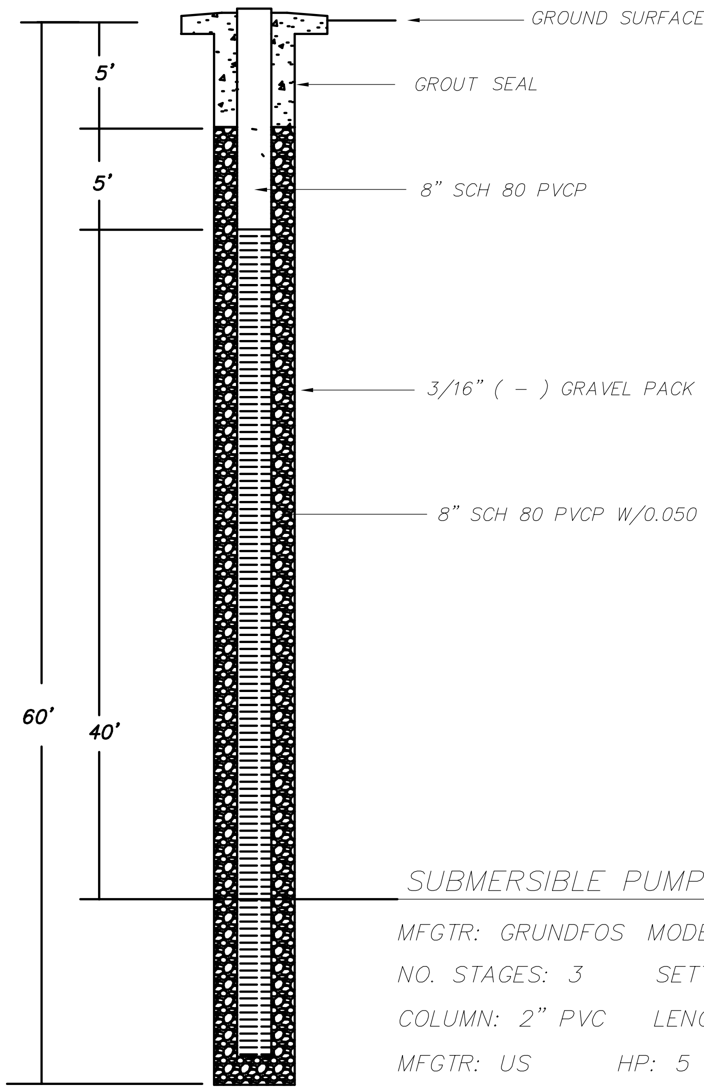
Appendix I – Shallow Well Diagrams

SHALLOW DEWATERING WELL BVS–1 (1/02)

T28S, R22E, SEC 27B



SOIL LOG

10' – CLAY
20' – CLAY
30' – CLAY
40' – FIND SAND
50' – FINE SAND
60' – FINE SAND

SUBMERSIBLE PUMP

MFGTR: GRUNDFOS MODEL: 150S SIZE: 6"
NO. STAGES: 3 SETTING DEPTH: 52'
COLUMN: 2" PVC LENGTH: 50'
MFGTR: US HP: 5 RPM: 3450
PHASE: 3 CY: 60 VOLT: 460
FLOW: 125 GPM HEAD: 83 FT

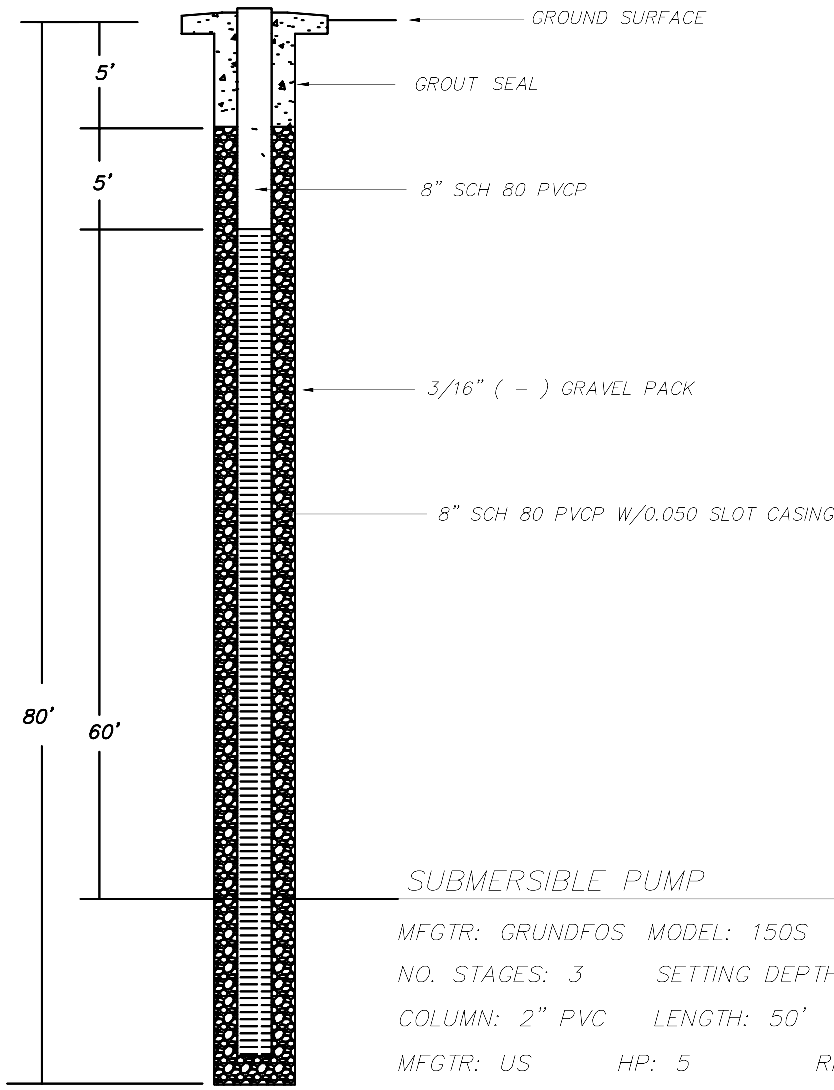
LOCATION

1300' WEST OF MAIN DRAIN RD AND PERRAL RD INTERSECTION
500' SOUTH OF PERRAL RD

PROJECT: SHALLOW DEWATERING WELL		
LOCATION: BVWSD		
DRAWN BY: DAN BARTEL		
DATE: 2/13/02	SCALE:	1 OF 1

SHALLOW DEWATERING WELL BVS-2 (1/02)

T28S, R22E, SEC 27B



SOIL LOG

10' – CLAY
20' – CLAY
30' – CLAY
40' – FIND SAND
50' – CLAY
60' – FINE SAND
70' – FINE SAND
80' – FINE SAND

SUBMERSIBLE PUMP

MFGTR: GRUNDFOS MODEL: 150S SIZE: 6"
NO. STAGES: 3 SETTING DEPTH: 52'
COLUMN: 2" PVC LENGTH: 50'
MFGTR: US HP: 5 RPM: 3450
PHASE: 3 CY: 60 VOLT: 460
FLOW: 125 GPM HEAD: 83 FT

LOCATION

1300' WEST OF MAIN DRAIN RD AND PERRAL RD INTERSECTION
950' SOUTH OF PERRAL RD

PROJECT: SHALLOW DEWATERING WELL		
LOCATION: BVWSD		
DRAWN BY: DAN BARTEL		
DATE: 2/13/02	SCALE:	1 OF 1