# Appendix 3.4-A

# BVWSD Brackish Groundwater Recovery Project Memo

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# TECHNICAL MEMORANDUM

To: Maurice Etchechury, General Manager, Buena Vista Water Storage District

From: Tom Haslebacher, Senior Geologist/Hydrogeologist, PG 4739, CHg 446

Subject: Buena Vista Water Storage District Brackish Groundwater Recovery Project

Date: July 17, 2014

## Purpose of Memorandum

The purpose of the memorandum is to provide a preliminary assessment of groundwater conditions associated with the Buena Vista Water Storage District (BVWSD or District) Brackish Groundwater Recovery Project (BGRP) in the Buttonwillow Service Area (BSA). The BSA (North of 7th Standard Road) overlies shallow perched groundwater that has a total dissolved solids (TDS) concentration between 850 and 4,000 mg/L. Depth to the shallow perched groundwater varies between 5 to 10 feet below ground surface (bgs) within the project area.

In particular, this memo focuses on the pilot study work performed by previous contractors and recommendations for the shallow groundwater well design and construction. The memorandum will contain information regarding the groundwater basin characteristics, aquifer system, groundwater depth and elevation, water supply availability and water quality.

## Project Description

The District would like to recover the shallow perched groundwater and blend it with other surface water supplies for delivery to farmers in the service area. The Project will consist of approximately 40 shallow groundwater wells that will be located within a three mile corridor along the east side of the Main Drain Canal. Well depth will be 100 feet and spacing will be 400 feet between each well. These wells will discharge into a collector pipeline that will be located parallel to the Northern Area Pipeline and the Main Drain Canal. With the construction of the Northern Area Pipeline system in late 2014/early 2015, no water is expected to flow down the Main Drain Canal except in flood years. The proposed design of the wells is shown in **Figure 1**. The project proposes to pump the well field for the majority of the year as required to help meet crop demands and potential wetland habitat. The brackish water from the well field will be blended with fresh surface water supplies. Projected water supply from the well field (40 wells) if the wells pump at a rate of 60 gallons per minute (gpm) will be approximately 2,000 to 3,000 acre feet.

## Previous Projects

Between 2001 and 2003 BVWSD contracted Boyle Engineering to perform a pilot desalination project to demonstrate the ability of commercially available Reverse Osmosis (RO) membranes to treat agricultural drainage water. (Desalination Demonstration Report for Buena Vista Water Storage District, Boyle Engineering, December 2003). Source water for this project was from a tile drainage system and two 60 to 80 feet deep wells, spaced approximately 250 feet apart, pumping from the shallow (perched) groundwater system.

BVS-1 (north) was completed to 60 feet below ground surface (bgs). The top ten feet of the well casing was blank with the remaining 50 feet being 0.050 inch slotted casing (**Figure x1**). BVS-2 (south) was completed to 80 feet bgs. The top ten feet of the well casing was blank with the remaining 70 feet being 0.050 inch slotted casing **(Figure x2**). In addition, 10 monitoring wells were installed to determine shallow groundwater levels out to a distance of 800 feet down hydraulic gradient of the center of the well field and 2800 feet up hydraulic gradient of the well field (**Figure x3**).

Production from the wells occurred over a 253 day period between March 25, 2002 and December 03, 2002. Each well pumped at a rate of approximately 100 gallons per minute (gpm). At a total production rate of approximately 200 gpm from the wells, this would have amounted to approximately 0.9 acre-feet/day or approximately 224 acre-feet for the 253 day period. The production of the wells resulted in a roughly elliptical cone of depression with its longest axis running approximately southwest to northeast. Changes in groundwater levels over this period were approximately 2 feet at 2,500 feet south east of the well field, 2 feet at 800 feet northeast of the well field, 4 feet at 4,300 feet westerly of the well field and approximately 4 feet at 2,800 feet from the center of the well field (**Figures G-1 through G-4**). Based upon this field derived data it is approximated that the radius of influence of the well field extends approximately 5,600 ft easterly and westerly of the wellfield. At approximately 5,600 feet easterly or westerly of the well field, after 253 days of pumping there would be little to no discernible change in the levels of the shallow (perched) groundwater.

A previous dewatering project in early 2014 was performed within the northern BSA for construction of a large diameter pipeline that crosses the district for State Water Project deliveries to Semitropic Water Storage District which is adjacent to BVWSD. The project consisted of four 24-inch diameter boreholes drilled to an approximate depth of 35 feet bgs. Slotted casing with a diameter of 8 inches was placed within each borehole. Pea gravel was used as the gravel pack medium in the annulus. Within each casing a 2.5 horsepower submersible pump was installed with a 2-inch discharge pipe. Each well was connected to a 6-inch manifold pipe that collected the discharge which emptied into the Main Drain Canal. Flow rates varied between 40 to 60 gallons per minute.

**Perched Aquifer Groundwater Quantity**

An attempt to approximate the amount of groundwater available for the BGRP is made with the following assumptions.

1. The wells for the BWRP will be constructed similar to those of the Boyle Engineering study and will pump between 60 and 100 gpm.
2. The radius of influence in an easterly and westerly direction will be similar to that produced by the wells of the Boyle study.
3. It must be recognized that the Boyle Engineering study consisted of two wells in a north south alignment. The BWRP will consist of 40 wells in a north south alignment, approximately 3 miles in length. Without adequate values for hydraulic conductivity and Sy, the values arrived at are rough approximations.
4. The analysis essentially views the area of influence of the wells in a "storage tank" type model. It is assumed that there is no groundwater inflow and outflow from the area. This approach only indicates the amount of water in storage within the area of influence of the wells at the time before pumping begins.
5. Based on analysis of the Boyle Engineering study, the distance at which no influence of the wells is seen is approximately 5,600 feet from each well. As this is a very rough calculation based on groundwater elevation maps from the Boyle Engineering study, a conservative estimate is 4,000 feet from the alignment of the wells will be used and assumed that there will be between 2 feet to 5 feet of drawdown at that distance.

Based on data from the "Report on Investigation of Optimization and Enhancement of the Water Supplies of Kern County (Optimization Report)", January 1983, (Table 5, page 34), the Specific Yield (Sy) BVWSD is 11.5% (0.115). This is a value that the Report uses for the production zone of the BVWSD area (approximately 100 feet to 600 feet below ground surface). In calculating volumes for the brackish water (perched groundwater) to be utilized by the BGRP, this value is probably too high based on the upper 100 feet of sediments being more predominantly fine grained sand and more inter-bedded clays than what is found in the production zone of the aquifer . The Sy is probably closer to the value listed for Henry Miller WD (8.5%). This is also alluded to by R.A. Crewdson (2009) in his hydrogeology section in the BVWSD GWMP. Crewdson does not specify a Sy, but does refer to the shallower sediments as being a lower Sy than the production zone. For this analysis a range using the higher and lower Sy values is used.

The project will call for 40 wells in a three mile, north south alignment along the east side of the Main Drain Canal. As each well will have a radius of influence of 4,000 feet, the area that will be influenced will be 3 miles (15,840 feet) plus 4,000 feet north of the northernmost well and 4,000 feet south of the southernmost well. Total length of the area will be 23,840 feet. Total width of the area will be 8,000 feet. Total area for calculation of available groundwater will be approximately 4,400 acres. Depth to groundwater is approximated to be 5 feet below ground surface and the depth of the wells will be 100 feet. This results in a saturated thickness of 95 feet. Based on these

values, available groundwater will be between 35,400 to 47,800 acre-feet. This is a conservative estimate as it does not factor in deep percolation from the irrigation water, recharge within the canal systems, and inflows into the area of influence.

*As a background to the groundwater in BVWSD, in particular perched shallow groundwater aquifer, the following information is excerpted from "Groundwater Management Plan Buena Vista Water Storage District", Provost and Pritchard Consulting Group, 2014.*

## Location

BVWSD is located in Kern County, approximately sixteen miles westerly of the City of Bakersfield. A location map of the District is shown as **Figure 2**. The District provides water within its service area to primarily agricultural users. The District's service areas are located in the trough of California's southern San Joaquin Valley and comprise approximately 50,000 acres within the lower Kern River watershed. The District is separated into two distinct areas: the northern BSA comprising 45,800 acres, and the southern Maples Service Area (MSA) comprising 4,350 acres. These two areas are separated by about 15 miles. A portion of BVWSD to the west of the MSA is also covered by Henry Miller Water District (HMWD); however this area is not actively managed or served water by BVWSD.

The District is bordered by several water agencies including Belridge Water Storage District, Semitropic Water Storage District, Rosedale-Rio Bravo Water Storage District, Kern Delta Water District and the Kern Water Bank. In some areas the District also borders un-districted land that is not governed by any water district, but lies within the jurisdiction of the County of Kern and Kern County Water Agency. **Figure 3** shows BVWSD and neighboring water agencies.

## Geology

The District, as is the case with much of The San Joaquin Valley, is covered by Pleistocene to Recent unconsolidated, non-marine sediments with thickness of up to 1,000 feet. These sediments are laid down mostly by alluvial and fluvial with occasional lacustrine processes. Sedimentary types are mostly sand and silt with occasional clays. Sources of sedimentary material are from both the eastern Diablo coastal range and the western Sierra Nevada mountains. The Diablo range contributes marine sandstone and shale while the Sierra contributes granitic, sedimentary, and metamorphic rock. It is common for the top 10 feet of soil to be of the Lokern Series which is very clayish and poorly drained in nature. The above described sediments sit on older, better lithified late Jurassic to late Tertiary marine sediments of more than 20,000 feet thickness in most parts of the valley. These older formations below are coarse textured sediments in-laid with various thin clay layers. Thus the aquifer underlying BVWSD and much of the valley reacts as a combination of an unconfined, semi-confined and confined system.

## Surface Water Supplies

The District controls an average pre-1914 entitlement of approximately 158,000 AF/yr of surface water from the Kern River, based on the Miller-Haggin Agreement of July 28, 1888. In 1973, the District contracted with the Kern County Water Agency (KCWA) for an additional surface water supply from the State Department of Water Resources (DWR) via the California Aqueduct. The contract provided for an annual firm supply of 21,300 AF and surplus supply of 3,750 AF. The District's geographic location, with respect to the California Aqueduct and other Kern County Water Agency member units, provides the opportunity for exchanges of the District's Kern River water for east side member unit's State water. The District has also been a historic user of surplus Friant-Kern Canal flows to serve irrigation demands and for groundwater recharge programs. The availability of these supplies will be diminished due to the San Joaquin River Restoration, which will reserve more water for environmental flows.

## Groundwater Supplies

The District landowners are fortunate to possess valuable Kern River water rights and a State water contract, with the average supply providing 100% of their crop needs. However, due to the delivery systems and canal losses, water is not always delivered when it is needed. The remaining demands are filled via landowner and District-owned wells. Annual groundwater replenishment via District canal losses/recharge and deep percolation from irrigation serve to offset overall pumping and thus maintain groundwater levels within the District. Hydrologic calculations show that the District has a long-term positive water balance (see **Table 1**). Therefore, even though the southern San Joaquin Valley has been classified by the DWR as an overdrafted groundwater basin, this District has historically been able to achieve a positive groundwater balance. The District has also participated in groundwater banking programs, purchased other supplemental surface supplies, and developed irrigation tailwater recovery programs to insure its long term positive balance within the groundwater basin.

## Surface Water Quality

The District receives surface water supplies from the Kern River, the State Water Project (SWP), and occasionally the federal Central Valley Project. Surface water supplies have the following water quality, based on data from the Kern County Water Agency: Average SWP surface water Total Dissolved Solids (TDS) = 350 - 450 milligrams per liter (mg/l); Average Kern River surface water TDS = 90 - 120 mg/l; Average Friant-Kern surface water TDS = 50 mg/l. Based on District records, the average tailwater TDS = 200 - 400 mg/l.

## Groundwater Basin

BVWSD overlies the Kern County Sub-basin (DWR Basin No. 5-22.14) portion of the San Joaquin Valley Groundwater Basin (DWR). The Kern County Sub-basin and neighboring basins are shown in **Figure 4**

## Confining Layers

The Corcoran Clay, or stratigraphically equivalent clay, has been mapped or inferred to exist under the BSA and MSA. The clay layer is about 450 - 600 feet deep under much of the BSA, but rises to about 100 feet deep under the south end and 250 feet deep under the north end. The clay layer is about 500 feet deep under the MSA.

## Stratigraphy

The groundwater aquifer under the BSA consists of a sequence of interbedded, laterally discontinuous, sandy and silty sediments. Down to a depth of about 200 feet, silty sediments tend to predominate, but from 200 - 600 feet sandy and silty sediments occur in approximately equal proportion. The sandy strata constitute the groundwater aquifer being used. The Corcoran clay or its stratigraphic equivalent, referred to above, is an important hydrogeologic unit in the stratigraphy of the BVWSD area.

## Groundwater Quality

In the southern portions of the BSA, the TDS of the groundwater varies from 300 to 1,000 mg/l. In the northern portions of the BSA, the TDS varies from 1,000 to 4,500 mg/l. The TDS of the shallow, perched zone ranges from 850 - 5,500 mg/l based on district yearly data from shallow piezometers. In the MSA the TDS ranges from 200 to 1,600 mg/l. **Figure 5** shows pumping zone TDS in the BSA in March 2012. Groundwater quality is generally better in the south, and improves in the interior of the District, possibly due to dilution with surface water from canal seepage and deep percolation from irrigation.

## Groundwater Levels

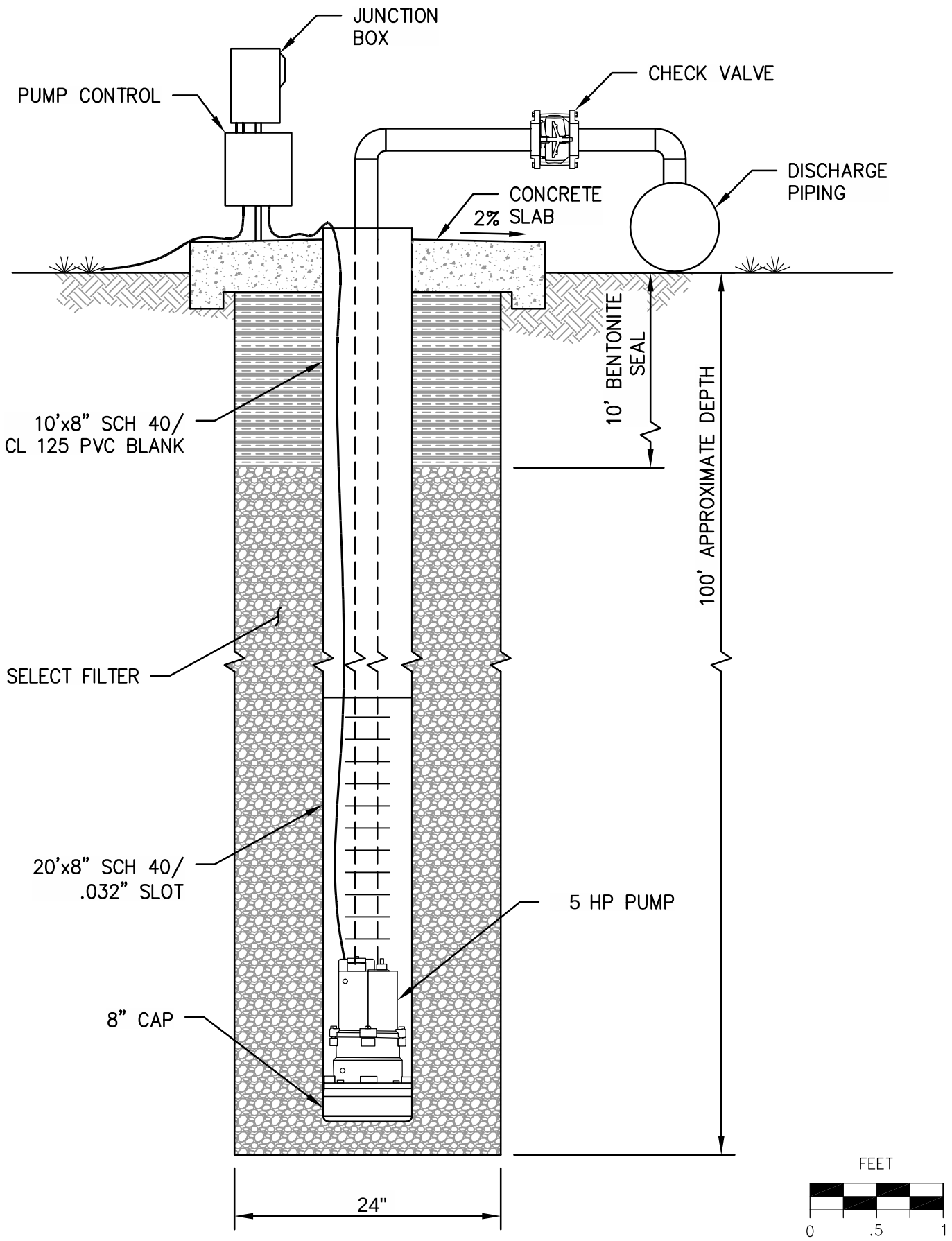
**Figures 6 and 7** show, respectively, the groundwater depth and groundwater elevation in the BSA in March 2012. These maps represent the main aquifer and not the northern perched aquifer. Groundwater depth varies from about 30 feet to 140 feet, generally increasing in a southerly direction. Groundwater elevations vary from about 230 feet to 130 feet, and also generally decrease in a southerly direction. This suggests that groundwater may flow from north to south within the district.

## Perched Aquifer

The northern portion of the BSA (generally north of 7th Standard Road) includes fine grained soils near the surface resulting in a shallow perched aquifer. During the spring, the perched groundwater levels range from approximately two to twelve feet below ground surface. Approximately 12,000 to 15,000 acres are affected. Water quality in the perched aquifer is poor with TDS of 2,000 ppm or higher; this limits the types of crops that are grown in this area.

The perched aquifer is monitored with an extensive network of shallow piezometers. **Figure 8** is a map of the monitoring network. Depth contours for the shallow perched groundwater are shown in **Figure 9**. A water quality map with Total Dissolved Contours (TDS) is shown in **Figure 10**.

# Figures

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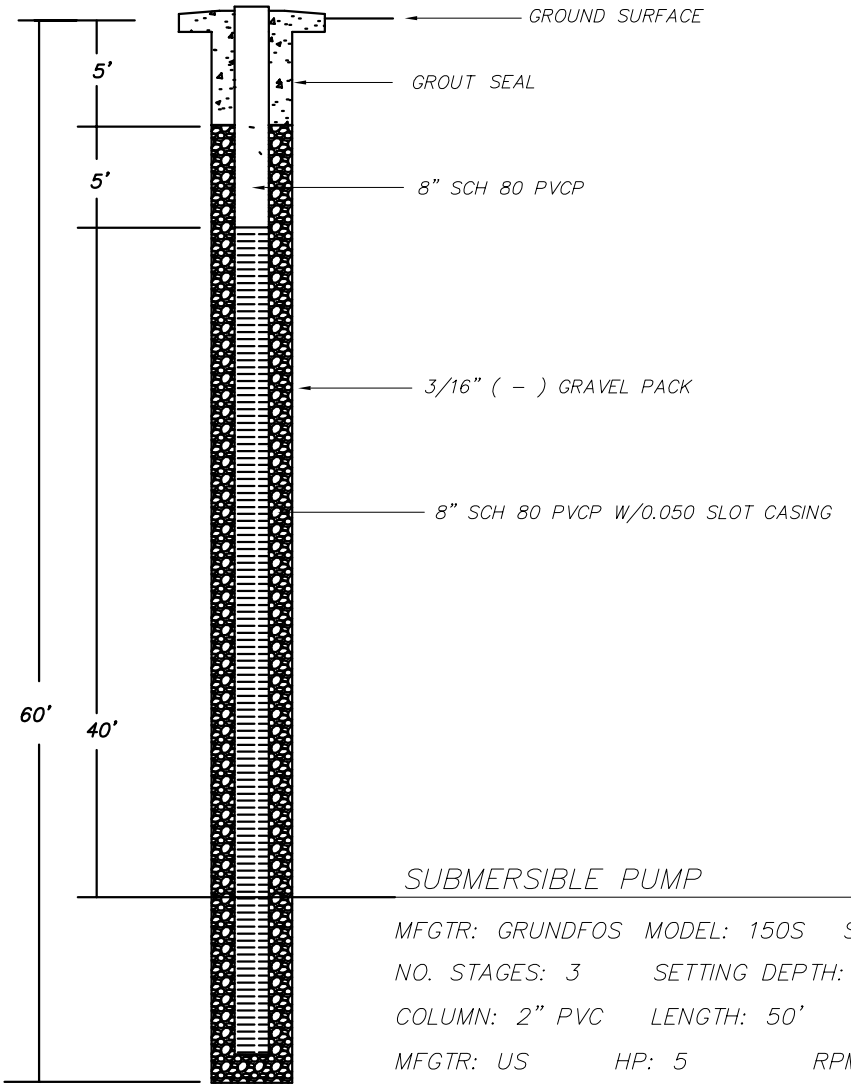
PROPOSED BRACKISH GROUNDWATER REMEDIATION PROGRAM WELL

FIGURE 1

Figure x1

# 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

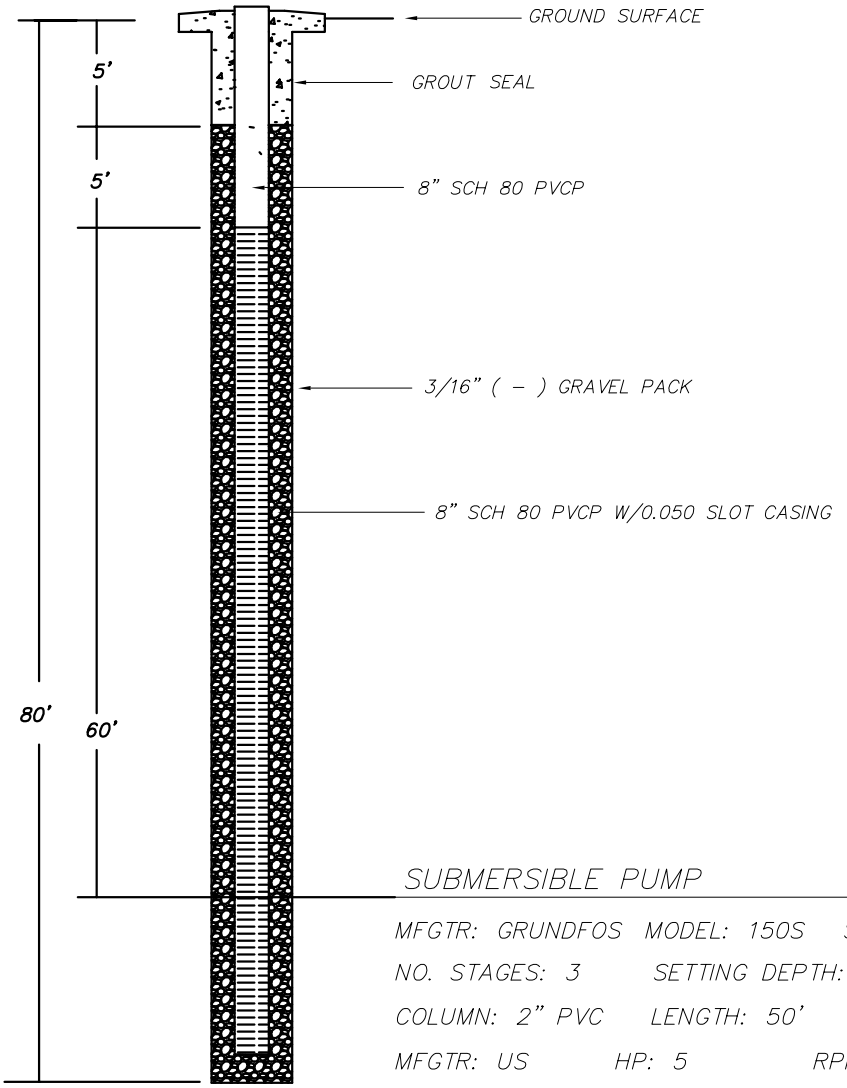
1300' WEST OF MAIN DRAIN RD AND PERRAL RD INTERSECTION
500' SOUTH OF PERRAL RD

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

Figure x2

# 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 |

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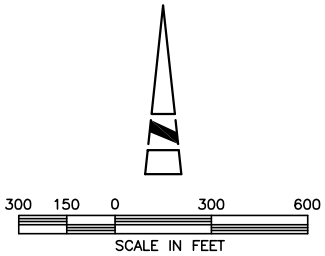


LEGEND

PEIZOMETER

BRACKISH WATER WELL

BUENA VISTA WATER STORAGE DISTRICT

Figure x3

**WELL LOCATION MAP**

BOYLE ENGINEERING CORPORATION

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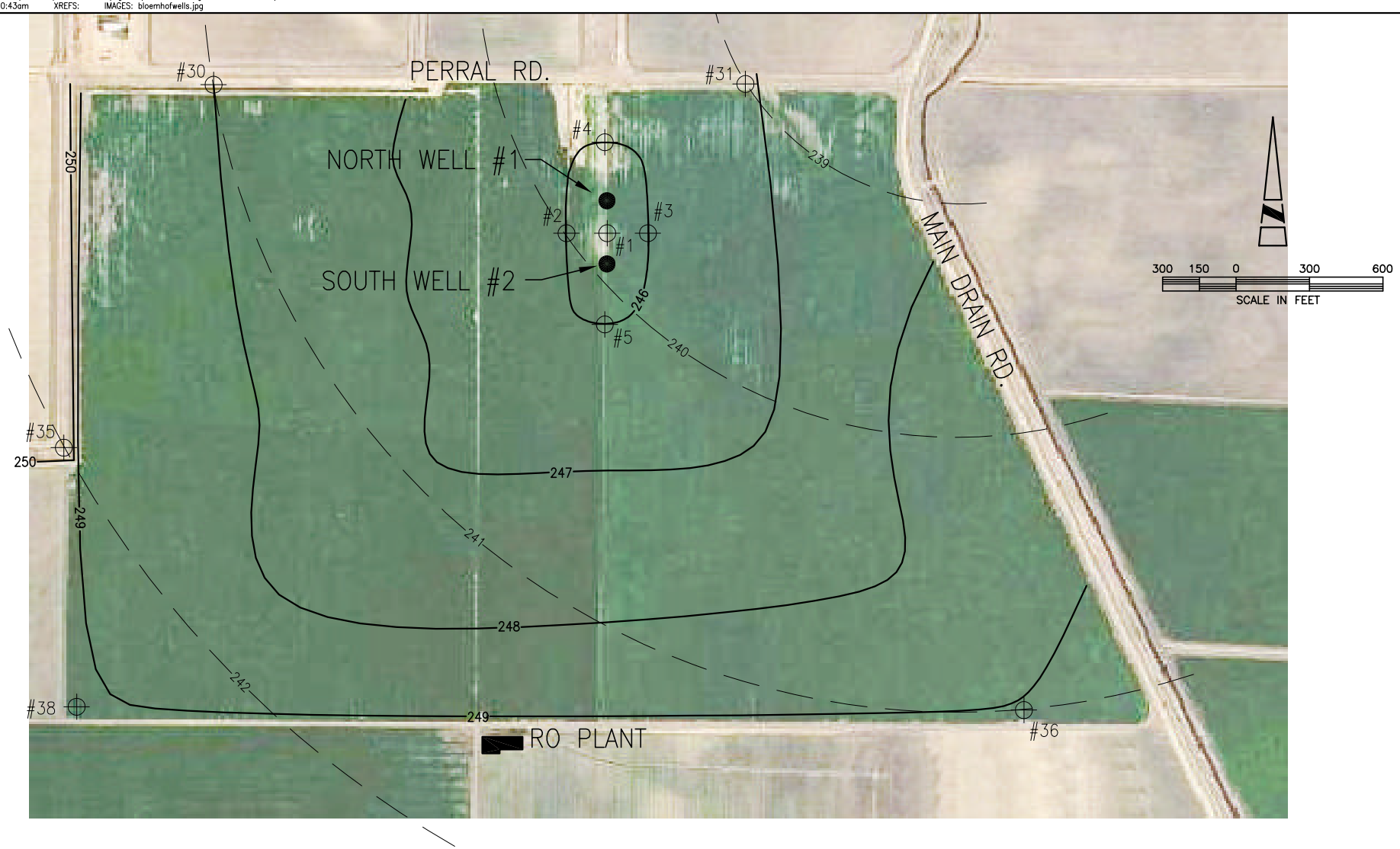


LEGEND

- 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

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LEGEND

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

BUENA VISTA WATER STORAGE DISTRICT

FIGURE G-2

**DEPTH TO GROUNDWATER**
**12-17-01**

BOYLE ENGINEERING CORPORATION

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LEGEND

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

BUENA VISTA WATER STORAGE DISTRICT

FIGURE G-3

DEPTH TO GROUNDWATER
9-23-02

BOYLE ENGINEERING CORPORATION

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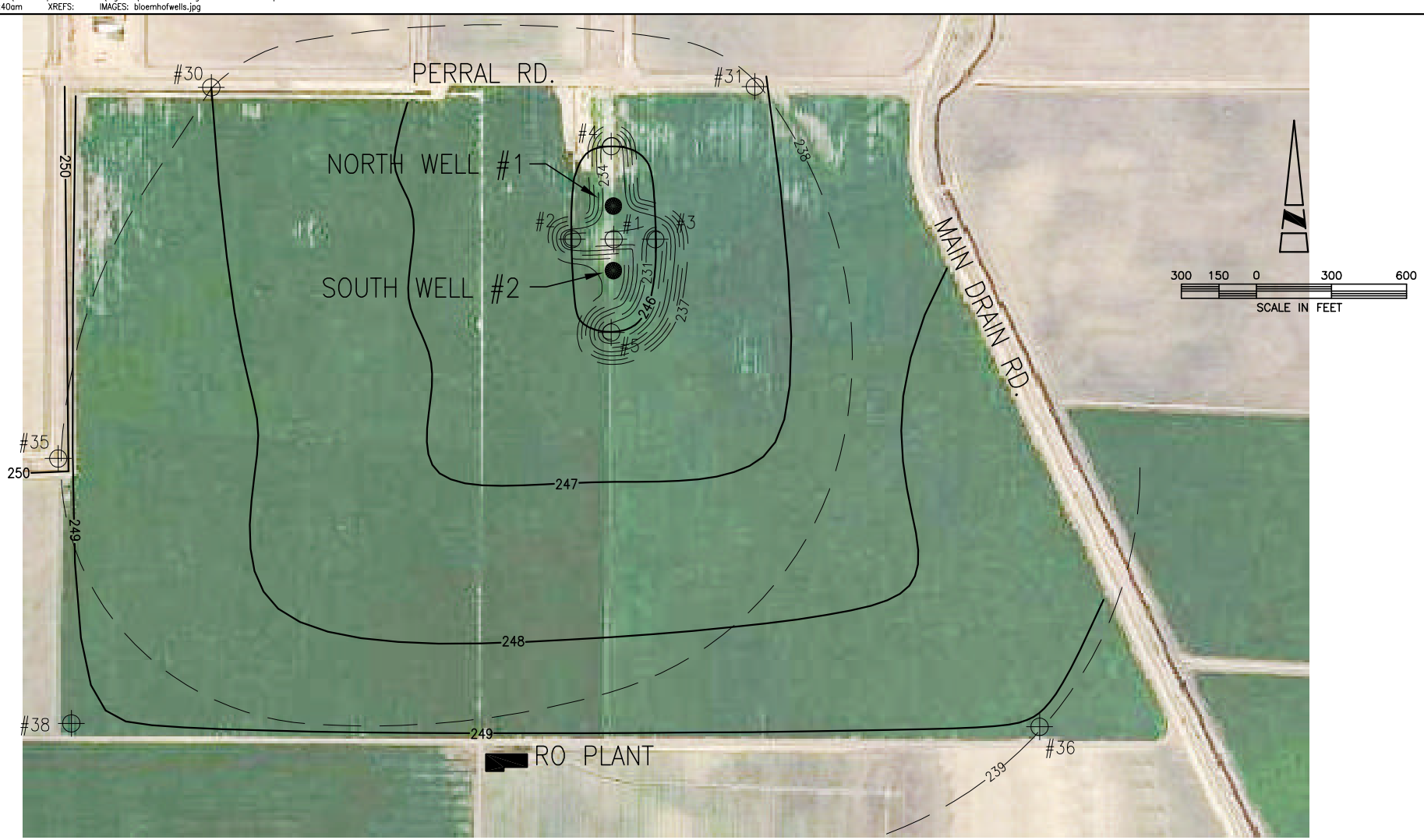



LEGEND

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

BUENA VISTA WATER STORAGE DISTRICT

FIGURE G-4

**DEPTH TO GROUNDWATER**
**12-9-02**

BOYLE ENGINEERING CORPORATION

# Location of Buena Vista Water Storage District

Figure 2

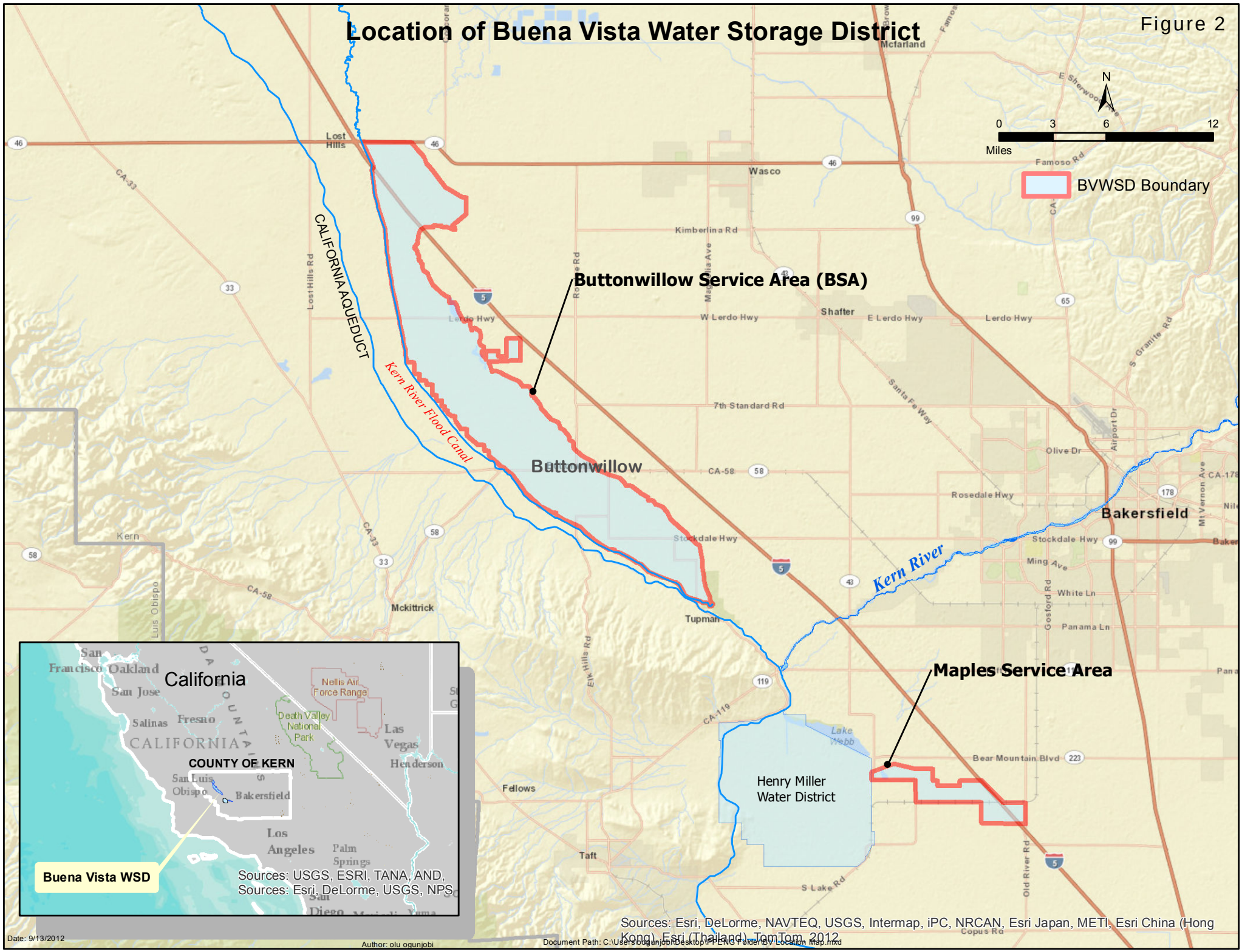
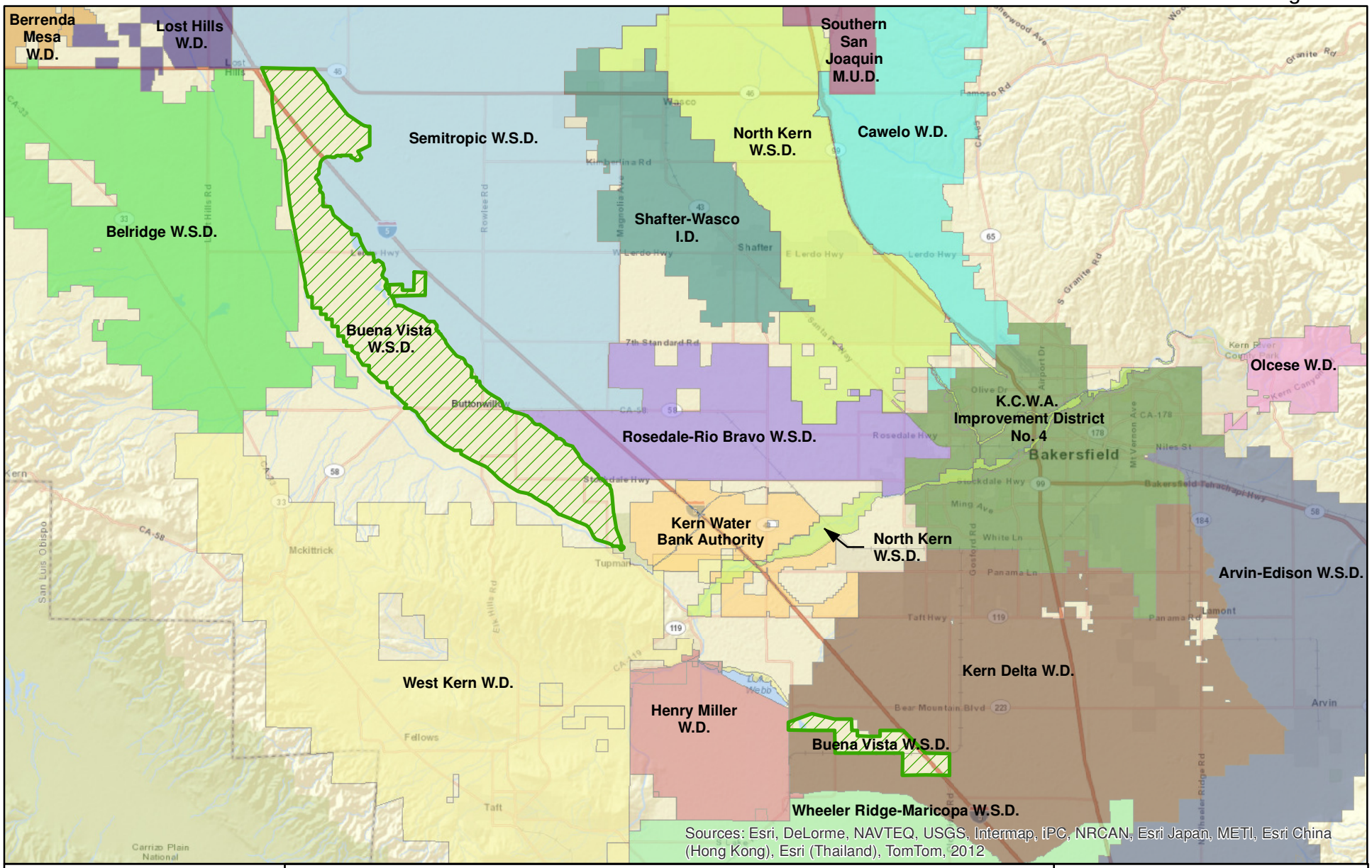


Figure 3




0 3 6 Miles

Buena Vista Water Storage District Boundary

**Buena Vista Water Storage District**

Neighboring Water Agencies

EST. 1988
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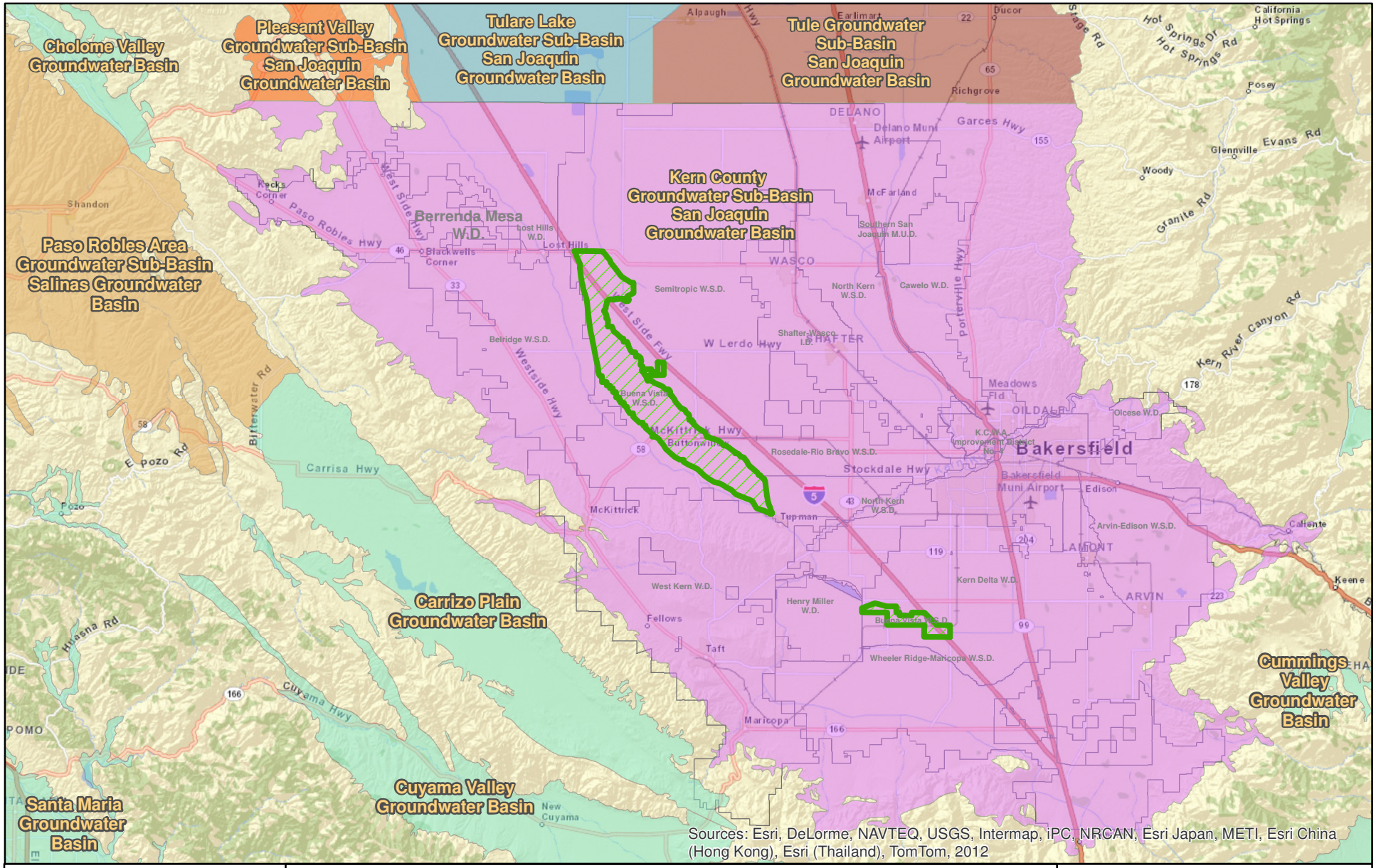
CONSULTING GROUP
An Employee Owned Company
286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

7/3/2014 : W:\Clients\Buena Vista WSD-1048\104812C1-GWMP Update\GIS\Map\BVWSD Agencies Map-Revised 2013-0701.mxd

Figure 4




0 5 10 Miles

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286 W. Cromwell Ave.
Fresno, CA 93711-6162
(559) 449-2700

BVWSD Boundary

**Buena Vista Water Storage District**

DWR Bulletin 118 Groundwater Basins and Sub-Basins

10/29/2012 : W:\Clients\Buena Vista WSD-1048\104812C1-GWMP Update\GIS\Map\GW Basin Map-2012.mxd

Figure 5

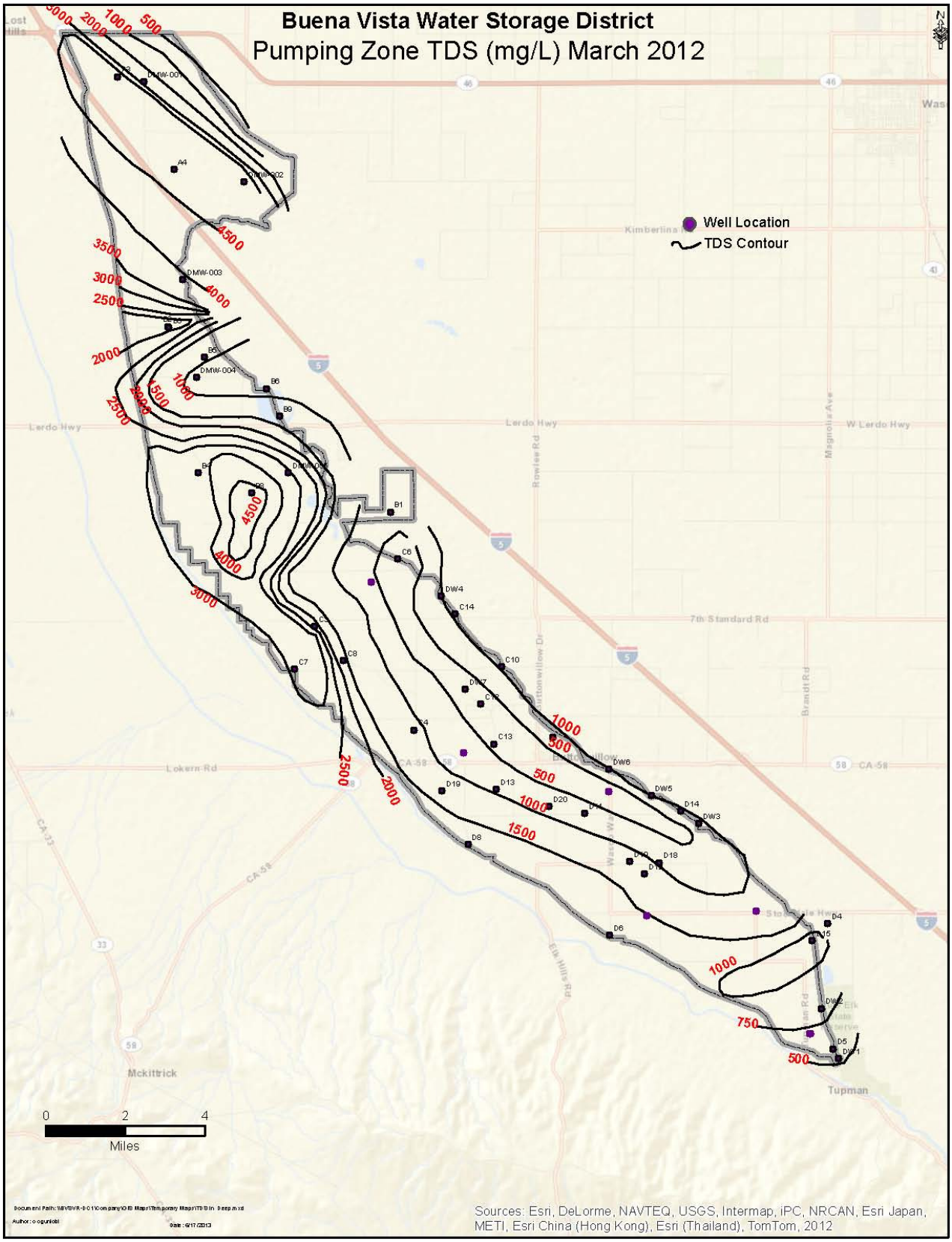

Buena Vista Water Storage District
Pumping Zone TDS (mg/L) March 2012
Well Location
TDS Contour
0 2 4
Miles
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2012

Figure 6

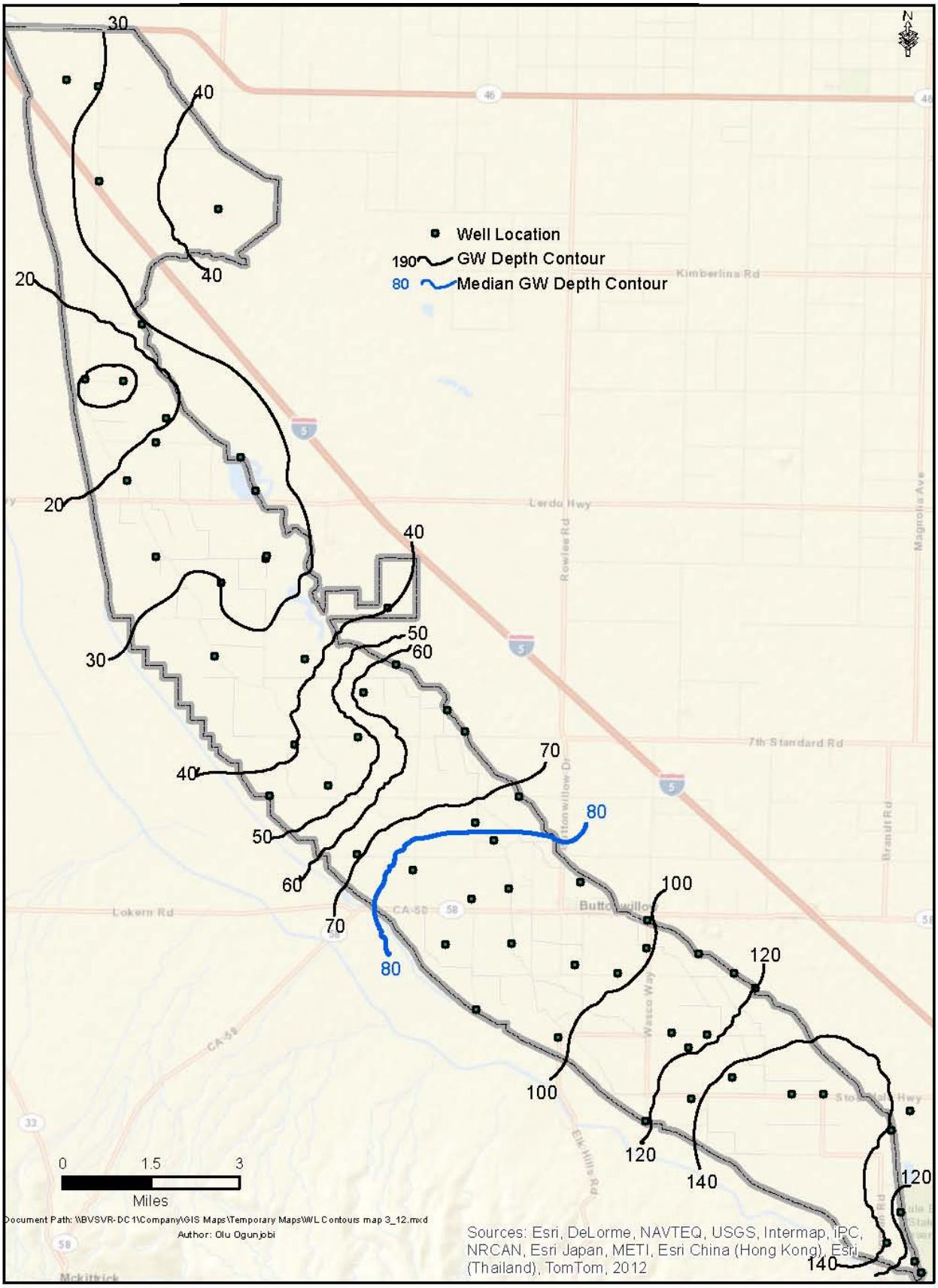
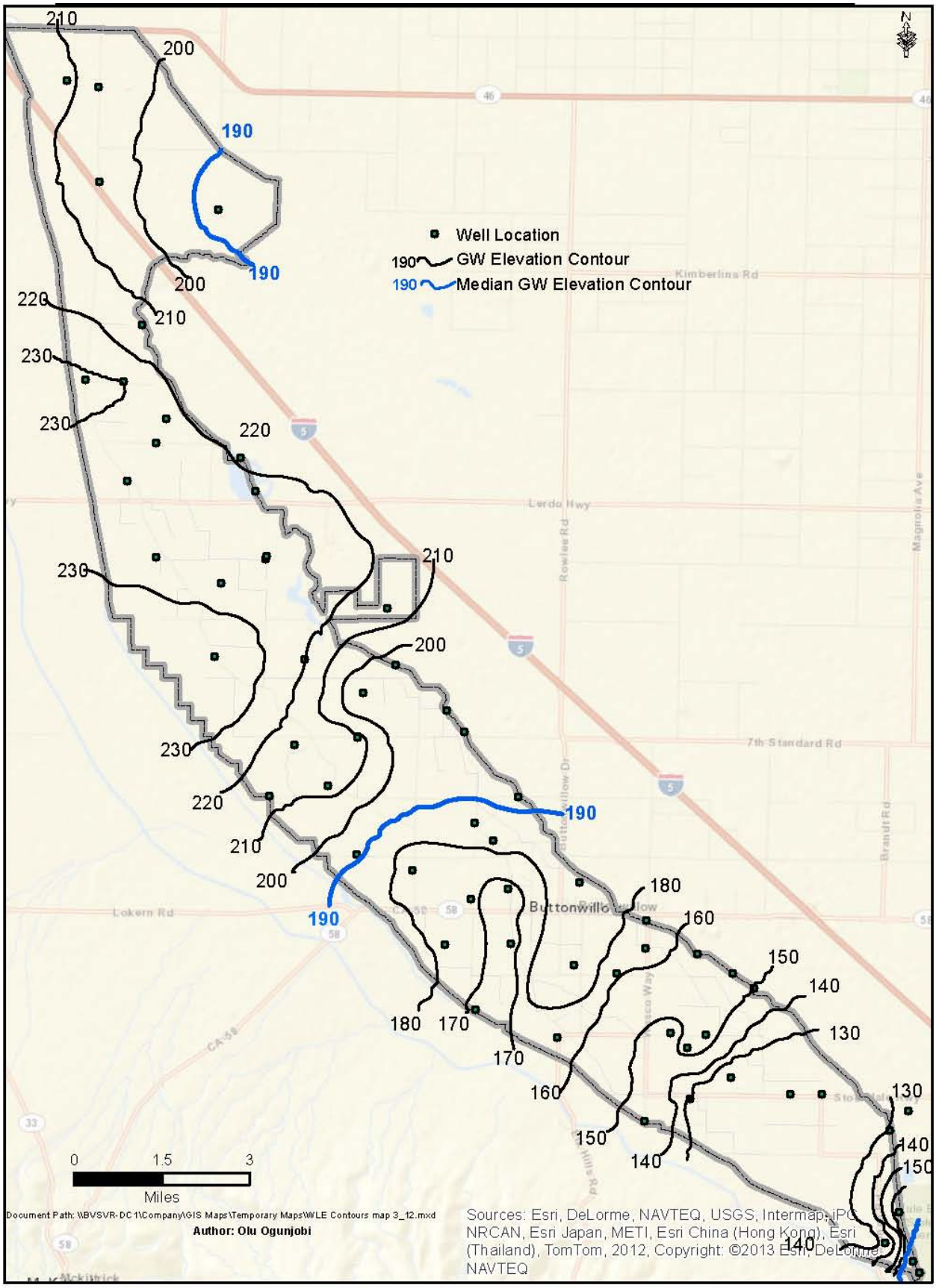

Well Location
190 GW Depth Contour
80 Median GW Depth Contour
30
40
20
50
60
70
80
100
120
140
Kimberlina Rd
Lerdo Hwy
Rowlee Rd
Magnolia Ave
7th Standard Rd
Brandt Rd
Lokern Rd
CA-58
Wasco Way
Elk Hills Rd
Mckittrick
0 1.5 3
Miles
Document Path: \\BVSVR-DC1\Company\GIS Maps\Temporary Maps\WL Contours map 3_12.mxd
Author: Olu Ogunjobi
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2012

Figure 7


Well Location
190 GW Elevation Contour
190 Median GW Elevation Contour
210
200
190
220
230
180
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160
150
140
130
Kimberlina Rd
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Magnolia Ave
7th Standard Rd
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Buttonwillow
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Author: Olu Ogunjobi
Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC
NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri
(Thailand), TomTom, 2012, Copyright: ©2013 Esri, DeLorme,
NAVTEQ

# Shallow Groundwater Piezometers

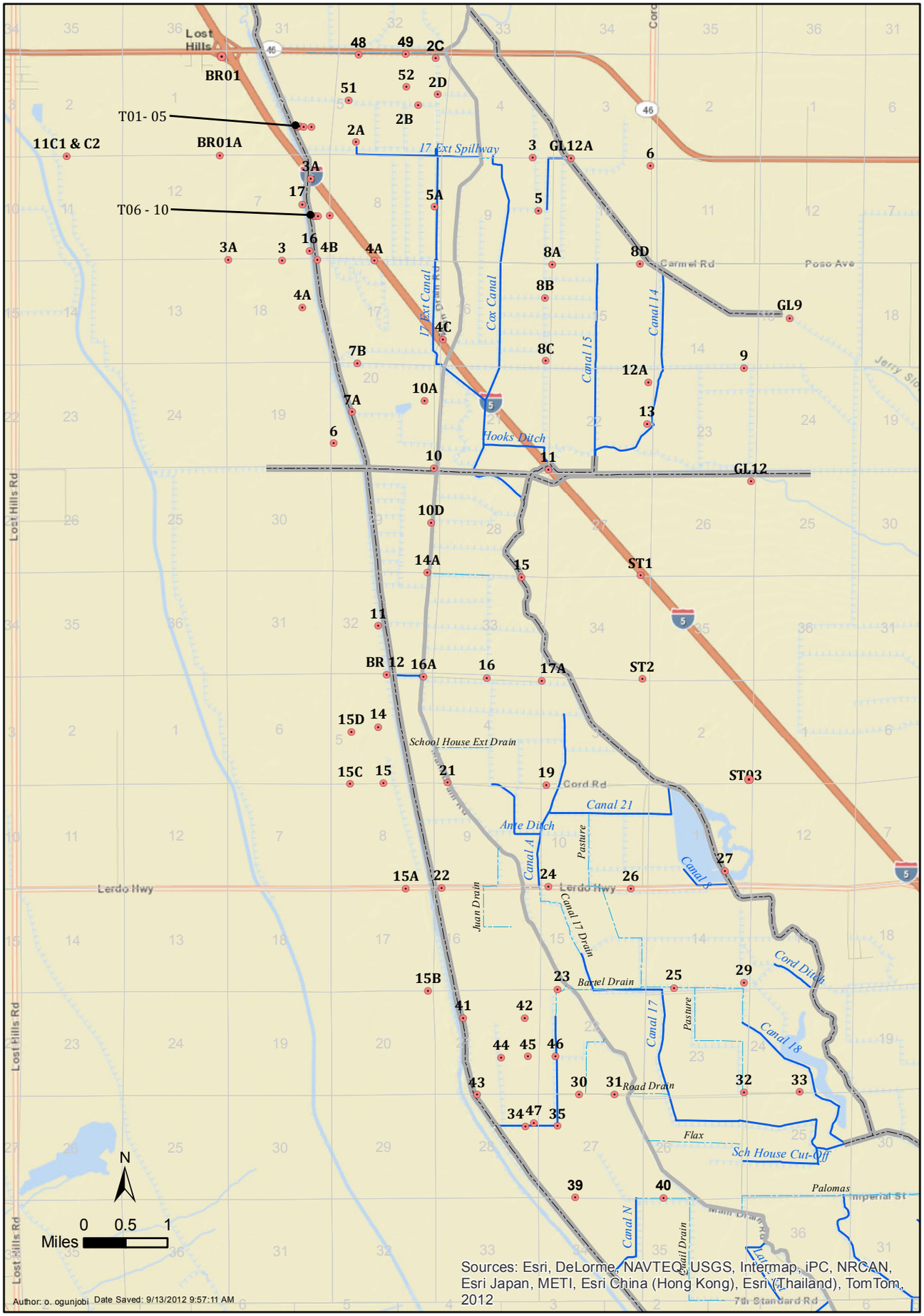



Figure 8

# Buena Vista Water Storage District

## Depth to Perched Groundwater (ft) March 2013

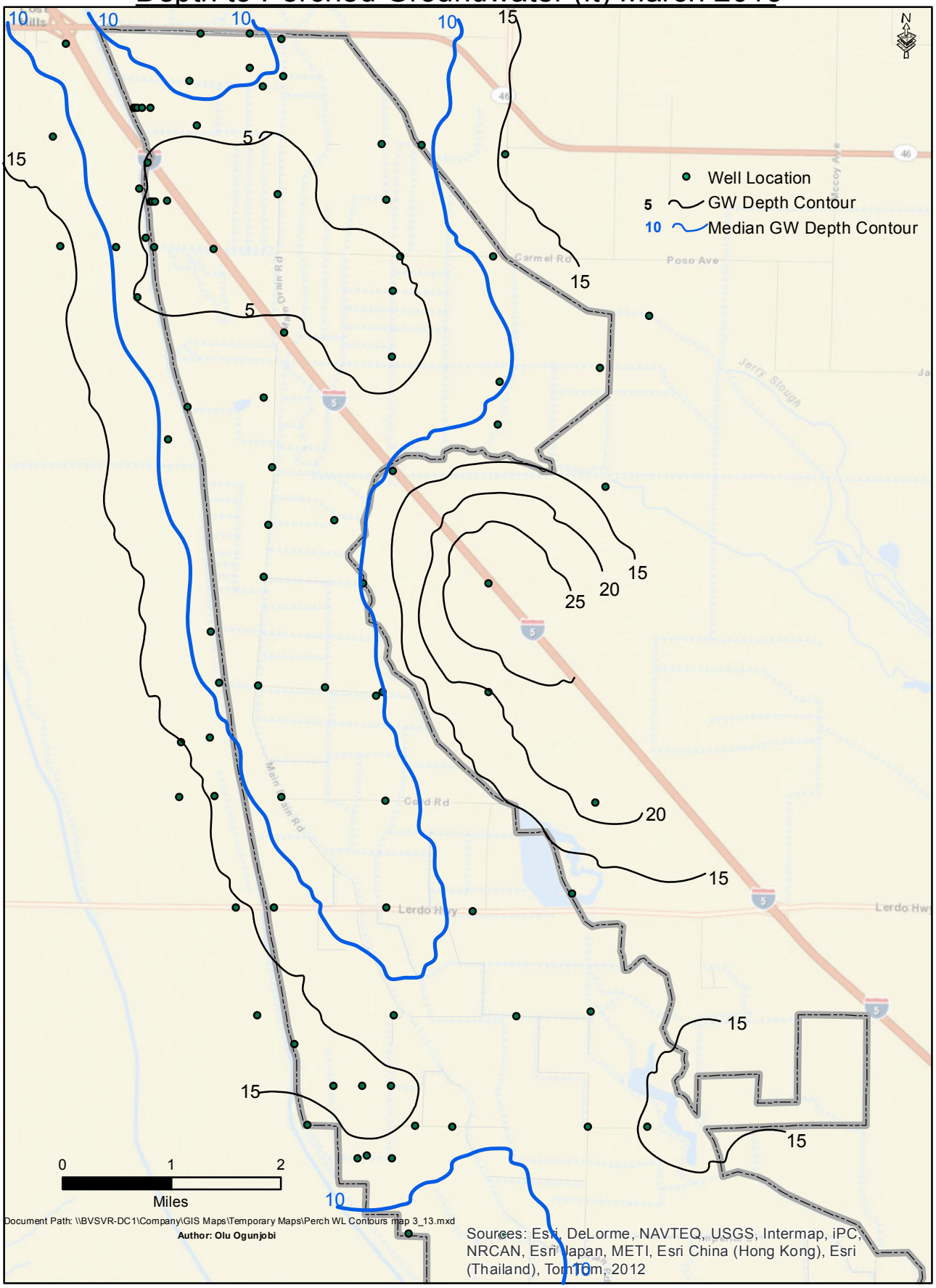



Figure 9

# Buena Vista Water Storage District

## Shallow Groundwater TDS (mg/L) March 2012

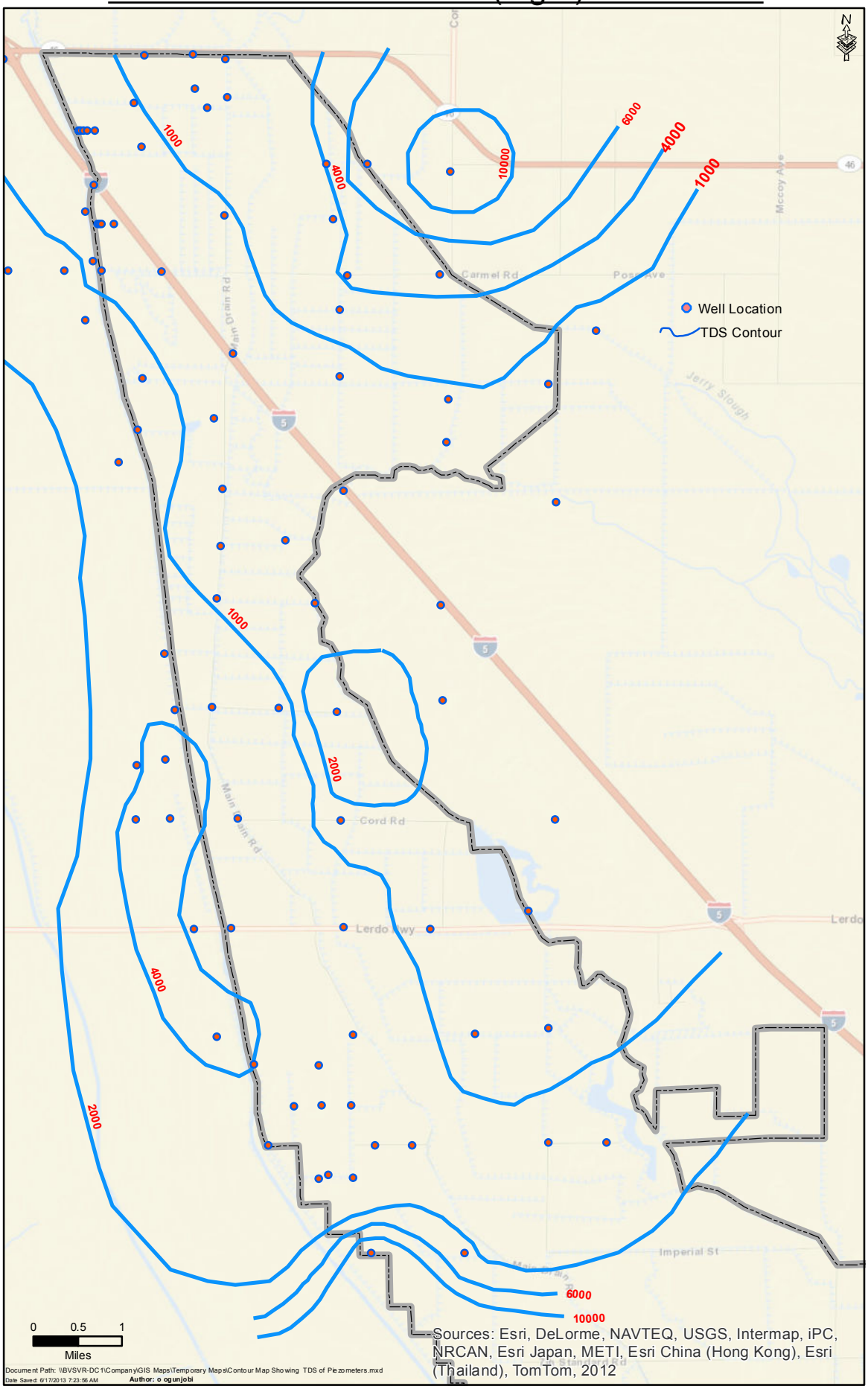



Figure 10

# Tables

Table 1

# BUENA VISTA WSD WATER BALANCE

| YEAR | [1] KR A-J RUNOFF % OF AVG | [2] WATER SUPPLY KR SUPPLY (AF) | [3] FK SUPPLY (AF) | [4] SWP SUPPLY (AF) | [5] SWP - A21 SUPPLY (AF) | [6] OTHER SUPPLY (AF) | [8] SAFE YIELD MINOR STREAMS (AF) | [9] SAFE YIELD PRECIP (AF) | [10] TOTAL WATER SUPPLY (AF) | [11] WATER DEMANDS CROP USE (AF) | [12] INDUSTRIAL USE (AF) | [14] PROJECT USE (AF) | [15] EVAP LOSS (AF) | [16] GOOSE LAKE OUTFLOW (AF) | [17] MOU LOSS (AF) | [18] WATER USE (AF) | [19] ANNUAL BALANCE (AF) | [20] ACCUM BALANCE (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 69 | 120,361 | 7,310 | 10,284 | - | | 0 | 17,647 | 155,602 | 105,076 | | | 2,332 | 9,086 | | 116,494 | 39,108 | 39,108 |
| 1971 | 53 | 81,466 | 7,787 | 14,638 | - | | 0 | 18,860 | 122,751 | 105,076 | | | 2,177 | 4,897 | | 112,150 | 10,601 | 49,709 |
| 1972 | 28 | 32,853 | 0 | 35,206 | 2,700 | | 0 | 9,879 | 80,638 | 99,391 | | | 2,288 | 740 | | 102,419 | (21,781) | 27,927 |
| 1973 | 156 | 149,082 | 746 | 5,548 | - | | 0 | 24,884 | 180,260 | 111,640 | | | 2,128 | 12,137 | | 125,905 | 54,355 | 82,282 |
| 1974 | 115 | 160,269 | 14,771 | 20,875 | - | | 0 | 25,217 | 221,132 | 115,768 | | | 2,122 | 6,121 | | 124,011 | 97,121 | 179,403 |
| 1975 | 83 | 138,779 | 0 | 32,464 | - | | 0 | 15,850 | 187,093 | 121,174 | | | 2,153 | 7,384 | | 130,711 | 56,382 | 235,784 |
| 1976 | 23 | 40,747 | 0 | 25,137 | - | | 0 | 18,086 | 83,970 | 115,063 | | | 2,138 | 4,463 | | 121,664 | (37,694) | 198,090 |
| 1977 | 21 | 5,310 | 0 | 4,912 | - | | 0 | 19,061 | 29,283 | 111,616 | | | 2,068 | 420 | | 114,104 | (84,821) | 113,270 |
| 1978 | 236 | 238,040 | 0 | 969 | - | | 0 | 36,914 | 275,923 | 120,059 | | 0 | 2,017 | 13,877 | | 135,953 | 139,970 | 253,240 |
| 1979 | 90 | 132,920 | 9,913 | 30,009 | 24,391 | | 0 | 22,018 | 219,251 | 111,286 | | | 1,935 | 12,807 | 0 | 126,028 | 93,223 | 346,463 |
| 1980 | 213 | 271,540 | 0 | 856 | - | | 0 | 20,889 | 293,285 | 112,780 | | 0 | 1,880 | 18,295 | 0 | 132,955 | 160,330 | 506,793 |
| 1981 | 54 | 64,454 | 0 | 62,000 | 11,692 | | 0 | 21,506 | 159,652 | 112,536 | 0 | 0 | 2,157 | 12,351 | 0 | 127,044 | 32,608 | 539,401 |
| 1982 | 172 | 182,654 | 34,882 | 14,200 | 15,976 | | 0 | 25,581 | 273,293 | 112,883 | 703 | 0 | 1,852 | 15,904 | | 131,342 | 141,951 | 681,351 |
| 1983 | 333 | 270,855 | 26,084 | 1,579 | - | | 0 | 32,075 | 330,593 | 97,927 | 1,103 | 20,888 | 1,955 | 13,264 | | 135,137 | 195,456 | 876,808 |
| 1984 | 91 | 154,914 | 2,289 | 55,937 | - | | 0 | 11,821 | 224,961 | 109,366 | 1,148 | 0 | 2,252 | 16,478 | | 129,244 | 95,717 | 972,524 |
| 1985 | 91 | 132,534 | 0 | 23,138 | 205 | | 0 | 13,122 | 168,999 | 106,262 | 1,363 | 0 | 1,965 | 16,123 | | 125,713 | 43,286 | 1,015,810 |
| 1986 | 191 | 230,925 | 10,276 | 1,438 | - | | 0 | 18,601 | 261,240 | 103,154 | 960 | 2,041 | 2,043 | 24,589 | | 132,787 | 128,453 | 1,144,264 |
| 1987 | 46 | 78,835 | 0 | 21,896 | - | | 0 | 19,433 | 120,164 | 99,168 | 927 | 6,000 | 1,937 | 14,916 | | 122,948 | (2,784) | 1,141,479 |
| 1988 | 35 | 50,470 | 0 | 25,328 | - | | 0 | 14,655 | 90,453 | 103,320 | 690 | 5,000 | 2,103 | 16,309 | | 127,422 | (36,969) | 1,104,511 |
| 1989 | 51 | 59,021 | 0 | 26,893 | - | | 0 | 9,446 | 95,360 | 100,317 | 643 | 3,138 | 2,037 | 5,080 | | 111,215 | (15,855) | 1,088,655 |
| 1990 | 25 | 21,124 | 0 | 4,885 | - | | 0 | 11,723 | 37,732 | 105,159 | 555 | 2,242 | 2,039 | 4,165 | | 114,160 | (76,428) | 1,012,227 |
| 1991 | 60 | 56,983 | 0 | 1,288 | - | 0 | 0 | 21,617 | 79,888 | 105,075 | 663 | 4,410 | 2,055 | 4,558 | | 116,761 | (36,873) | 975,354 |
| 1992 | 39 | 42,594 | 0 | 1,824 | - | 0 | 0 | 27,647 | 72,065 | 110,298 | 549 | 4,004 | 2,082 | 3,927 | | 120,860 | (48,796) | 926,558 |
| 1993 | 126 | 90,385 | 9,832 | 57,230 | - | | 0 | 26,198 | 183,645 | 113,622 | 529 | 0 | 1,968 | 8,641 | | 124,760 | 58,885 | 985,443 |
| 1994 | 41 | 73,712 | 0 | 11,267 | 5,403 | 0 | 0 | 22,341 | 112,723 | 103,758 | 536 | 0 | 2,167 | 8,404 | | 114,865 | (2,142) | 983,302 |
| 1995 | 200 | 293,072 | 12,451 | 21,300 | - | 0 | 0 | 33,072 | 359,895 | 112,902 | 649 | 2,000 | 1,895 | 28,394 | 3,997 | 149,837 | 210,059 | 1,193,360 |
| 1996 | 129 | 222,028 | 15,938 | 29,900 | - | 0 | 0 | 27,299 | 295,165 | 113,409 | 1,241 | 7,467 | 2,114 | 23,555 | 1,474 | 149,260 | 145,905 | 1,339,265 |
| 1997 | 123 | 221,942 | 19,456 | 21,300 | - | 0 | 0 | 20,172 | 282,870 | 106,883 | 1,406 | 7,080 | 1,974 | 28,118 | 2,813 | 148,274 | 134,596 | 1,473,861 |
| 1998 | 245 | 307,672 | 22,339 | 21,300 | - | 0 | 0 | 46,520 | 397,831 | 113,188 | 1,384 | 1,309 | 1,901 | 31,760 | 5,503 | 155,045 | 242,786 | 1,716,647 |
| 1999 | 54 | 55,237 | 13,701 | 46,300 | 1,107 | 0 | 0 | 20,472 | 136,817 | 106,919 | 1,232 | 0 | 1,796 | 23,067 | 13 | 133,027 | 3,790 | 1,720,437 |
| 2000 | 66 | 61,535 | 0 | 27,837 | 2,703 | 0 | 0 | 18,251 | 110,326 | 102,937 | 1,500 | 8,613 | 1,803 | 23,083 | 0 | 137,936 | (27,610) | 1,692,827 |
| 2001 | 54 | 44,697 | 0 | 8,786 | 480 | 1,693 | 0 | 23,722 | 79,378 | 99,924 | 571 | 29,915 | 1,908 | 7,060 | 1,020 | 140,398 | (61,020) | 1,631,807 |
| 2002 | 46 | 58,203 | 0 | 13,451 | 1,511 | | 0 | 12,715 | 85,880 | 93,321 | 1,264 | 33,073 | 1,302 | 5,035 | 771 | 134,766 | (48,886) | 1,582,921 |
| 2003 | 70 | 88,191 | 0 | 22,284 | 655 | | 0 | 16,109 | 127,239 | 97,971 | 1,372 | 42,187 | 1,343 | 9,913 | 825 | 153,611 | (26,373) | 1,556,548 |
| 2004 | 48 | 78,550 | 0 | 10,987 | 3,341 | | 0 | 17,497 | 110,375 | 102,224 | 1,328 | 28,005 | 1,415 | 9,098 | 310 | 142,380 | (32,005) | 1,524,544 |
| 2005 | 168 | 222,670 | 1,811 | 22,341 | 36,398 | | 0 | 21,432 | 304,652 | 99,375 | 1,303 | 14,458 | 2,452 | 7,864 | 9,783 | 135,235 | 169,417 | 1,693,960 |
| 2006 | 169 | 177,597 | 20,714 | 18,848 | 32,792 | | 0 | 20,262 | 270,213 | 102,145 | 1,569 | 1,966 | 2,343 | 12,591 | 6,314 | 126,928 | 143,285 | 1,837,245 |
| 2007 | 26 | 67,254 | 36,999 | 13,840 | 12,467 | | 0 | 9,429 | 139,989 | 98,519 | 2,209 | 68,779 | 1,460 | 7,867 | 3,676 | 182,510 | (42,521) | 1,794,724 |
| 2008 | 71 | 92,878 | 239 | 10,291 | - | | 0 | 9,786 | 113,194 | 91,705 | 1,864 | 42,537 | 1,586 | 4,093 | 413 | 142,198 | (29,004) | 1,765,721 |
| 2009 | 64 | 80,664 | 6,137 | 13,880 | - | | 0 | 15,375 | 116,056 | 93,951 | 1,422 | 25,313 | 1,366 | 2,627 | 413 | 125,092 | (9,035) | 1,756,686 |
| 1970-09 | 99.4 | 123,825 | 6,842 | 19,811 | 3,796 | | 0 | 20,430 | 174,746 | 106,179 | | | 1,963 | 11,977 | | 130,829 | 43,917 | |

NOTES:

[1] April-July Runoff of the Kern River in % of average (1894-2005 = 464,430 AF)
[2] BV KR Supply (Surface deliveries to KR Intertie and surface sales to other in county jurisdictions downstream of 2nd Point taken out)
[3] FK supplies (NO BANKING FOR 3RD PARTY)
[4] SWP + pool purchases (NO BANKING FOR 3RD PARTY)
[5] Art 21 purchases
[6] Other purchased supplies

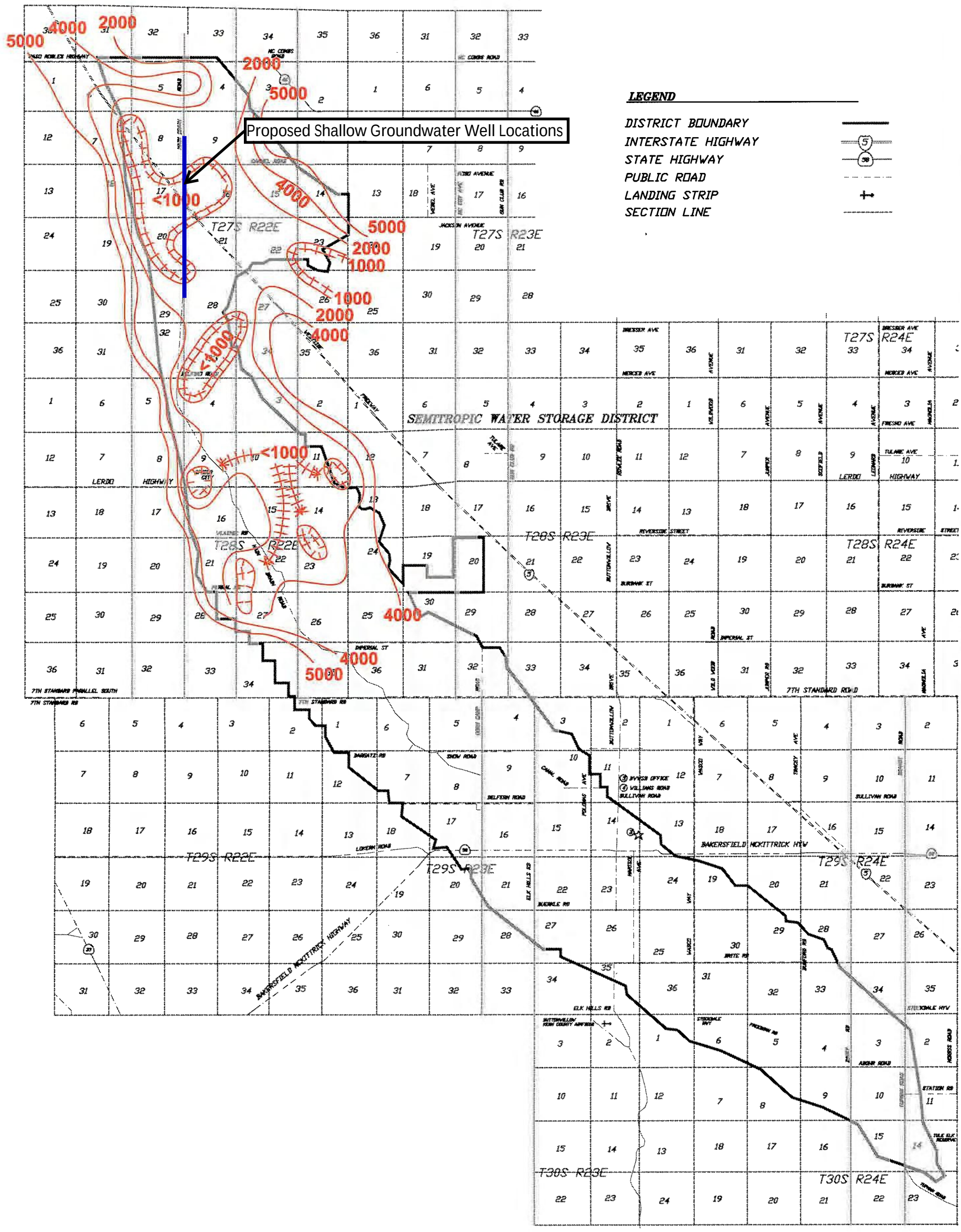
[8] Proportionate share of unappropriated minor local streams (#'s in discussion so left out for now)
[9] Gross Precip estimated at Meadows Field x cropped acreage + effective precip on other surfaces.
[10] = Sum of [2] through [9].

[11] Estimated crop water use (transpiration and soil evap) per CSPU.
[12] Industrial recovery contracts from BVWSD to westside oilfields

[14] Special project deliveries and Kern Fan pumping
[15] Water surface evaporation losses.
[16] Flows north of Hwy 46 (not including wheeling but including sales)
[17] MOU agreed to project losses start in 1995
[18] Sum of [11] through [17].

# Appendix 3.4-B

# BVWSD 2008 Shallow Perched Groundwater TDS




Buttonwillow Service Area

**NOTE:**

MAP PROVIDED BY BUENA VISTA WATER STORAGE DISTRICT.

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

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# BUENA VISTA WATER STORAGE DISTRICT

BUENA VISTA WATER MANAGEMENT PROGRAM

## SHALLOW PERCHED GROUNDWATER TOTAL DISSOLVED SOLIDS (MG/L), 2008

SCALE: 1"=10,000' DATE: 09/25/09 DRAWN BY: JGS CHECKED BY: VEM W.O.: 578-8.2

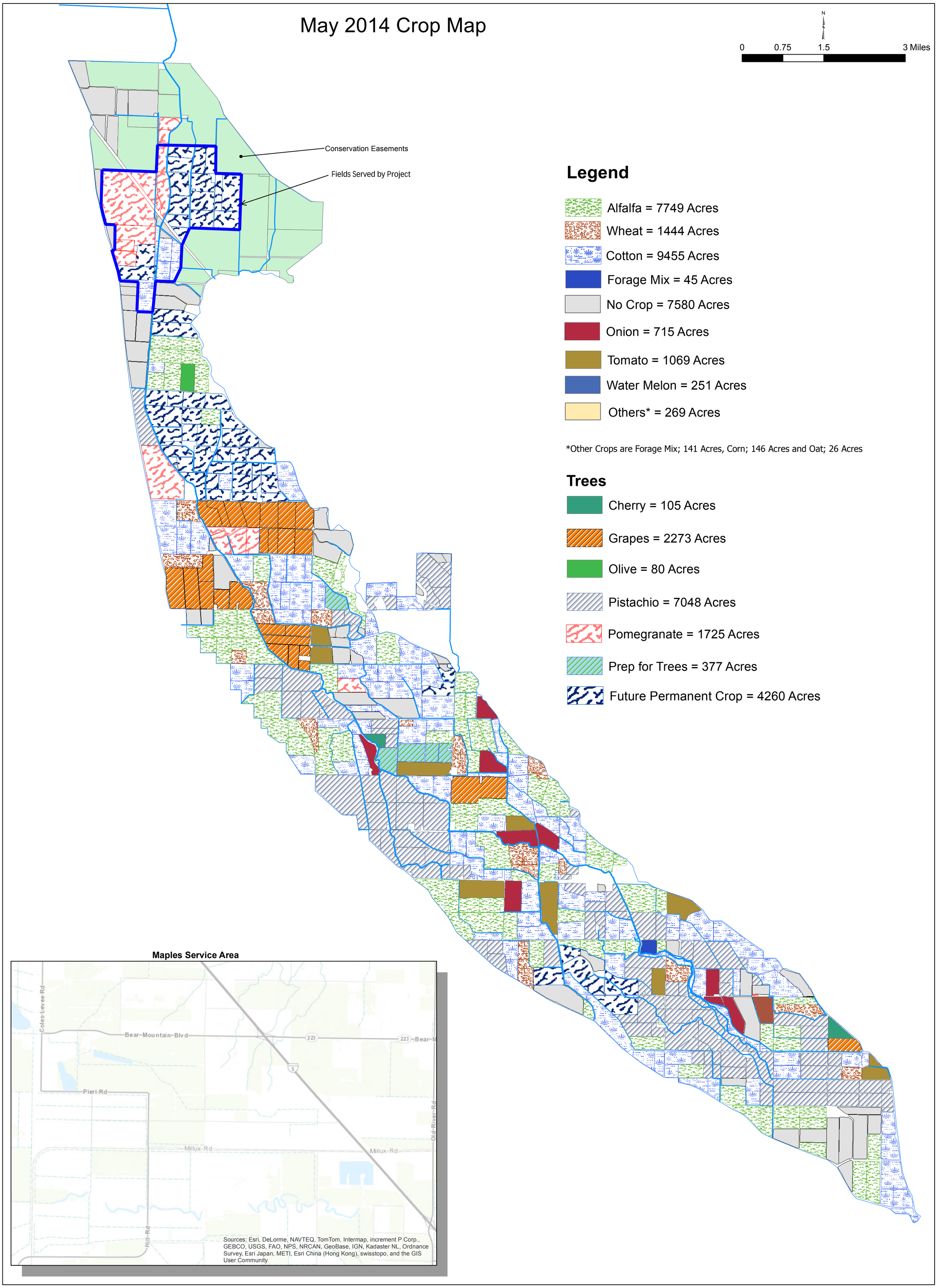
FIGURE 7 OF 10

578-8F7.DWG

# Appendix 3.4-C

# BVWSD May 2014 Crop Map

# May 2014 Crop Map




Author: Olu Ogunjobi

Document Path: \\shotgun\bkf_clients\Clients\Buena Vista WSD-1048\104814B1 DSIG App\GIS\Map\Crop Map May 2014.mxd

# Appendix 3.4-D

## BVWSD Project Crop ETc Effective Rainfall and Demands for Brackish Groundwater Service Area

## APPENDIX 3.4-D: BVWSD Project - CROP ETc, EFFECTIVE RAINFALL, AND DEMANDS FOR BRACKISH GROUNDWATER SERVICE AREA

**Crop Acreages:**

| | | |
|---|---|---|
| Pistachios = | 1,282 | ac |
| Pomegranates = | 985 | ac |
| Cotton = | 308 | ac |

**Table A - Pistachio ETc [1/]**

| Month | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9+ |
|---|---|---|---|---|---|---|---|---|---|
| **Jan** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Feb** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Mar** | 0.02 | 0.04 | 0.05 | 0.07 | 0.09 | 0.12 | 0.14 | 0.16 | 0.18 |
| **Apr** | 0.19 | 0.39 | 0.58 | 0.78 | 1.01 | 1.26 | 1.51 | 1.75 | 1.94 |
| **May** | 0.55 | 1.09 | 1.64 | 2.18 | 2.84 | 3.55 | 4.26 | 4.92 | 5.46 |
| **Jun** | 1.09 | 2.19 | 3.28 | 4.37 | 5.68 | 7.10 | 8.53 | 9.84 | 10.93 |
| **Jul** | 0.90 | 1.80 | 2.70 | 3.60 | 4.68 | 5.85 | 7.02 | 8.10 | 9.00 |
| **Aug** | 0.80 | 1.61 | 2.41 | 3.22 | 4.18 | 5.23 | 6.27 | 7.24 | 8.04 |
| **Sep** | 0.68 | 1.37 | 2.05 | 2.73 | 3.55 | 4.44 | 5.33 | 6.15 | 6.84 |
| **Oct** | 0.30 | 0.59 | 0.89 | 1.19 | 1.54 | 1.93 | 2.32 | 2.67 | 2.97 |
| **Nov** | 0.10 | 0.21 | 0.31 | 0.42 | 0.54 | 0.68 | 0.81 | 0.94 | 1.04 |
| **Dec** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ***Subtotal*** | 4.64 | 9.28 | 13.92 | 18.56 | 24.13 | 30.16 | 36.19 | 41.76 | 46.40 |

**Table B - Pomegranates and Cotton ETc, Effective Rainfall, and Required Irrigation [2/]**

| | Rainfall | Eff Rain | ETc (in) | | Required Irrig (in) | | Required Irrig (AF) | |
|---|---|---|---|---|---|---|---|---|
| Month | (in) | (in) | Deciduous | Cotton | Deciduous | Cotton | Deciduous | Cotton |
| Jan | 3.46 | 2.71 | 0.67 | 0.70 | 0.00 | 0.00 | 0 | 0 |
| Feb | 0.39 | 0.00 | 1.36 | 0.92 | 1.36 | 0.92 | 112 | 24 |
| Mar | 0.07 | 0.00 | 2.27 | 1.68 | 2.27 | 1.68 | 186 | 43 |
| Apr | 0.59 | 0.00 | 3.61 | 1.39 | 3.61 | 1.39 | 296 | 36 |
| May | 0.01 | 0.00 | 7.02 | 1.29 | 7.02 | 1.29 | 576 | 33 |
| Jun | 0.00 | 0.00 | 7.19 | 5.02 | 7.19 | 5.02 | 590 | 129 |
| Jul | 0.01 | 0.00 | 7.39 | 9.09 | 7.39 | 9.09 | 607 | 233 |
| Aug | 0.00 | 0.00 | 6.30 | 8.27 | 6.30 | 8.27 | 517 | 212 |
| Sep | 0.02 | 0.00 | 4.62 | 5.81 | 4.62 | 5.81 | 379 | 149 |
| Oct | 0.33 | 0.15 | 2.44 | 1.67 | 2.29 | 1.52 | 188 | 39 |
| Nov | 1.91 | 1.26 | 0.82 | 0.86 | 0.00 | 0.00 | 0 | 0 |
| Dec | 1.28 | 0.66 | 0.15 | 0.15 | 0.00 | 0.00 | 0 | 0 |
| ***Subtotal*** | ***8.07*** | ***4.78*** | ***43.84*** | ***36.85*** | ***42.05*** | ***34.99*** | ***3,452*** | ***898*** |

**Table C - Pistachio Effective Rainfall, and Required Irrigation**

| | Rainfall | Eff Rain | Required Irrigation (in) | | | | | | | | | Required Irrigation (AF) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | (in) | (in) | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9+ | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9+ |
| Jan | 3.46 | 2.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Feb | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mar | 0.07 | 0.00 | 0.02 | 0.04 | 0.05 | 0.07 | 0.09 | 0.12 | 0.14 | 0.16 | 0.18 | 2 | 4 | 6 | 8 | 10 | 12 | 15 | 17 | 19 |
| Apr | 0.59 | 0.00 | 0.19 | 0.39 | 0.58 | 0.78 | 1.01 | 1.26 | 1.51 | 1.75 | 1.94 | 21 | 41 | 62 | 83 | 108 | 135 | 162 | 187 | 207 |
| May | 0.01 | 0.00 | 0.55 | 1.09 | 1.64 | 2.18 | 2.84 | 3.55 | 4.26 | 4.92 | 5.46 | 58 | 117 | 175 | 233 | 303 | 379 | 455 | 525 | 583 |
| Jun | 0.00 | 0.00 | 1.09 | 2.19 | 3.28 | 4.37 | 5.68 | 7.10 | 8.53 | 9.84 | 10.93 | 117 | 234 | 350 | 467 | 607 | 759 | 911 | 1,051 | 1,168 |
| Jul | 0.01 | 0.00 | 0.90 | 1.80 | 2.70 | 3.60 | 4.68 | 5.85 | 7.02 | 8.10 | 9.00 | 96 | 192 | 289 | 385 | 500 | 625 | 750 | 866 | 962 |
| Aug | 0.00 | 0.00 | 0.80 | 1.61 | 2.41 | 3.22 | 4.18 | 5.23 | 6.27 | 7.24 | 8.04 | 86 | 172 | 258 | 344 | 447 | 558 | 670 | 773 | 859 |
| Sep | 0.02 | 0.00 | 0.68 | 1.37 | 2.05 | 2.73 | 3.55 | 4.44 | 5.33 | 6.15 | 6.84 | 73 | 146 | 219 | 292 | 380 | 475 | 570 | 657 | 730 |
| Oct | 0.33 | 0.15 | 0.15 | 0.44 | 0.74 | 1.04 | 1.39 | 1.78 | 2.17 | 2.52 | 2.82 | 16 | 47 | 79 | 111 | 149 | 190 | 232 | 270 | 301 |
| Nov | 1.91 | 1.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec | 1.28 | 0.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Subtotal*** | ***8.07*** | ***4.78*** | ***4.39*** | ***8.92*** | ***13.46*** | ***17.99*** | ***23.44*** | ***29.33*** | ***35.23*** | ***40.67*** | ***45.21*** | ***469*** | ***953*** | ***1,438*** | ***1,922*** | ***2,504*** | ***3,134*** | ***3,764*** | ***4,345*** | ***4,830*** |

**Table D - Annual Crop Demands for Project Service Area [3/]**

| YEAR | ANNUAL CROP DEMAND (AF) |
|---|---|
| 1 | 4,818 |
| 2 | 5,303 |
| 3 | 5,787 |
| 4 | 6,272 |
| 5 | 6,854 |
| 6 | 7,483 |
| 7 | 8,113 |
| 8 | 8,695 |
| 9+ | 9,179 |

Effective rainfall is calculated using the work of Mac Gilverrey, CA Department of Water Resources. 1989.

| | |
|---|---|
| Nov-Feb | EFF = -0.54 + (0.94 * GROSS) |
| Mar-May | EFF = -1.07 + (0.837 * GROSS) |
| Oct | EFF = -0.06 + (0.635 * GROSS) |

**NOTES:**

1/ Adapted from Blake Sanden, Irrigation & Agronomy Advisor, UCCE Kern County.

2/ Adapted from ITRC Cal-Poly SLO "ETc Table for Irrigation Scheduling and Design" for drip/micro irrigation systems in a typical year type.

3/ Irrigation efficiency and leaching fractions were not included in crop demand calculations, making the calculated demands conservative.

# Appendix 3.4-E

## KNWR Water Deliveries – 1984-2013

## APPENDIX 3.4-E: KERN NATIOAL WILDLIFE REFUGE DELIVERIES (BOR)

**KERN NATIONAL WILDLIFE REFUGE DELIVERIES (BOR)**
1984-2013

| MONTH | REFUGE DELIVERIES IN ACRE-FEET BY MONTHS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| JAN | | 178 | | | | | | | | | 2,369 | 1,069 | 2,020 | | 1,101 | 254 | | 571 | 808 | 1,296 | 1,355 | 411 | 472 | 1,142 | 553 | 1,148 | 1,204 | 957 | 1,585 | 2,685 |
| FEB | | | | | | | | | | 120 | 1,843 | 555 | | | | | | 641 | 690 | 2,037 | 870 | | 524 | 684 | 2,202 | 862 | 1,807 | 549 | 1,609 | 622 |
| MAR | | | | | | | | | | | | | | | | | | | | 1,233 | 970 | 620 | | | | | 67 | 534 | | |
| APR | | | | | | | | | | | | | 385 | | | | 348 | | | 220 | | 849 | 255 | 305 | | | 70 | 734 | | 171 |
| MAY | | | | | | | | | | | | 200 | 656 | | | 645 | 321 | 294 | 89 | 294 | | 506 | 493 | 500 | 276 | 315 | 290 | 1,485 | 400 | 850 |
| JUN | | | | | | | | | | | | | | | | 61 | | 260 | 280 | 87 | 468 | | | 200 | | | | 637 | | |
| JUL | | | | | | | | | | | | | | | | 205 | | 59 | 60 | | | | 40 | | | | | 460 | | 426 |
| AUG | | | | | | | | | | | | | 1,139 | 2,298 | 1,786 | 1,997 | 359 | 742 | 1,216 | 1,055 | 1,372 | 1,700 | 1,672 | 2,126 | 1,640 | 1,002 | 1,319 | 4,336 | | 2,953 |
| SEP | | | 856 | 197 | 107 | | | | | | | 1,244 | 1,807 | 2,728 | 3,136 | 3,612 | 2,759 | 3,870 | 3,919 | 3,509 | 3,221 | 5,131 | 4,643 | 3,467 | 3,955 | 3,600 | 4,988 | 4,887 | 3,575 | 4,417 |
| OCT | | 1,646 | 3,144 | 3,096 | 5,434 | 3,661 | 3,055 | 3,116 | 2,103 | 4,104 | 2,741 | 3,804 | 2,628 | 4,017 | 3,702 | 3,702 | 2,670 | 4,967 | 5,206 | 6,329 | 5,708 | 5,383 | 4,697 | 4,086 | 3,597 | 4,106 | 4,760 | 4,948 | 5,128 | 3,638 |
| NOV | 1,168 | 3,352 | | 2,594 | 2,574 | 2,686 | 2,557 | 2,157 | 3,301 | 4,116 | 3,435 | 1,620 | 310 | 2,228 | 3,568 | | 1,434 | 4,596 | 4,659 | 4,901 | 5,086 | 5,223 | 5,157 | 2,983 | 4,947 | 5,161 | 4,663 | 4,046 | 3,337 | 3,288 |
| DEC | 3,633 | 1,384 | | 240 | 85 | 853 | 999 | 927 | 626 | 4,429 | 2,853 | 1,345 | | | 783 | | 2,638 | 2,674 | 1,349 | 3,975 | 3,299 | 3,124 | 3,329 | 2,033 | 4,023 | 2,796 | 2,597 | 2,288 | 3,112 | 1,126 |
| Total AF | 4,801 | 6,560 | 4,000 | 6,127 | 8,200 | 7,200 | 6,611 | 6,200 | 6,030 | 12,769 | 13,241 | 9,837 | 8,945 | 11,271 | 14,076 | 10,476 | 10,529 | 18,674 | 18,276 | 24,936 | 22,349 | 22,947 | 21,282 | 17,526 | 21,193 | 18,990 | 21,765 | 25,861 | 18,746 | 20,176 |

**With CVPIA Allocations**

Average 2001 - 2013 = 21,000 AF/yr

**Source: BVWSD Delivery Records**

# Appendix 3.4-F

## BVWSD Project Demands and Brackish Groundwater Blending Calculations for Service Area

## APPENDIX 3.4-F: BVWSD PROJECT DEMANDS AND BRACKISH GROUNDWATER BLENDING CALCULATIONS FOR SERVICE AREA

**ANNUAL CROP DEMAND - ETc (AF)**

| MONTH | PISTACHIOS YEAR 1 | PISTACHIOS YEAR 5 | PISTACHIOS YEAR 9 | POMEGRANATES | COTTON | WILDLIFE REFUGE |
|---|---|---|---|---|---|---|
| JAN | 0 | 0 | 0 | 0 | 0 | 530 |
| FEB | 0 | 0 | 0 | 112 | 24 | 549 |
| MAR | 2 | 10 | 19 | 186 | 43 | 0 |
| APR | 21 | 108 | 207 | 296 | 36 | 0 |
| MAY | 58 | 303 | 583 | 576 | 33 | 0 |
| JUN | 117 | 607 | 1,168 | 590 | 129 | 0 |
| JUL | 96 | 500 | 962 | 607 | 233 | 0 |
| AUG | 86 | 447 | 859 | 517 | 212 | 1,000 |
| SEP | 73 | 380 | 730 | 379 | 149 | 1,418 |
| OCT | 16 | 149 | 301 | 188 | 39 | 1,899 |
| NOV | 0 | 0 | 0 | 0 | 0 | 1,500 |
| DEC | 0 | 0 | 0 | 0 | 0 | 1,088 |
| SUBTOTAL | 469 | 2,504 | 4,830 | 3,452 | 898 | 7,984 |

**Crop Acreages:**

| | | |
|---|---|---|
| Pistachios = | 1,282 | ac |
| Pomegranates = | 985 | ac |
| Cotton = | 308 | ac |

| | | |
|---|---|---|
| Year 1 Demand = | 4,800 | AF |
| Year 5 Demand = | 6,900 | AF |
| Year 9+ Demand = | 9,200 | AF |
| KNWR Demand = | 8,000 | AF |

**SURFACE WATER QUALITY**

SWP:

| | | |
|---|---|---|
| TDS = | 450 | mg/L |
| EC = | 703.125 | µS/cm |
| EC = | 0.70 | dS/m |

Kern River:

| | | |
|---|---|---|
| TDS = | 120 | mg/L |
| EC = | 187.5 | µS/cm |
| EC = | 0.19 | dS/m |

FK:

| | | |
|---|---|---|
| TDS = | 50 | mg/L |
| EC = | 78.125 | µS/cm |
| EC = | 0.08 | dS/m |

**GW WELL RECOVERY INFO**

| | | |
|---|---|---|
| # Groundwater Recovery Wells = | 40 | wells |
| Well Recovery = | 60 | gpm/well |
| Total Recovery = | 2,400 | gpm |
| Total Recovery = | 5.35 | CFS |
| Total Recovery = | 322 | AF/mon |
| Total Recovery = | 3,869 | AF/yr |
| TDS = | 2,000 | mg/L |
| EC = | 3,125 | µS/cm |
| EC = | 3.13 | dS/m |

**Blend Ratio to meet Pomegranate Requirements (1 GW : X SW):**

100% = 3.06 Blended Concentration: EC = 1.3 dS/m; TDS = 832 mg/L

**Blend Ratio to meet Cotton Requirements (1 GW : X SW):**

100% = 3.06 Blended Concentration: EC = 1.3 dS/m; TDS = 832 mg/L

**Blend Ratio to meet Pistachios Requirements (1 GW : X SW):**

100% = 3.06 Blended Concentration: EC = 1.3 dS/m; TDS = 832 mg/L

**Blend Ratio to meet Refuge Requirements (1 GW : X SW):**

100% = 5.00 Blended Concentration: EC = 1.1 dS/m; TDS = 708 mg/L

**YEAR 1**

| CROP | BLEND RATIO [1/] | SUPPLY | CROP DEMAND (AF) JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POMEGRANATES | 3.06 | SW | 0 | 84 | 140 | 223 | 434 | 445 | 457 | 390 | 286 | 142 | 0 | 0 | 2,601 |
| | | GW | 0 | 28 | 46 | 73 | 142 | 145 | 149 | 127 | 93 | 46 | 0 | 0 | 851 |
| COTTON | 3.06 | SW | 0 | 18 | 32 | 27 | 25 | 97 | 176 | 160 | 112 | 29 | 0 | 0 | 677 |
| | | GW | 0 | 6 | 11 | 9 | 8 | 32 | 57 | 52 | 37 | 10 | 0 | 0 | 221 |
| PISTACHIOS | 3.06 | SW | 0 | 0 | 1 | 16 | 44 | 88 | 72 | 65 | 55 | 12 | 0 | 0 | 353 |
| | | GW | 0 | 0 | 0 | 5 | 14 | 29 | 24 | 21 | 18 | 4 | 0 | 0 | 115 |
| WILDLIFE REFUGE | 5.00 | SW | 442 | 458 | 0 | 0 | 0 | 0 | 0 | 833 | 1,182 | 1,583 | 1,250 | 907 | 6,653 |
| | | GW | 88 | 92 | 0 | 0 | 0 | 0 | 0 | 167 | 236 | 317 | 250 | 181 | 1,331 |
| CROP SUBTOTAL | | SW | 0 | 102 | 174 | 266 | 503 | 630 | 705 | 614 | 453 | 183 | 0 | 0 | 3,631 |
| | | GW | 0 | 33 | 57 | 87 | 165 | 206 | 231 | 201 | 148 | 60 | 0 | 0 | 1,187 |
| SUBTOTAL | | SW | 442 | 559 | 174 | 266 | 503 | 630 | 705 | 1,448 | 1,635 | 1,765 | 1,250 | 907 | 10,284 |
| | | GW | 88 | 125 | 57 | 87 | 165 | 206 | 231 | 368 | 385 | 376 | 250 | 181 | 2,518 |

**YEAR 5**

| CROP | BLEND RATIO [1/] | SUPPLY | CROP DEMAND (AF) JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POMEGRANATES | 3.06 | SW | 0 | 84 | 140 | 223 | 434 | 451 | 427 | 405 | 294 | 142 | 0 | 0 | 2,601 |
| | | GW | 0 | 28 | 46 | 73 | 142 | 139 | 180 | 112 | 85 | 46 | 0 | 0 | 851 |
| COTTON | 3.06 | SW | 0 | 18 | 32 | 27 | 25 | 92 | 223 | 175 | 120 | 29 | 0 | 0 | 742 |
| | | GW | 0 | 6 | 11 | 9 | 8 | 37 | 10 | 37 | 29 | 10 | 0 | 0 | 156 |
| PISTACHIOS | 3.06 | SW | 0 | 0 | 7 | 81 | 229 | 461 | 368 | 351 | 294 | 112 | 0 | 0 | 1,903 |
| | | GW | 0 | 0 | 2 | 27 | 75 | 146 | 132 | 96 | 86 | 37 | 0 | 0 | 600 |
| WILDLIFE REFUGE | 5.00 | SW | 442 | 458 | 0 | 0 | 0 | 0 | 0 | 923 | 1,296 | 1,583 | 1,250 | 907 | 6,857 |
| | | GW | 88 | 92 | 0 | 0 | 0 | 0 | 0 | 77 | 122 | 317 | 250 | 181 | 1,127 |
| CROP SUBTOTAL | | SW | 0 | 102 | 180 | 331 | 688 | 1,004 | 1,018 | 931 | 708 | 283 | 0 | 0 | 5,246 |
| | | GW | 0 | 33 | 59 | 108 | 225 | 322 | 322 | 245 | 200 | 93 | 0 | 0 | 1,607 |
| SUBTOTAL | | SW | 442 | 559 | 180 | 331 | 688 | 1,004 | 1,018 | 1,854 | 2,004 | 1,866 | 1,250 | 907 | 12,104 |
| | | GW | 88 | 125 | 59 | 108 | 225 | 322 | 322 | 322 | 322 | 409 | 250 | 181 | 2,734 |

**YEAR 9+**

| CROP | BLEND RATIO [1/] | SUPPLY | CROP DEMAND (AF) JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POMEGRANATES | 3.06 | SW | 0 | 84 | 140 | 223 | 423 | 575 | 532 | 497 | 332 | 183 | 0 | 0 | 2,990 |
| | | GW | 0 | 28 | 46 | 73 | 153 | 15 | 75 | 20 | 47 | 5 | 0 | 0 | 461 |
| COTTON | 3.06 | SW | 0 | 18 | 32 | 27 | 19 | 97 | 220 | 176 | 92 | 29 | 0 | 0 | 711 |
| | | GW | 0 | 6 | 11 | 9 | 14 | 32 | 13 | 36 | 57 | 10 | 0 | 0 | 187 |
| PISTACHIOS | 3.06 | SW | 0 | 0 | 14 | 156 | 428 | 893 | 728 | 684 | 527 | 268 | 0 | 0 | 3,699 |
| | | GW | 0 | 0 | 5 | 51 | 155 | 275 | 234 | 175 | 203 | 33 | 0 | 0 | 1,131 |
| WILDLIFE REFUGE | 5.00 | SW | 442 | 458 | 0 | 0 | 0 | 0 | 0 | 909 | 1,403 | 1,625 | 1,250 | 907 | 6,993 |
| | | GW | 88 | 92 | 0 | 0 | 0 | 0 | 0 | 91 | 15 | 274 | 250 | 181 | 991 |
| CROP SUBTOTAL | | SW | 0 | 102 | 187 | 406 | 871 | 1,565 | 1,480 | 1,357 | 952 | 481 | 0 | 0 | 7,401 |
| | | GW | 0 | 33 | 61 | 133 | 322 | 322 | 322 | 231 | 307 | 48 | 0 | 0 | 1,779 |
| SUBTOTAL | | SW | 442 | 559 | 187 | 406 | 871 | 1,565 | 1,480 | 2,266 | 2,355 | 2,106 | 1,250 | 907 | 14,393 |
| | | GW | 88 | 125 | 61 | 133 | 322 | 322 | 322 | 322 | 322 | 322 | 250 | 181 | 2,770 |

**NOTES:**

1/ Blend ratio to meet required crop salinity requirements.

# Appendix 3.4-G

# Crop Salinity Tolerance and Yield Potential

## APPENDIX 3.4-G: CROP SALINITY TOLERANCE AND YIELD POTENTIAL

### CROP TOLERANCE AND YIELD POTENTIAL INFLUENCED BY SALINITY [A/]

| | | ECw (dS/m) | | | | | |
|---|---|---|---|---|---|---|---|
| **FIELD CROPS** | **TOLERANCE** | **100%** | **90%** | **75%** | **50%** | **0%** | |
| ALFALFA | MS | 1.3 | 2.2 | 3.6 | 5.9 | 10.0 | |
| COTTON | T | 5.1 | 6.4 | 8.4 | 12.0 | 18.0 | |
| WHEAT | MT | 4.0 | 4.9 | 6.3 | 8.7 | 13.0 | |
| **VEGETABLE CROPS** | | | | | | | |
| ONIONS | S | 0.8 | 1.2 | 1.8 | 2.9 | 5.0 | |
| TOMATOES | MS | 1.7 | 2.3 | 3.4 | 5.0 | 8.4 | |
| WATERMELONS | MS | 1.9 | 2.7 | 4.0 | 6.3 | 10.8 | |
| **FRUIT & NUT CROPS** | | | | | | | |
| CHERRIES | S | 0.8 | 1.1 | 1.9 | 3.0 | 5.1 | |
| GRAPES | MS | 1.0 | 1.7 | 2.7 | 4.5 | 7.9 | |
| OLIVES | MT | 1.8 | 2.6 | 3.7 | 5.6 | 9.3 | |
| PISTACHIOS [B/] | T | 6.3 | 7.1 | 8.2 | 10.2 | 14.2 | **1.3** |
| POMEGRANATES | MT | 1.8 | 2.6 | 3.7 | 5.6 | 9.3 | |

[A/] Adapted from FAO Irrigation and Drainage Paper 29 (1985)

[B/] Adapted from UCCE Publication Managing Salinity, Soil and Water Amendments

# Appendix 3.4-H

# BVWSD Project Benefits Summary

## APPENDIX 3.4-H: BVWSD PROJECT BENEFITS SUMMARY

| (A) | (B) | (C) | (D) | (E) | (F) | (G) | (H) | (I) | (J) | (K) | (L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Phy Benefit #1 | | | Phy Benefit #2 | | | Phy Benefit #3 | Phy Benefit #4 |
| Analysis Year [1/] | SWP Model Year [1/] | Crop ETc (AF) [2/] | KNWR Drought Allocation (AF) [3/] | Brackish GW Crop Deliveries (AF) [4/] | Brackish GW KNWR Deliveries (AF) [5/] | Water Supply Produced (AF) [6/] | KNWR Wetland Habitat Protected (AC) [7/] | Shallow GW Pumping Energy Cnsmpt (MWh) [8/] | Pumping Zone Pumping Energy Cnsmpt (MWh) [9/] | Annual Total Energy Savings (MWh) [10/] | Greenhouse Gasses Avoided (MT CO2) [11/] |
| 2015 | 1979 | 4,818 | | 409 | 0 | 409 | 0 | 11 | 60 | 49 | 21 |
| 2016 | 1980 | 5,327 | | 1,292 | 0 | 1,292 | 0 | 34 | 189 | 155 | 66 |
| 2017 | 1981 | 5,836 | | 1,397 | 0 | 1,397 | 0 | 37 | 204 | 168 | 71 |
| 2018 | 1982 | 6,345 | | 1,502 | 0 | 1,502 | 0 | 40 | 220 | 180 | 76 |
| 2019 | 1983 | 6,854 | | 1,607 | 0 | 1,607 | 0 | 42 | 235 | 193 | 82 |
| 2020 | 1984 | 7,435 | | 1,650 | 0 | 1,650 | 0 | 43 | 241 | 198 | 84 |
| 2021 | 1985 | 8,017 | | 1,693 | 0 | 1,693 | 0 | 45 | 248 | 203 | 86 |
| 2022 | 1986 | 8,598 | | 1,736 | 0 | 1,736 | 0 | 46 | 254 | 208 | 88 |
| 2023 | 1987 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2024 | 1988 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2025 | 1989 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2026 | 1990 | 9,179 | 8,000 | 1,779 | 991 | 2,770 | 300 | 47 | 260 | 213 | 90 |
| 2027 | 1991 | 9,179 | 8,000 | 1,779 | 991 | 2,770 | 300 | 47 | 260 | 213 | 90 |
| 2028 | 1992 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2029 | 1993 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2030 | 1994 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2031 | 1995 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2032 | 1996 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2033 | 1997 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2034 | 1998 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2035 | 1999 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2036 | 2000 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2037 | 2001 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2038 | 2002 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| 2039 | 2003 | 9,179 | | 1,779 | 0 | 1,779 | 0 | 47 | 260 | 213 | 90 |
| | **TOTAL** | **209,281** | **16,000** | **41,526** | **1,982** | **43,509** | **-** | **1,093** | **6,075** | **4,981** | **2,108** |
| | **AVERAGE** | **8,371** | **8,000** | **1,661** | **79** | **1,740** | **-** | **44** | **243** | **199** | **84** |

**ASSUMPTIONS:**

*GW WELL RECOVERY INFO:*

| | | |
|---|---|---|
| # Groundwater Recovery Wells = | 40 | wells |
| Well Recovery = | 60 | gpm/well |
| Total Recovery = | 2,400 | gpm |
| Total Recovery = | 5.35 | CFS |
| Total Recovery = | 322 | AF/mon |
| Total Recovery = | 3,869 | AF/yr |
| Well Op Eff = | 70% | |
| **KWh/AF-ft =** | **1.46** | **KWh/AF-ft** |

*ANNUAL NON-BASELOAD OUTPUT EMISSION RATE:*

http://epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_GHG_Rates.pdf

| | | |
|---|---|---|
| CO2 Emission Rate = | 932.82 | lbs/MWh |
| **CO2 Emission Rate =** | **0.423** | **MT/MWh** |

*DEPTH TO GROUNDWATER:*

| | | |
|---|---|---|
| Depth to Shallow Groundwater = | 8 | ft |
| Pumping Drawdown = | 10 | ft |
| Total Lift = | 18 | ft |
| TDS) = | 90 | ft |
| Pumping Drawdown = | 10 | ft |
| Total Lift = | 100 | ft |

**NOTES:**

1/ Analysis Water Contract Year [Col (A)] and corresponding State Water Project model year [Col (B)].

2/ Annual crop water demand (ETc) during corresponding water contract year [Col (A)].

3/ Kern National Wildlife Refuge groundwater demand based on historical data. Demand only required during critical water years.

4/ Brackish groundwater from Project wells blended with suface water for crop deliveries. Physical Benefit #1

5/ Brackish groundwater from Project wells blended with surface water for Kern National Wildlife Refuge deliveries.

6/ Brackish groundwater pumped from Project groundwater wells.

7/ Wetland habitat created by supplied brackish groundwater from Project wells, assumed 3.3 AF/ac was needed for habitat creation. Physical Benefit #2.

8/ Shallow groundwater well energy consumed during operations [{1.46 KWh/AF-ft x 18 ft x Col (E)}/1,000].

9/ Pumping zone groundwater well energy consumed to meet crop demands [{1.46 KWh/AF-ft x 100 ft x Col (E)}/1,000].

10/ Total annual energy benefits from the project [Col (J) - Col (I)]. Physical Benefit #3.

11/ Annual GHG emission reductions due to reduced energy use [Col (K) x 0.423 MT/MWh]. Physical Benefit #4.

# Appendix 3.4-I

## Water Quality Data - Desalination Demonstration Report for BVWSD

# Desalination Demonstration Report for Buena Vista Water Storage District


**Buena Vista Water Storage District**

Client Representative Dan Bartel

**Boyle Engineering Corporation**

Project Manager Christopher J. Martin, PE

Project Engineer Asabi E. Goodman, EIT



Prepared in cooperation with the California Department of Water Resources, the Kern County Water Agency, and the University of California at Los Angeles.

December 2003



BOYLE 5001 E. Commercenter Dr., Suite 100 Bakersfield, CA 93309

**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 |

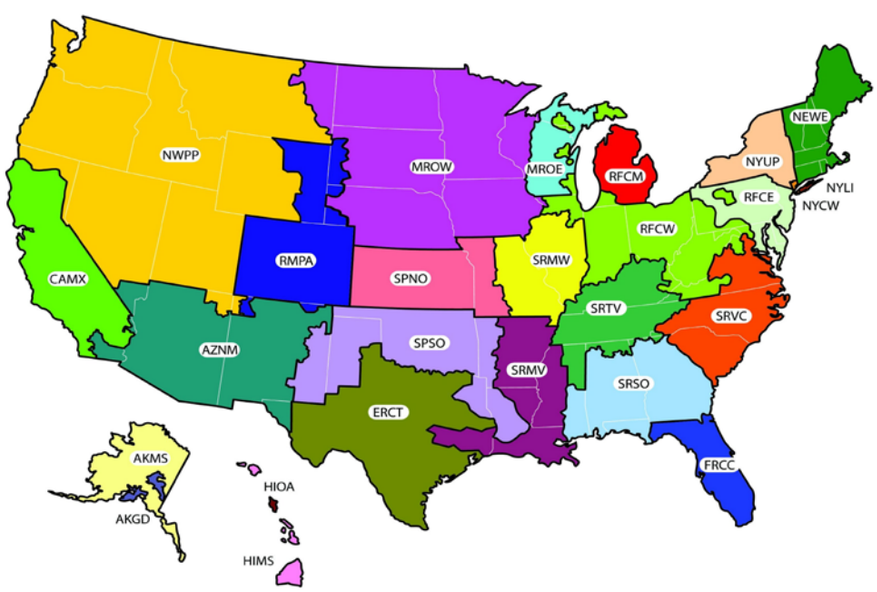
# Appendix 3.4-J

## Year 2010 eGrid Subregion Emissions – GHG

# eGRID 9th edition Version 1.0 Year 2010 GHG Annual Output Emission Rates

Annual total output emission rates for greenhouse gases (GHGs) can be used as default factors for estimating GHG emissions from electricity use when developing a carbon footprint or emission inventory. Annual non-baseload output emission rates should not be used for those purposes, but can be used to estimate GHG emissions reductions from reductions in electricity use.

| eGRID subregion acronym | eGRID subregion name | Annual total output emission rates | | | Annual non-baseload output emission rates | | |
|---|---|---|---|---|---|---|---|
| | | Carbon dioxide ($CO_2$) (lb/MWh) | Methane ($CH_4$) (lb/GWh) | Nitrous oxide ($N_2O$) (lb/GWh) | Carbon dioxide ($CO_2$) (lb/MWh) | Methane ($CH_4$) (lb/GWh) | Nitrous oxide ($N_2O$) (lb/GWh) |
| AKGD | ASCC Alaska Grid | 1,256.87 | 26.08 | 7.18 | 1,387.37 | 34.05 | 6.93 |
| AKMS | ASCC Miscellaneous | 448.57 | 18.74 | 3.68 | 1,427.76 | 59.97 | 11.80 |
| AZNM | WECC Southwest | 1,177.61 | 19.21 | 15.72 | 1,210.44 | 21.88 | 9.86 |
| CAMX | WECC California | 610.82 | 28.49 | 6.03 | 932.82 | 35.91 | 4.55 |
| ERCT | ERCOT All | 1,218.17 | 16.85 | 14.07 | 1,181.70 | 20.12 | 7.63 |
| FRCC | FRCC All | 1,196.71 | 38.91 | 13.75 | 1,277.42 | 38.73 | 10.83 |
| HIMS | HICC Miscellaneous | 1,330.16 | 73.98 | 13.88 | 1,690.72 | 104.05 | 19.12 |
| HIOA | HICC Oahu | 1,621.86 | 99.30 | 22.41 | 1,588.23 | 119.48 | 20.10 |
| MROE | MRO East | 1,610.80 | 24.29 | 27.52 | 1,755.66 | 31.53 | 27.99 |
| MROW | MRO West | 1,536.36 | 28.53 | 26.29 | 2,054.55 | 59.86 | 35.53 |
| NEWE | NPCC New England | 722.07 | 71.76 | 12.98 | 1,106.82 | 61.55 | 12.07 |
| NWPP | WECC Northwest | 842.58 | 16.05 | 13.07 | 1,340.34 | 41.38 | 17.84 |
| NYCW | NPCC NYC/Westchester | 622.42 | 23.81 | 2.80 | 1,131.63 | 23.58 | 2.44 |
| NYLI | NPCC Long Island | 1,336.11 | 81.49 | 10.28 | 1,445.94 | 34.03 | 3.91 |
| NYUP | NPCC Upstate NY | 545.79 | 16.30 | 7.24 | 1,253.77 | 36.83 | 13.67 |
| RFCE | RFC East | 1,001.72 | 27.07 | 15.33 | 1,562.72 | 35.93 | 20.02 |
| RFCM | RFC Michigan | 1,629.38 | 30.46 | 26.84 | 1,744.52 | 32.31 | 26.00 |
| RFCW | RFC West | 1,503.47 | 18.20 | 24.75 | 1,982.87 | 24.50 | 31.07 |
| RMPA | WECC Rockies | 1,896.74 | 22.66 | 29.21 | 1,808.03 | 24.56 | 22.89 |
| SPNO | SPP North | 1,799.45 | 20.81 | 28.62 | 1,951.83 | 25.15 | 26.90 |
| SPSO | SPP South | 1,580.60 | 23.20 | 20.85 | 1,436.29 | 27.94 | 12.10 |
| SRMV | SERC Mississippi Valley | 1,029.82 | 20.66 | 10.76 | 1,222.40 | 27.71 | 6.63 |
| SRMW | SERC Midwest | 1,810.83 | 20.48 | 29.57 | 1,964.98 | 23.93 | 29.65 |
| SRSO | SERC South | 1,354.09 | 22.82 | 20.89 | 1,574.37 | 26.52 | 21.49 |
| SRTV | SERC Tennessee Valley | 1,389.20 | 17.70 | 22.41 | 1,873.83 | 24.99 | 28.88 |
| SRVC | SERC Virginia/Carolina | 1,073.65 | 21.69 | 17.64 | 1,624.71 | 36.42 | 23.06 |
| **U.S.** | | **1,232.35** | **24.14** | **18.26** | **1,520.20** | **31.27** | **18.34** |




This is a representational map; many of the boundaries shown on this map are approximate because they are based on companies, not on strictly geographical boundaries.

http://www.epa.gov/egrid

# Appendix 3.4-K

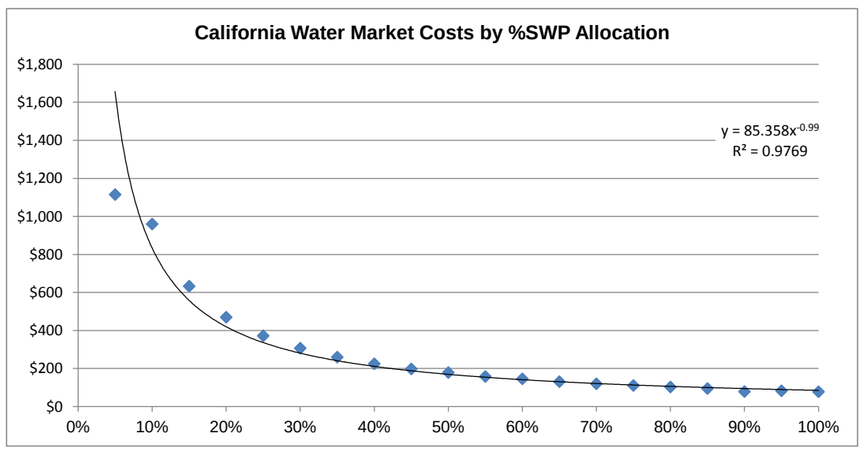
# BVWSD Alternative Project Cost Analysis

## APPENDIX 3.4-K: BVWSD ALTERNATIVE PROJECT COST ANALYSIS

**California Water Market Costs by %SWP Allocation**

| % SWP | $/ac-ft | |
|---|---|---|
| 100% | $78 | 1/ |
| 95% | $83 | 1/ |
| 90% | $79 | 1/ |
| 85% | $95 | 1/ |
| 80% | $103 | 1/ |
| 75% | $111 | 1/ |
| 70% | $120 | 1/ |
| 65% | $131 | 1/ |
| 60% | $146 | 1/ |
| 55% | $158 | 1/ |
| 50% | $179 | 1/ |
| 45% | $198 | 1/ |
| 40% | $225 | 1/ |
| 35% | $260 | 1/ |
| 30% | $307 | 1/ |
| 25% | $372 | 1/ |
| 20% | $470 | 1/ |
| 15% | $633 | 1/ |
| 10% | $960 | 1/ |
| 5% | $1,115 | 2/ |

1/ Historical water prices based on percent SWP allocations.
2/ From BVWSD 2013 Water Sales (Average $/af)




| (A) Model Year 1/ | (B) Analysis Year 1/ | (C) %SWP 2/ | (D) Crop Deliveries (AF) 3/ | (E) KNWR Deliveries (AF) 4/ | (F) Total (AF) 5/ | (G) Water Cost ($/af) 6/ | (H) Capital Cost ($) 7/ | (I) Pumping & O&M Cost ($) 8/ | (J) Purchased Water Cost ($) 9/ | (K) Discount Factor 10/ | (L) Alternative Cost Increase ($) 11/ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 2014 | 76% | 0 | 0 | 0 | $ 112 | $ 2,728,000 | $ - | $ - | 1 | $ (2,728,000) |
| 1979 | 2015 | 73% | 1,187 | 0 | 1,187 | $ 117 | $ - | $ 7,627 | $ 138,415 | 0.943 | $ 123,333 |
| 1980 | 2016 | 91% | 1,292 | 0 | 1,292 | $ 94 | $ - | $ 8,299 | $ 121,075 | 0.89 | $ 100,371 |
| 1981 | 2017 | 60% | 1,397 | 0 | 1,397 | $ 142 | $ - | $ 8,973 | $ 197,729 | 0.84 | $ 158,555 |
| 1982 | 2018 | 91% | 1,502 | 0 | 1,502 | $ 94 | $ - | $ 9,647 | $ 140,755 | 0.792 | $ 103,837 |
| 1983 | 2019 | 97% | 1,607 | 0 | 1,607 | $ 88 | $ - | $ 10,324 | $ 141,398 | 0.747 | $ 97,912 |
| 1984 | 2020 | 76% | 1,671 | 0 | 1,671 | $ 112 | $ - | $ 10,733 | $ 187,161 | 0.705 | $ 124,382 |
| 1985 | 2021 | 73% | 1,735 | 0 | 1,735 | $ 117 | $ - | $ 11,144 | $ 202,234 | 0.665 | $ 127,075 |
| 1986 | 2022 | 87% | 1,799 | 0 | 1,799 | $ 98 | $ - | $ 11,555 | $ 176,259 | 0.627 | $ 103,269 |
| 1987 | 2023 | 23% | 1,862 | 0 | 1,862 | $ 366 | $ - | $ 11,963 | $ 681,104 | 0.592 | $ 396,132 |
| 1988 | 2024 | 27% | 1,862 | 0 | 1,862 | $ 312 | $ - | $ 11,963 | $ 581,131 | 0.558 | $ 317,596 |
| 1989 | 2025 | 60% | 1,862 | 0 | 1,862 | $ 142 | $ - | $ 11,963 | $ 263,605 | 0.527 | $ 132,616 |
| 1990 | 2026 | 19% | 1,862 | 1,034 | 2,896 | $ 442 | $ - | $ 18,602 | $ 1,279,650 | 0.497 | $ 626,741 |
| 1991 | 2027 | 16% | 1,862 | 1,034 | 2,896 | $ 524 | $ - | $ 18,602 | $ 1,516,975 | 0.469 | $ 702,737 |
| 1992 | 2028 | 26% | 1,862 | 0 | 1,862 | $ 324 | $ - | $ 11,963 | $ 603,254 | 0.442 | $ 261,351 |
| 1993 | 2029 | 64% | 1,862 | 0 | 1,862 | $ 133 | $ - | $ 11,963 | $ 247,290 | 0.417 | $ 98,131 |
| 1994 | 2030 | 46% | 1,862 | 0 | 1,862 | $ 184 | $ - | $ 11,963 | $ 342,921 | 0.394 | $ 130,398 |
| 1995 | 2031 | 81% | 1,862 | 0 | 1,862 | $ 105 | $ - | $ 11,963 | $ 195,850 | 0.371 | $ 68,222 |
| 1996 | 2032 | 72% | 1,862 | 0 | 1,862 | $ 118 | $ - | $ 11,963 | $ 220,072 | 0.35 | $ 72,838 |
| 1997 | 2033 | 84% | 1,862 | 0 | 1,862 | $ 101 | $ - | $ 11,963 | $ 188,924 | 0.331 | $ 58,574 |
| 1998 | 2034 | 90% | 1,862 | 0 | 1,862 | $ 95 | $ - | $ 11,963 | $ 176,451 | 0.312 | $ 51,320 |
| 1999 | 2035 | 73% | 1,862 | 0 | 1,862 | $ 117 | $ - | $ 11,963 | $ 217,087 | 0.294 | $ 60,307 |
| 2000 | 2036 | 71% | 1,862 | 0 | 1,862 | $ 120 | $ - | $ 11,963 | $ 223,140 | 0.278 | $ 58,707 |
| 2001 | 2037 | 31% | 1,862 | 0 | 1,862 | $ 272 | $ - | $ 11,963 | $ 506,846 | 0.262 | $ 129,659 |
| 2002 | 2038 | 60% | 1,862 | 0 | 1,862 | $ 142 | $ - | $ 11,963 | $ 263,605 | 0.247 | $ 62,156 |
| 2003 | 2039 | 62% | 1,862 | 0 | 1,862 | $ 137 | $ - | $ 11,963 | $ 255,186 | 0.233 | $ 56,671 |
| | | | | | | | | | | **Total =** | **$ 1,494,890** |

**NOTES:**

1/ State Water Project model year [Col (A)] and corresponding analysis Water Contract year [Col (B)].
2/ SWP percent allocation for analysis year [Col (B)] based on State Water Project model year [Col (A)].
3/ Annual crop water demand (ETc) during corresponding analysis year [Col (B)].
4/ Kern National Wildlife Refuge groundwater demand based on historical data. Demand only required during critical water years.
5/ Total brackish groundwater recovered from Project wells [Col (D) + Col (E)].
6/ California water market water costs for delivery to Kern County based on percent SWP allocations.
7/ Project capital costs.
8/ Annual cost to pump groundwater from Project [ {1.46 KWh/af-ft x 18 ft x Col (F) x $0.13/KWh} + {Col (F) x $3/af} ].
9/ Cost to purchase available surface water supplies to match groundwater supply produced [ Col (F) x Col (G) ].
10/ Discount factor based on 6% interest rate.
11/ Difference between price to purchase available surface water supply and price to implement the Project [ Col (K) x { Col (J) - Col (I) - Col (H) } ].

**Pumping Costs**

| | | |
|---|---|---|
| Average Pumping Lift = | 18 | ft |
| Well Operating Efficiency = | 70% | |
| KWh/af-ft = | 1.46 | KWh/af-ft |
| Power Cost = | $ 0.13 | /KWh |
| Operations & Maitenance = | $3 | /af |

**Capital Costs**

| | |
|---|---|
| Capital = | $ 2,728,000 |
| Interest = | 6% |

# Appendix 3.4-L

# BVWSD Project Costs

**BUENA VISTA WATER STORAGE DISTRICT**
**BRACKISH GROUNDWATER RECOVERY PROJECT**

**ENGINEER'S OPINION OF PROBABLE PROJECT COST**

**Construction Cost Estimate:**

| ITEM NO. | ESTIMATED QUANTITY Qty. | Unit | ITEM DESCRIPTION | | UNIT PRICE | | SUBTOTAL |
|---|---|---|---|---|---|---|---|
| *General* | | | | | | | |
| 1 | 1 | LS | Mobilization/Demobilization | $ | 110,000 | $ | 110,000 |
| | | | | | *Subtotal* | | 110,000 |
| *Well Construction* | | | | | | | |
| 2 | 40 | EA | 8"Φ 80' Groundwater Well | $ | 10,900 | $ | 436,000 |
| 3 | 40 | EA | 5Hp 460V 3Φ Submersible Pump | $ | 8,500 | $ | 340,000 |
| 4 | 40 | EA | 480V/3Φ Electrical Service | $ | 15,600 | $ | 624,000 |
| 5 | 40 | EA | Well discharge, fittings, and appurtenances | $ | 5,000 | $ | 200,000 |
| | | | | | *Subtotal* | | 1,600,000 |
| *Pipeline Construction* | | | | | | | |
| 6 | 2,400 | LF | F&I 8" CL 100 PIP PVC Pipeline | $ | 15 | $ | 36,000 |
| 7 | 1,600 | LF | F&I 10" CL 100 PIP PVC Pipeline | $ | 20 | $ | 32,000 |
| 8 | 2,400 | LF | F&I 12" CL 100 PIP PVC Pipeline | $ | 25 | $ | 60,000 |
| 9 | 4,000 | LF | F&I 15" CL 100 PIP PVC Pipeline | $ | 30 | $ | 120,000 |
| 10 | 5,600 | LF | F&I 18" CL 100 PIP PVC Pipeline | $ | 45 | $ | 252,000 |
| | | | | | *Subtotal* | | 500,000 |
| | | | | | Construction Cost Subtotal | $ | 2,210,000 |
| | | | | | Contingency (10%) | | 221,000 |
| | | | | | **Construction Total** | | **2,431,000** |

**Project Cost Estimate:**

| | | |
|---|---|---|
| **DWR Category (a): Direct Project Administration** | | |
| Tasks 1 - Administration | $ | 40,900 |
| Tasks 2 - Labor Compliance | $ | 13,600 |
| Tasks 3 - Reporting | $ | 27,200 |
| **Category (a) Total:** | $ | 81,700 |
| **DWR Category (b): Land Purchase/Easement** | | |
| Task 4 - Land Aquistion - N/A | $ | 0 |
| **DWR Category (c): Planning/Design/Engineering/Environmental Documentation** | | |
| Task 5 - Assessment and Evaluation | $ | 25,000 |
| Task 6 - Final Design | | |
| 6.1 Survey & Utility Investigation | $ | 0 |
| 6.2 Well Design | $ | 15,000 |
| 6.3 Electrical Design | $ | 25,000 |
| 6.4 Project Design | $ | 148,000 |
| Task 7 - Environmental Documentation | $ | 0 |
| Task 8 - Permitting | $ | 45,000 |
| **Category (d) Total:** | $ | 258,000 |
| **DWR Category (d) - Construction/Implementation Costs** | | |
| Task 9 - Construction Contracting | $ | 5,000 |
| Task 10 - Construction (from construction estimate above) | $ | 2,431,000 |
| Task 11 - Environmental Compliance/Mitigation/Enhancement | $ | 10,000 |
| Task 12 - Construction Administration [1] | $ | 15,000 |
| **Category (d) Total:** | $ | 2,461,000 |
| **TOTAL PROJECT COST** | **$** | **2,800,700** |

[1/] $10,000 for electrical construction review services, $5,000 for operational startup assistance.
[2/] 3% of Construction Cost.