Administrative Draft

Water Supply Assessment for The Cannery EIR

City of Davis

Prepared for

DeNovo Planning Group

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Table of Contents

Chapter 7 Determination of Water Supply Sufficiency

Chapter 8 Water Supply Assessment Approval Process

List of Appendices

List of Tables

Table of Contents

List of Figures

EXECUTIVE SUMMARY

ConAgra Foods Inc. proposes The Cannery Project (Project) on its 98.4-acre property north of East Covell Boulevard in the City of Davis (City).

In September 2010, ConAgra Foods, Inc. (ConAgra or Project Applicant) filed a pre-application for development of the Project site. On October 26, 2010, the City Council authorized a pre-application process for the Project site. A formal application for development was submitted by ConAgra to the City on September 23, 2011.

The Project includes a mix of residential, commercial, office, restaurants, and recreational uses covering approximately 98.4 acres. The Project includes 610 residential units (Low Density, Medium Density, and High Density), 236,000 square feet of commercial space, a neighborhood park, and 27.5 acres of open space.

As documented below, the Project is projected to have a total water demand of approximately 438 acre-feet per year (af/yr). According to the City's 2010 Urban Water Management Plan (UWMP), the City's current water demand is about 12,000 acre-feet per year and its current water supply is about 15,000 af/yr. The City is actively engaged in the Woodland-Davis Clean Water Agency (WDCWA) Davis Woodland Water Supply Project (DWWSP). This project includes pumping raw water from the Sacramento River, treating it to potable water quality, and conveying it to the Cities of Davis and Woodland. Once this surface water supply source is in place, anticipated to be during the year 2016, the 2010 UWMP indicates that the City's total water supply will be over 19,000 af/yr.

Thus, based on the analysis described herein and as shown in Tables ES-1 and ES-2, this water supply assessment (WSA) demonstrates that both the current and projected City water supplies are sufficient to serve the proposed Project through the year 2035 under all hydrologic conditions (including normal, single dry, and multiple-dry years). This finding of sufficiency is based on the following points:

1. The Water Well Agreement was perfected with the construction of DDW-33 and conveying title of that well to the City in 2008.
2. The projected water demand of the Cannery Project is substantially less than the projected growth of water demand and supplies as documented in the City's 2010 UWMP.
3. The proposed surface water supply project will be sized to serve projected growth in the City.
4. The City currently has sufficient groundwater capacity available to serve the Project's projected water demand, even without the proposed surface water project.

These points are discussed in greater detail throughout this WSA.

Table ES-1. Existing Water Supply and Demand (Existing Demands + Proposed Project)

Supply	Current Dry Year Water Supply Availability, af/yr[(a)]		
	Normal Years	Single Dry Year	Multiple Dry Years
Existing Water Supplies Groundwater[(b)]	15,000	15,000	15,000
Total Potable Water Supply	15,000	15,000	15,000
Existing Potable Water Demand (2010)	11,955	11,955	11,955
Existing Potable Water Demand (2010) plus the Project [(c)]	12,393	12,393	12,393
Potable Water Supply Surplus (Deficit)	2,607	2,607	2,607

(a) See Dry Year Water Supply Availability and Reliability discussion in Chapter 6.
(b) The City is planning to decrease groundwater use 6,000 af/yr or less by the year 2015 (based on normal year supply conditions). However, studies described in this WSA have indicated 8,500 af/yr or more of groundwater capacity would be available to the City to make up for shortfalls in the event of a severe drought or other water shortage.
(c) Includes projected 438 af/yr water demand for the Project.

Table ES-2. Existing and Additional Year 2035 Water Supply and Demand

Supply	Year 2035 Dry Year Water Supply Availability, af/yr[(a)]		
	Normal Years	Single Dry Years	Multiple Dry Years
Existing Water Supplies Groundwater[(b)]	6,000	8,500	6,000
Additional Water Supplies WDCWA Surface Water Project Aquifer Storage and Recovery	13,104 --	7,642 unknown	11,242 unknown
Total Potable Water Supply	19,104	16,142	17,242
Projected 2035 Projected Potable Water Demand[(c)]	15,916	15,916	15,916
Potable Water Supply Surplus (Deficit)	3,188	226	1,326

(a) See Dry Year Water Supply Availability and Reliability discussion in Chapter 6.
(b) The City is planning to decrease groundwater use 6,000 af/yr or less by the year 2015 (based on normal year supply conditions). However, studies described in this WSA have indicated 8,500 af/yr or more of groundwater capacity would be available to the City to make up for shortfalls in the event of a severe drought or other water shortage.
(c) Includes projected 438 ac/yr water demand for the Project.

CHAPTER 1
Introduction

ConAgra Foods Inc. proposes The Cannery Project (Project) on its 98.4-acre property north of East Covell Boulevard in the City of Davis (City).

The legal requirement for a water supply assessment (WSA) and the project background are discussed below.

1.1 LEGAL REQUIREMENT FOR A WATER SUPPLY ASSESSMENT

California Senate Bill 610 (SB 610) was approved by Governor Davis on October 9, 2001, and made effective on January 1, 2002. SB 610 amended California state law to improve the link between information on water supply availability and certain land use decisions made by cities and counties. Specifically, certain sections of the California Water Code were amended to require coordination between land use, lead agencies, and public water purveyors. The purpose of this coordination is to ensure that prudent water supply planning has been conducted, and that planned water supplies are adequate to meet existing demands, anticipated demands from approved projects and tentative maps, and the demands of proposed projects.

The amended Water Code sections 10910 through 10915 (inclusive) require land use lead agencies to: (1) identify any public water purveyor that may supply water for a proposed development project; and (2) request from the identified purveyor a WSA. The purpose of a WSA is to demonstrate the sufficiency of the purveyor's water supplies to satisfy the water demands of the project, while still meeting the water purveyor's existing and planned future uses. Water Code sections 10910 through 10915 delineate the specific information that must be included in a WSA.

The purpose of this WSA is to perform the evaluation required by Water Code sections 10910 through 10915 in connection with the City Project. It is not to reserve water, or to function as a "will serve" letter or any other form of commitment to supply water (see Water Code section 10914). The provision of water service will continue to be undertaken in a manner consistent with applicable City policies and procedures and consistent with existing law.

1.2 BACKGROUND

According to the Project Description, dated February 1, 2012, the site was annexed by the City and previously developed by the Hunt-Wesson division of ConAgra Foods, Inc., for food processing and warehousing products more than fifty years ago. The Cannery was constructed in 1961 and operated for 38 years before closing in October 1999. The obsolete canning facilities were demolished, and a few building foundations remain in the southern portion of the site. The northern portion of the site, once intended for facilities plant expansion, remains undeveloped.

In approximately 2004, Lewis Planned Communities (Lewis) acquired the Project site from ConAgra and proceeded with the pursuit of residential mixed use development of the project site. On March 16, 2009, just prior to embarking on the environmental Impact Report (EIR) preparation process for the Project application, Lewis withdrew their application.

In September 2010, ConAgra Foods, Inc. (ConAgra, or Project Applicant) filed a pre-application for development of the project site. On October 26, 2010, the Davis City Council authorized a pre-application process for the project site. A formal application for development was submitted by ConAgra to the City on September 23, 2011. The City processed the applications and commissioned the preparation of the City of Davis/ConAgra Development Agreement. ConAgra is currently preparing The Cannery Environmental Impact Report (The Cannery EIR).

A Project Description and Illustrative Land Use Plan for The Cannery were provided to the City in February 2012. A Notice of Preparation of The Cannery EIR was prepared in March 2012. As a part of the processing of the applications and the preparation of The Cannery EIR, the Project Applicant commissioned the preparation of a WSA.

1.3 WATER SUPPLY ASSESSMENT PREPARATION, FORMAT AND ORGANIZATION

This WSA for The Cannery has been prepared by West Yost Associates (West Yost), as requested by De Novo Planning Group (De Novo), which is preparing the EIR for The Cannery Project.

The format of this WSA is intended to follow Water Code sections 10910 through 10915 to clearly delineate compliance with the specific requirements for a WSA. The WSA includes the following sections:

- Chapter 1: Introduction
- Chapter 2: Description of Project
- Chapter 3: Required Determinations
- Chapter 4: City of Davis Water Service Area
- Chapter 5: City of Davis Water Demands
- Chapter 6: City of Davis Water Supplies
- Chapter 7: Determination of Water Supply Sufficiency
- Chapter 8: Water Supply Assessment Approval Process

Relevant citations of Water Code sections 10910 through 10915 are included throughout this WSA in *italics* to demonstrate compliance with the specific requirements of SB 610.

1.4 ACRONYMS AND ABBREVIATIONS USED IN THIS WATER SUPPLY ASSESSMENT

The following acronyms and abbreviations have been used throughout this WSA.

af	acre-feet
af/ac/yr	acre-feet per acre per year
af/yr	acre-feet per year
Bgs	below ground surface
CEQA	California Environmental Quality Act
City	City of Davis
DPH	California Department of Public Health
DWR	California Department of Water Resources
DWWSP	Davis Woodland Water Supply Project
EIR	Environmental Impact Report
ET_o	Evapotranspiration
GMP	Groundwater Management Plan
gpm	gallons per minute
LAFCo	Local Area Formation Commission
M&I	Municipal and industrial
Mgd	million gallons per day
mg/L	milligrams per liter
msl	mean sea level
MY	Million Years
NEPA	National Environmental Policy Act
Project	The Cannery Project
RWQCB	Regional Water Quality Control Board
SB 610	California State Senate Bill 610 of 2001
sf	square feet
SOI	Sphere of Influence
TBD	To be determined
TDS	Total Dissolved Solids
USBR	United States Bureau of Reclamation
UWMP	Urban Water Management Plan
WSA	Water Supply Assessment
West Yost	West Yost Associates
WWTP	Wastewater Treatment Plant

CHAPTER 2
Description of Project

A description of the Project, including Project Location, Proposed Land Usages and Acreages, Projected Water Demand, and Projected Water Supply are described below.

2.1 PROJECT LOCATION

The Project is located in the City and consists of approximately 98.4 acres that is currently zoned PD-1-00 (Planned Development-Industrial) and designated in the City's General Plan as Industrial. The site is generally a slanted rectangle and its boundaries are defined by East Covell Boulevard on the south, existing Union Pacific Railroad (UPRR) line and the F Street open drainage channel on the west, and agricultural lands on the north and east. Residential neighborhoods are located west of the UPRR line and F Street Channel. Multi-family residential (Cranbrook Apartments) and office uses are south of East Covell Boulevard, south of the site. Adjacent lands to the north and east are currently zoned Limited Industrial (M-L) under the jurisdiction of Yolo County, and are seasonally farmed with rotating annual crops. The Project location is presented in Figure 2-1.

2.2 PROPOSED LAND USES AND ACREAGES

The Project includes a mix of residential, commercial, office, restaurants, and recreational uses covering approximately 98.4 acres. The Project includes 610 residential units (Low Density, Medium Density, and High Density), 236,000 square feet of commercial space, a neighborhood park, and 27.5 acres of open space (see Figure 2-2).

Proposed land uses for the Project based on the Project Description are summarized in Table 2-1.

Table 2-1. Proposed Land Uses for The Cannery

Proposed Land Use and Developed Square Footage[a]	Land Use Summary Gross Acres[a]
Low Density Residential (96 dwelling units)	14.8
Medium Density Residential (240 dwelling units)	25.2
High Density Residential (250 dwelling units)	10.0
Neighborhood Center	1.0
Mixed Use - Cannery Commerce District (236,000 sf commercial plus 24 dwelling units)[b]	15.0
Neighborhood Park	4.7
Open Space – includes greenbelts, multi-use areas and Cannery Farm/Ag buffer	27.5
Public/Semi-Public (Water Well)	0.2
Total Gross Area	**98.4**

(a) Based on Project Description dated February 1, 2012.
(b) See Cannery Committee District Conceptual Plan, Project Description, Pg 15.

Development of the Project is anticipated to occur over the next several years, depending on market conditions.

It should be noted that this WSA evaluates the availability and reliability of the City's water supplies to serve buildout of the Project.

2.3 PROJECTED WATER DEMAND

The projected water demand is documented below, including:

- Water Use Factors and Assumptions
- Water Demand Calculations
- Comparison with Water Demand Calculations in the Urban Water Management Plan

2.3.1 Water Use Factors and Assumptions

The City adopted unit water use factors for use in projecting potable water demand based on the proposed future land uses within the City's General Plan. Water use factors for various land uses were established in 1991 and do not take into consideration reduced water use as a result of new building codes, improved water use efficiency, and water conservation measures. The projected water demands, therefore, are considered very conservative.

The City's adopted unit water use factors for the land use designations applicable to the Project are shown in Table 2-2.

Table 2-2. City of Davis Adopted Water Use Factors[(a)]

Proposed Land Use	Water Use Factor (units as shown)
Low Density Residential	450 gpd/du
Medium Density Residential	450 gpd/du
High Density Residential	225 gpd/du
Commercial	2,125 gpd/ac
Clubhouse	2,500 gpd/ac
Parks and Open Space	4.0 af/ac/yr[(b)]

(a) As provided by City staff, August 2012.
(b) The Project may irrigate landscaping with non-potable water drawn from an existing on-site agricultural groundwater well, which would not require potable water from the City. The water use factor for Parks and Open Space was proposed in in the Water Master Plan.

The unit water use factors listed in Table 2-2 were applied to the number of dwelling units and gross acres for the respective land uses for the Project to estimate the total potable water demand.

As indicated in the Project Description, the project includes significant water saving measures aimed at reducing overall water demands for potable water to the extent feasible and practicable.

2.3.2 Water Demand Calculations

The total projected water demand for the Project at buildout is presented in Table 2-3. As shown, the projected potable water demand for the Project (including the non-potable irrigation uses) is estimated to be approximately 440 acre-feet per year (af/yr). No recycled water demand has been assumed for the Project. The City standard maximum-day peaking factor and peak hour peaking factor are 2.0 and 1.8, respectively. The projected average day, maximum day, and peak hour demands are shown in Table 2-3.

The values shown in Table 2-3 are based on the land use types described in the Project Description and the water demand factors described in the Water Supply Master Plan (WSMP). These values differ slightly from the values in the WSMP due to slightly different land use quantities and calculation rounding.

It should also be noted that although water demands for the Project will develop incrementally over time as various portions of the Project are developed, this WSA only provides analysis of the total estimated demands for the Project at buildout.

2.3.3 Comparison with Water Demand Calculations in the Urban Water Management Plan

The water demands for the Project assumed in this WSA are well within those calculated for the City's 2010 UWMP, which show an increase in the water demand of over 1,000 acre-feet by 2015.

2.4 PROJECTED WATER SUPPLY

It is anticipated that the Project would be served from the City's existing and future portfolio of water supplies as described in *Section 6.0 City of Davis Water Supplies*.

In November 2005, Pole Line Road Holding Company, LLC (also known as Lewis) and the City entered into a **Water Well Agreement** (Appendix A). The **Water Well Agreement** stipulated that, if Lewis met certain terms, including construction of a water supply well to be turned over to the City, the City would provide water to the Project up to the capacity of the water supply well. The Agreement did not stipulate that the City would approve the development application, but rather that water would be provided to an accepted development. The well was constructed and turned over to the City in 2008, and is now City Well DDW-33. Well DDW-33 has a nominal pumping capacity of 1,750 gallons per minute (gpm).

The groundwater production well (Well DDW-33) that was completed and conveyed to the City in 2008 (capacity of 1,750 gpm) exceeds the projected Project peak hour demand of 1,280 gpm, and thus meets the peak demand requirements of the water supply service agreement. In addition, this well can produce more than 2,800 acre-feet per year (running constantly), which exceeds the annual Project water demand of 440 af/yr.

Table 2-3. Preliminary Potable Water Demand Projection for the Cannery

Land Use Type	Water Demand Units	No. of Units[a]	Unit Water Demand Factor, af/yr/unit[b]	Projected Annual Demand, af/yr	Average Day Demand, gpm	Maximum Day Demand, gpm[c]	Peak Hour Demand, gpm[d]
Low Density Residential	Dwelling Units	96	0.54	52.0	32.3	64.5	116.1
Medium Density Residential	Dwelling Units	240	0.54	130.0	80.6	161.3	290.3
High Density Residential	Dwelling Units	250	0.27	67.7	42.0	84.0	151.2
Mixed Use Residential at HDR Rate	Dwelling Units	24	0.27	6.5	4.0	8.1	14.5
Commercial	Acres	16	2.59	41.4	25.7	51.4	92.5
Neighborhood Center	Acres	0.7	3.01	2.1	1.3	2.6	4.7
Parks / OS / Greenbelts / Paseos	Acres	32.5	4.30	139.8	86.6	203.6	610.8
Public/Quasi-Public	Acres	0.2	—	—	—	—	—
Totals				**439.6**	**272.5**	**575.4**	**1,280.0**

[a] From Project Description, February 2012.

[b] From Table 2 converted to acre-feet per year. Includes 7.5% unaccounted-for water factor as described in the Water Master Plan, September 2011.

[c] Uses City standard of 2 times average day demand, except Parks, etc. which uses 2.35 times average day demand.

[d] Uses City standard of 1.8 times maximum day demand, except Parks, etc. which uses 3.0 times maximum day demand.

N:\Clients\487 De Novo Planning Group\00-12-02 DavisCanneryEIR\GIS\Figures\Figure 2-1 Cannery Location Plan.mxd 6/25/2012

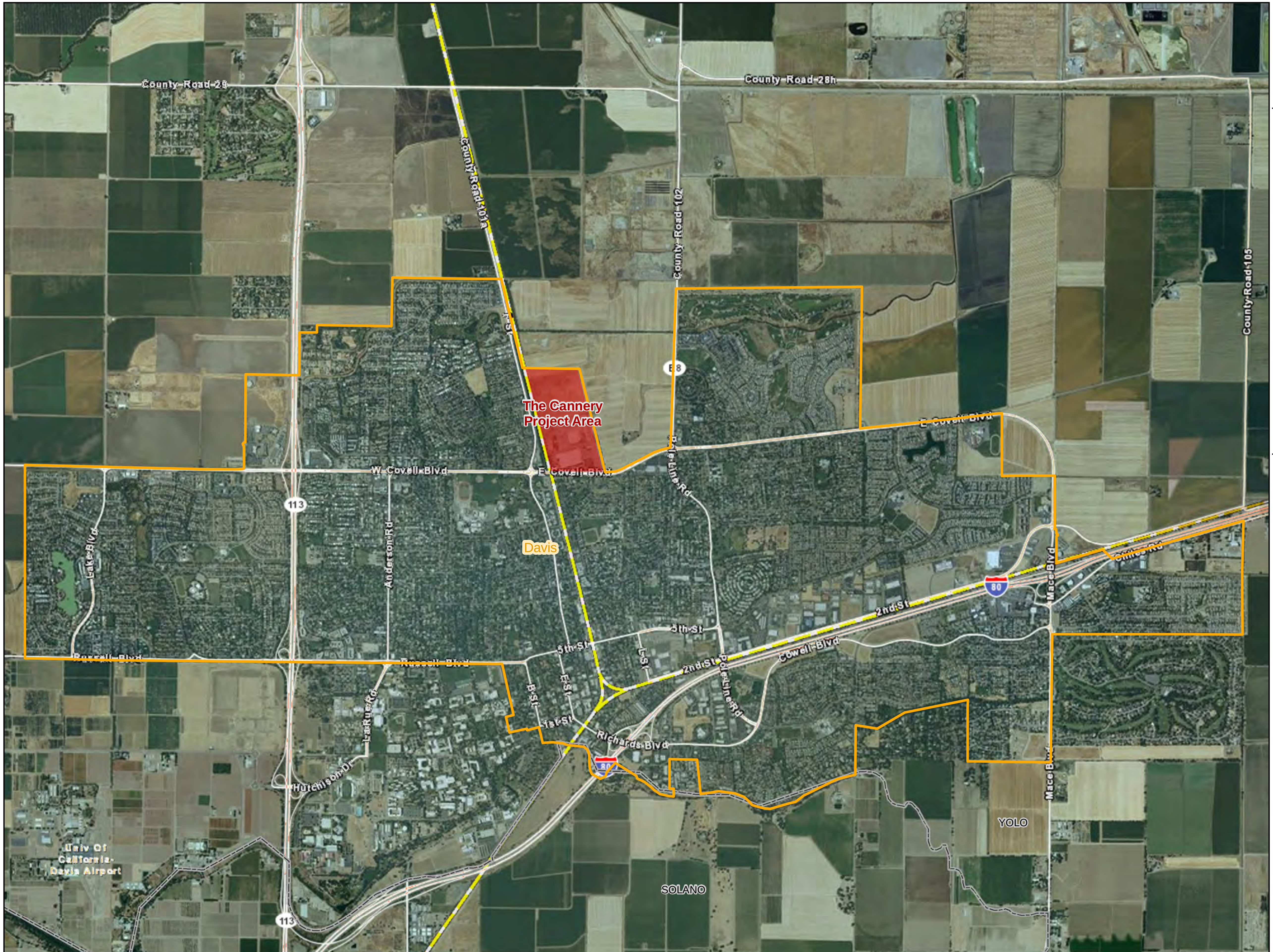

FIGURE 2-1

The Cannery Water Supply Assessmentt

THE CANNERY LOCATION PLAN

0 0.25 0.5 Miles

LEGEND

- The Cannery Project Area
- City Limits
- County

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Type	Description	Acres	Units
LDR	Low Density Residential	14.8 ac	96 units
MDR	Medium Density Residential	25.2 ac	240 units
HDR	High Density Residential	10.0 ac	250 units
MU	Mixed-Use	15.0 ac	24 units
REC	Recreation/Clubhouse (HOA)	1.0 ac	
P/SP	Existing Well Site	0.2 ac	
P	Parks & Recreation	5.2 ac	
OS	Open Space / Greenbelt	27.0 ac	
	Total:	98.4 ac	610 units

N:\Clients\487 De Novo Planning Group\00-12-02 DavisCannery\EIR\GIS\Figures\Figure 2 Illustrative Land Plan.mxd 6/18/2012

FIGURE 2-2

The Cannery
Water Supply Assessment

ILLUSTRATIVE LAND USE PLAN

N

0 110 220
Scale in Feet

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CHAPTER 3
Required Determinations

This Chapter describes some of the required determinations for a WSA.

3.1 DOES SB 610 APPLY TO THE PROJECT?

10910 (a) Any city or county that determines that a project, as defined in Section 10912, is subject to the California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) under Section 21080 of the Public Resources Code shall comply with this part.

10912 (a) "Project" means any of the following:

(1) A proposed residential development of more than 500 dwelling units.

(2) A proposed shopping center or business establishment employing more than 1,000 persons or having more than 500,000 square feet of floor space.

(3) A proposed commercial office building employing more than 1,000 persons or having more than 250,000 square feet of floor space.

(4) A proposed hotel or motel, or both, having more than 500 rooms.

(5) A proposed industrial, manufacturing, or processing plant, or industrial park planned to house more than 1,000 persons, occupying more than 40 acres of land, or having more than 650,000 square feet of floor area.

(6) A mixed-use project that includes one or more of the projects specified in this subdivision.

(7) A project that would demand an amount of water equivalent to, or greater than, the amount of water required by a 500-dwelling unit project.

Based on the following facts, SB 610 does apply to the Project.

- The City has determined that the Project is subject to the California Environmental Quality Act (CEQA) and that an EIR is required.
- The Project, with 610 residential dwelling units and 236,000 square feet (sf) of commercial development, meets the definition of a "Project" as specified in Water Code section 10912(a) paragraph (1) as defined for proposed residential developments.

Therefore, according to Water Code section 10910(a), a WSA is required for the Project.

3.2 WHO IS THE IDENTIFIED PUBLIC WATER SYSTEM?

10910(b) The city or county, at the time that it determines whether an environmental impact report, a negative declaration, or a mitigated negative declaration is required for any project subject to the California Environmental Quality Act pursuant to Section 21080.1 of the Public Resources Code, shall identify any water system that is, or may become as a result of supplying water to the project identified pursuant to this subdivision, a public water system, as defined by Section 10912, that may supply water for the project.

10912 (c) "Public water system" means a system for the provision of piped water to the public for human consumption that has 3,000 or more service connections…

As shown on Figure 2-1, the Project is located within the existing City limits.

The City's water system service area includes all areas within the City limits and a few unincorporated areas outside of City limits. As of December 2010, the City had 16,519 water service connections. The City is the identified public water system for the Project.

3.3 DOES THE CITY HAVE AN ADOPTED URBAN WATER MANAGEMENT PLAN (UWMP) AND DOES THE UWMP INCLUDE THE PROJECTED WATER DEMAND FOR THE PROJECT?

10910(c)(1) The city or county, at the time it makes the determination required under Section 21080.1 of the Public Resources Code, shall request each public water system identified pursuant to subdivision (b) to determine whether the projected water demand associated with a proposed project was included as part of the most recently adopted urban water management plan adopted pursuant to Part 2.6 (commencing with Section 10610).

The City's most recently adopted UWMP (the City's 2010 UWMP) was adopted by the City Council on July 19, 2011[1]. The City's 2010 UWMP included existing and projected water demands for existing and projected future land uses to be developed within the City's General Plan SOI through 2035. The water demand projections in the City's 2010 UWMP included existing City water demands, future water demands for developments within the existing City limit, and future water demands for future service areas outside the existing City limit.

The City's 2010 UWMP potable water demand projections do not specifically state that potable water demands for the Project were included in water demand projections. The water demand projections were based on achieving and maintaining the Senate Bill x7-7 per capita water demand of 167 gallons per capita per day (gpcd) multiplied by the projected population. The population was projected to grow by 2.5 percent between 2010 and 2015, and by 5 percent for each subsequent five-year interval, without regard for the location of the added population.

Total water use throughout the City service area is projected in the 2010 UWMP to increase from 11,955 af/yr in 2010 to 15,917 af/yr in 2035, an increase of 3,962 af/yr. The Project's projected water demand of 438 af/yr is slightly more than one-tenth of the City's projected growth in water demand through 2035. Both water demand projections include unaccounted-for water losses.

The City's 2010 UWMP also indicated that the total water supply would grow from the current (2010) 15,000 af/yr to 23,450 af/yr by the year 2035. Therefore, it not only appears that the Project water demands are included in the City's 2010 UWMP demand projection, but that sufficient water supply exists to serve the project.

[1] *City of Davis 2010 Urban Water Management Plan*, prepared by Brown and Caldwell, Inc., July 2011.

CHAPTER 4
City of Davis Water Service Area

4.1 WATER SERVICE AREA

As indicated in the City's 2010 UWMP, the City is located in the Central Valley in the southeastern corner of Yolo County and to the east of the coastal mountain range and San Francisco Bay Area, and 12 miles west of the state capital of Sacramento. It occupies an area of about 9.8 square miles (6,281 acres). Incorporation of the City occurred in 1917, and water service is provided to all residential (single and multi-family), commercial, industrial, and irrigation customers, and for open space and fire protection uses. The City's water service area, bordered by the UC Davis campus, includes the City, El Macero (located south of Interstate 80), and additional areas to the north, south, east, and west of the City.

4.2 POPULATION

According to the City's 2010 UWMP, the City's population has been increasing since the 1960's. Population increases were above normal for the 1996-2000 period as strong regional economic forces and UC Davis campus growth exerted pressure on urban land development needs. Population has and is expected to continue to grow more gradually in accordance with the recently adopted update of the City's General Plan. Most of the City's growth has been in the residential and open space land categories, with a relatively small increase of commercial development. Significant multi-family residential development occurred to meet increasing student population housing needs. In the commercial sector, there was some growth in high technology and tourist related businesses.

The City continues to primarily be a residential community, with modest but growing commercial and industrial sectors. The City has a mix of commercial customers, including restaurants, markets, retail stores, insurance offices, beauty shops, gas stations, office buildings, and some retail providing services in support of local resident and visitor populations. The City draws visitors from its close affiliation with UC Davis, proximity to the Interstate 80 corridor, and annual special events drawing visitors from the entire region.

The City has a very small industrial sector, primarily centered on technology and light manufacturing. The industrial sector has not grown relative to other sectors in the last decade. The City has a stable institutional/governmental sector, consisting primarily of local government, schools, public facilities, and hospitals.

Since 2005, population, housing and employment have increased, but not as significantly as previously projected because of the economic recession. However, UC Davis' increased annual enrollment targets are resulting in additional growth in the region. Recent historical and projected future population in five-year increments to the year 2035 are shown in Table 4-1.

Table 4-1. Historical and Projected Population

Historical Population	1995	54,946
	2000	63,324
	2005	66,229
	2010	68,289
Projected Population	2015	69,996
	2020	73,496
	2025	77,171
	2030	81,029
	2035	85,081

Source: City of Davis 2010 UWMP, Table 3-1 Historical and Projected Service Area Population, July 2011 and Water Distribution System Optimization Plan, May 2011.

4.3 CLIMATE

As documented in the City's 2010 UWMP, summers in the City are warm and dry, and winters are cool and mild. The region is subject to wide variations in annual precipitation, and also experiences periodic dry periods and wild fires in the regional watershed and surrounding areas with chaparral and oak lands. Summers can be hot at times with weekly periods of 100 degree Fahrenheit temperatures, which greatly increase summer irrigation requirements.

Based on the historical data obtained from the Western Regional Climate Center, the City's average monthly temperature ranges from 45 to 75 degrees Fahrenheit, but the extreme low and high daily temperatures have been 12 and 116 degrees Fahrenheit, respectively. The historical annual average precipitation is approximately 19 inches. The rainy season normally begins in November and ends in March. Evapotranspiration (ETo) records, which measure the loss of water from the soil both by evaporation and by transpiration from the plants growing thereon, indicate average monthly values ranging from 1.2 inches in January to 8.3 inches in June and July. Low humidity usually occurs in the summer months, from May through September. The combination of hot and dry weather results in high water demands during the summer. Table 4-2 summarizes the City's average climatic conditions.

Table 4-2. Historical Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Average Et_o, inches[a]	1.2	1.9	3.7	5.4	7.2	8.3	8.3	7.6	5.9	4.2	2.1	1.2	56.9
Average Temperature, °F[b]	45	49	54	58	65	71	73	72	69	62	52	45	—
Average Rainfall, inches[b]	3.4	4.0	2.6	1.1	0.6	0.2	0.1	0.1	0.3	1.5	2.1	3.2	19.3

(a) Source: Davis 2010 UWMP Table 2-1. Data from CIMIS Website: wwwcimis.water.ca.gov, Station 6 Davis, Monthly Average Evapotranspiration (Eto) Report, data from July 1982 to January 2011.

CHAPTER 5
City of Davis Water Demands

10910(c)(2) If the projected water demand associated with the proposed project was accounted for in the most recently adopted urban water management plan, the public water system may incorporate the requested information from the urban water management plan in preparing the elements of the assessment required to comply with subdivisions (d), (e), (f), and (g).

As described previously, the water demands for the Project are included in the City's 2010 UWMP. Therefore, the descriptions provided below for the City's water demands have been taken, for the most part, from the City's 2010 UWMP, which was adopted by City Council in July 2011, and from the City's Water Distribution System Optimization Plan, completed in May 2011.

5.1 HISTORICAL AND EXISTING WATER DEMAND

The City's water demand fluctuated over the past 15 years as population has increased and water conservation practices have been implemented. In 1995, the City's water demand was 12,494 af/yr and, in 2010, the City's water demand was 11,955 af/yr. Table 5-1 shows the City's water demand (based on water production) for 2005 through 2010.

Table 5-1. Historical Potable Water Demand, af/yr[a]

	2005	2006	2007	2008	2009	2010
Total UWMP Water Demand	14,452	14,333	14,762	14,219	12,835	11,955

[a] Table 3-2: Groundwater – Volume Pumped (DWR Table 18), City of Davis 2010 Urban Water Management Plan, July 2011.

As shown in Table 5-1, the City's 2009 and 2010 potable water demands (based on water production) were about 2,000 to 2,800 af/yr lower than 2007 demands. This reduction in potable water demand is partially due to additional water conservation measures which were implemented during the recent drought, relatively wet conditions in 2010, and a declining economy. This trend has generally been experienced by water utilities throughout California for these years.

5.2 FUTURE WATER DEMAND

The City's future water demand is anticipated to continue to increase as approved projects build out and new developments are approved and constructed within the City's water service area. However, the rate of growth within the City service area has slowed as a result of the Growth Management Ordinance and the current economic downturn. Hence, water demands are not anticipated to increase as rapidly as they have in past years. The Water Distribution System Optimization Plan documented water demand projections (also used in the 2010 UWMP) as based on the Senate Bill x7-7 per capita water demand Regional Target of 167 gpcd by 2020. Using that per capita water demand, and assuming the population would grow by 2.5 percent between 2010 and 2015, and then by 5 percent for each five-year increment from 2015 to 2035, the City developed its water demand projection. Based on these reports, the City is planning for a potential population increase of 1,700 persons (equivalent to 688 dwelling units based on the current occupancy of 2.48 persons per dwelling unit) from 2010 to 2015, and of 5,200 persons (equivalent to 2,100 dwelling units based on the current occupancy of 2.48 persons per dwelling unit) from 2010 to 2020. The Project's 610 dwelling units and expected population of 1,513 persons is well within the planned-for population growth.

The projected water demand through 2035, calculated as described above and presented in the City's 2010 UWMP, is shown in Table 5-2. The projected water demand includes the existing and projected future water demand by existing users, on-going development projects (including the Project) and future service areas located outside City limits.

Table 5-2. Projected Future Water Demand, af/yr[(a)]

	2015	2020	2025	2030	2035
Total Water Demand[(a)]	13,095	13,749	14,437	15,158	15,917

(a) Table 3-14 Total Water Use (DWR Table 11), City of Davis 2010 Urban Water Management Plan, July 2011.

As shown in Table 5-2, based on a per capita water demand of 167 gpcd, existing users, and the projected growth rate, the projected water demand is 15,917 af/yr by 2035.

5.3 DRY YEAR WATER DEMAND

The City currently has an extensive water conservation program in place, as described in Chapter 6 of the City's 2010 UWMP. The projected future water demand presented in Table 5-2 includes continued implementation of the City's existing water conservation program, and is based on future normal hydrologic conditions. In single dry or multiple dry years, the projected future water demand presented in Table 5-2 is also applicable (does not include any additional water conservation beyond that assumed in normal years). Table 5-3 presents the projected future dry year water demand.

Table 5-3. Projected Future Dry Year Water Demand, af/yr[(a)]

Hydrologic Condition	Demand Reduction	2015	2020	2025	2030	2035
Normal Year	0%	13,095	13,749	14,437	15,158	15,916
Single Dry Year	0%	13,095	13,749	14,437	15,158	15,916
Multiple Dry Years[(b)]	0%	13,095	13,749	14,437	15,158	15,916

(a) See Section 7 Water Supply versus Demand Comparison of the City's 2010 UWMP, based on 167 gpcd.
(b) Represents demands for each year of a 3-year multiple dry year period.

CHAPTER 6
City of Davis Water Supplies

10910(c)(2) If the projected water demand associated with the proposed project was accounted for in the most recently adopted urban water management plan, the public water system may incorporate the requested information from the urban water management plan in preparing the elements of the assessment required to comply with subdivisions (d), (e), (f) and (g).

10910(d)(1) The assessment required by this section shall include an identification of any existing water supply entitlements, water rights, or water service contracts relevant to the identified water supply for the proposed project, and a description of the quantities of water received in prior years by the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), under the existing water supply entitlements, water rights, or water service contracts

10910(d)(2) An identification of existing water supply entitlements, water rights, or water service contracts held by the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), shall be demonstrated by providing information related to all of the following:

- *(A) Written contracts or other proof of entitlement to an identified water supply.*
- *(B) Copies of a capital outlay program for financing the delivery of a water supply that has been adopted by the public water system.*
- *(C) Federal, state, and local permits for construction of necessary infrastructure associated with delivering the water supply.*
- *(D) Any necessary regulatory approvals that are required in order to be able to convey or deliver the water supply.*

10910(e) If no water has been received in prior years by the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), under the existing water supply entitlements, water rights, or water service contracts, the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), shall also include in its water supply assessment pursuant to subdivision (c), an identification of the other public water systems or water service contract-holders that receive a water supply or have existing water supply entitlements, water rights, or water service contracts, to the same source of water as the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), has identified as a source of water supply within its water supply assessments..

The Project, if approved by the City, is capable of being served by the City from the City's existing and future portfolio of water supplies. The water supply for the Project will have the same water supply reliability and water quality as the water supply available to each of the City's other existing and future water customers.

The water demands for the Project (together with existing water demands and planned future uses) are included in the City's 2010 UWMP. Therefore, the descriptions provided below for the City's water supplies have been taken, for the most part, from the City's 2010 UWMP, which was adopted in July 2011.

6.1 EXISTING POTABLE WATER SUPPLIES

10910(f) If a water supply for a proposed project includes groundwater, the following additional information shall be included in the water supply assessment.

10910(f)(1) *A review of any information contained in the urban water management plan relevant to the identified water supply for the proposed project.*

10910(f)(2) *A description of any groundwater basin or basins from which the proposed project will be supplied. For those basins for which a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), has the legal right to pump under the order or decree. For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current bulletin of the department that characterizes the condition of the groundwater basin, and a detailed description by the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), of the efforts being undertaken in the basin or basins to eliminate the long-term overdraft condition.*

10910(f)(3) *A detailed description and analysis of the amount and location of groundwater pumped by the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), for the past five years from any groundwater basin from which the proposed project will be supplied. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historical use records.*

A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), from any basin from which the proposed project will be supplied. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historical use records.

10910(f)(4) *An analysis of the sufficiency of the groundwater from the basin or basins from which the proposed project will be supplied to meet the projected water demand associated with the proposed project.*

A water assessment shall not be required to include the information required by this paragraph if the public water system determines, as part of the review required by paragraph (1), that the sufficiency of groundwater necessary to meet the initial and projected water demand associated with the project was addressed in the description and analysis required by paragraph (4) of subdivision (b) of Section 10631.

The City currently receives water supplies from groundwater pumped from 21 groundwater wells located within the City.

As described in the City’s Groundwater Management Plan (2006), the City is located in the Yolo Subbasin (Subbasin 5-21.67) of the Sacramento Valley Groundwater Basin as defined in the California DWR Bulletin 118 update (DWR, 2003). Figure 6-1 shows the location of the groundwater subbasins. The Yolo Subbasin is bounded by Cache Creek on the north; the Sacramento River on the east; Putah Creek on the south; and the Coast Range on the west.

Land surface elevations within the Yolo Subbasin range from approximately 0 feet along the southeastern edge to approximately 630 feet along the western edge. Except near the western edge of the basin, where land surface elevations increase with proximity to the Coast Range, the topographic relief is low. Land surface elevations within the City service area range from approximately 30 to 80 feet. The Plainfield Ridge, the topographic expression of the Dunnigan Hills anticline, is an area of slightly elevated rolling hills located approximately four miles west of Davis. The Yolo Basin, the flood basin of the Sacramento River, is located approximately three miles northwest of the City (Figure 6-1).

The City maintains 21 active wells in the intermediate depth and deep aquifer zones. The wells and the corresponding approximate groundwater production capacity are listed in Table 6-1.

Table 6-1. Existing City Groundwater Production Capacity

Well No.	Aquifer	Capacity, gpm
1	Intermediate	1,040
EM3	Intermediate	1,165
7	Intermediate	946
11	Intermediate	1,360
14	Intermediate	—
15	Intermediate	1,178
19	Intermediate	1,200
20	Intermediate	1,108
21	Intermediate	1,120
22	Intermediate	1,183
23	Intermediate	1,700
24	Intermediate	1,855
25	Intermediate	1,035
26	Intermediate	1,591
27	Intermediate	1,058
28	Deep	591
29	Deep	1,221[a]
30	Deep	1,712
31	Deep	2,759
32	Deep	2,339
33[b]	Deep	1,750
34	Deep	2,348[c]
Total Capacity		**30,259**
Firm Capacity[d]		27,500

Source: City of Davis Water Distribution System Optimization Plan, May 2011.

(a) Well DDW-29 is not active due to water quality concerns.
(c) The Lewis Well, which is located on the Project Site.
(b) Offline while manganese treatment system is constructed.
(d) Assumes the largest well (DDW-31) is not in service.

Figure 6-2 shows the locations of the City's wells and the Yolo Sub-basin.

The City has completed several studies and plans in the past ten years related to the groundwater system. The most significant studies are:

- Davis Deep Aquifer Study
- Davis Well Capacity Replacement Study and EIR
- Davis Groundwater Management Plan

These studies and reports are described in more detail below. Summary tables listing the City's existing and additional water supply sources and historical and anticipated future quantities are provided following the discussion of the City's additional water supplies.

6.1.1 Davis Deep Aquifer Studies

In 1999, the City obtained all of its potable water from groundwater wells, most of which were less than 700 feet deep. UC Davis obtained all of its domestic water supply from groundwater wells, all of which are deeper than 700 feet and also obtained groundwater for utility purposes from wells shallower than 700 feet deep.

Beginning with the City's Water Master Plan in 1989, several studies had recommended that the City use deep wells or treated surface water to supply all its future potable water supply needs because of water quality problems with intermediate depth wells. The UC Davis Water Management Plan also recommended that UC Davis secure a high quality surface water source to supply new water demands and reduce the use of groundwater.

The Davis Area Deep Aquifer Study was completed as a follow-up to the City of Davis Future Water Supply Study (1996) to obtain more information about the capacity, water quality, and reliability of the deep (greater than 700 feet) groundwater aquifer zone in the vicinity of the City and UC Davis.

Phase I of the Davis Area Deep Aquifer Study (West Yost & Associates and Montgomery Watson, March 1999) was completed in 1999 by the City and UC Davis. At that time, the City obtained its water supply from 20 intermediate depth wells (depth less than 700 feet) and one deep well (depth greater than 700 feet). The City had recently completed the construction of a second deep well, and planned to construct additional deep wells. Conversely, UC Davis obtained all its domestic water from the deep wells. One of the questions that this study was designed to address was "What are the potential impacts of supplying most or all of the City's and UC Davis' domestic water needs with water from deep wells?"

A preliminary simulation of Year 2035 average summer conditions was modeled assuming all water for the City and UC Davis was derived from deep wells. Pumping was simulated for 90 days using projected average summertime demands of 21,000 gpm for Davis and 3,200 gpm for UC Davis. The assumed hydraulic properties were consistent with the lower range of measured values, with a transmissivity of 3,500 square feet per day and a storage coefficient of 0.00005.

The modeling effort predicted that the additional water level drawdown in the deep aquifer in the central Davis area would be approximately 280 feet. Adding in the drawdown within and immediately surrounding a pumping well, the total additional lift could be in the 350- to 400-foot range.

Findings of the investigation include:

- The deep aquifer zone has the following physical characteristics:
  - It appears to exist throughout the study area, but may be less predominant toward the north and west.
  - It conducts water moderately well in the horizontal direction.
  - It is highly confined, meaning that future deep wells in the study area will interfere with each other and draw recharge water from a wide area.
- Future City deep wells could significantly impact existing UC Davis deep wells. Increased drawdown in the deep aquifer zone could also induce ground surface subsidence as deep clay layers become compressed.
- The deep aquifer zone has:
  - Chemical and isotopic water quality characteristics which are distinct from the intermediate aquifer zone.
  - Moderately good water quality in terms of aesthetics, taste, selenium, and nitrate.
  - Moderately elevated levels of arsenic, manganese and temperature, especially in the eastern portion of the study area.
- While water from the deep aquifer would generally be higher in quality than water from existing intermediate wells, there would still be some short- and long-term water quality issues.
- Additional water quality, subsidence, and general aquifer physical data should be gathered for the deep aquifer zone in the eastern portion of the study area.
- The deep aquifer zone may not provide an adequate degree of long-term reliability for the total domestic water needs of the City and UC Davis.

The Phase II Deep Aquifer Study (Brown and Caldwell and West Yost & Associates, July 2005) was completed in 2005 by the City in conjunction with UC Davis and the City of Woodland.

At that time, the City obtained its water supply from a combination of intermediate depth wells (depth less than 700 feet) and four deep wells (depth greater than 700 feet), while UC Davis obtained all its domestic water from the six deep wells. At that time, the City of Woodland and Pacific Coast Producers in Woodland had also completed wells into at least the upper portions of the deep aquifer in the Woodland area. The primary purpose of the Phase II Deep Aquifer Study was to gain a greater understanding of the regional deep aquifer, especially in regards to its suitability as a long-term potable drinking water supply source.

A series of pumping tests were conducted between January 22, and March 10, 2004. One objective of the tests was to assess the horizontal extent and continuity of the deep aquifer zone to the south and east of the City's Deep Well 30 and to assess the interaction between the City and UC Davis deep aquifer production wells. The pump in Well 30 was operated for 13 days at maximum capacity (2,700 gpm average), with no attempt to regulate the flow rate. Total drawdown in Well 30 was 155 feet. This pumping test produced slightly more than 10 feet of drawdown in UC Davis Deep Well 6A. The results showed that even pumping of limited duration in this City well affects water levels in UC Davis wells in the deep aquifer.

Well logs from gas exploration and water supply wells were used to develop geologic cross-sections of the City area and are documented in the Phase II report.

Observations and conclusions included:

- The deep aquifer is characterized by water quality that is distinct from the quality of water from intermediate depth wells. Deep wells produce water that is softer, less saline, and older than water from intermediate depth wells. These characteristics are found in water from deep wells throughout the study area. The transition from "intermediate" to "deep" aquifer zones based on water quality occurs at roughly 700 feet below ground surface in the Davis area and about 500 feet below ground surface in the east Woodland area.
- Natural recharge to the Deep Aquifer in the Davis and Woodland areas is likely from Coast Range drainage sources to the west.
- Boron is widespread in groundwater throughout Yolo County, even in the deep aquifer. This indicates that recharge is primarily through the Cache and Putah Creek watersheds.
- Carbon dating indicates that deep groundwater beneath Davis and Woodland is between 8,000 – 25,000 years old.
- Manganese and arsenic levels in deep groundwater vary both vertically and horizontally, and may exceed permitted drinking water levels.
- Potential water production from the deep aquifer is greatest in the western portion of the City based on drilling and testing conducted to date, and the same may be true in the Woodland area, based on geologic analysis of oil and gas logs in the Woodland area.
- Pumping of new deep wells in west Davis produced up to 10 feet of drawdown in existing UC Davis deep wells.
- Deep wells should be spaced no closer than three-fourths of a mile apart to minimize subsidence, interference, and other adverse impacts.
- Average water levels in deep existing wells do not appear to be decreasing over time. Sustainability for deep wells is likely to be limited by excessive drawdown which could result in subsidence, increased power costs, well performance deterioration, and other adverse impacts.

6.1.2 Davis Deep Aquifer Impact Assessment and Well Capacity Replacement EIR

The Davis Deep Aquifer Assessment Technical Memorandum (Brown and Caldwell and Winzler & Kelley, December 2004) was prepared in support of the City's EIR for its Well Capacity Replacement Project.

The objective of the technical memorandum (TM) was to assess the impacts of the City's proposed project to construct four to six new wells and associated pumping and storage facilities to obtain approximately 9,250 gpm of peak groundwater supply capacity from the deep aquifer. This capacity was proposed to replace lost groundwater capacity from wells removed from service since 1987. The TM's Summary of Findings contained the following statement regarding potentially significant adverse impacts:

- **Well Interference.** The anticipated pumping from new deep wells could induce up to 40 feet of piezometric water level interference on UC Davis' central campus deep wells and slightly less at City Well 31. At this time, no definitive solution exists to avoid the interference impacts. Depending upon the incremental analysis of logs and drawdown effects from new deep wells, it may be possible to design subsequent wells to minimize interference effects by drawing water from deep aquifer layers with less connectivity to UC Davis wells.
- **Aquifer Depletion.** With anticipated increased pumping in the Deep Aquifer by the City and UC Davis, increased lateral recharge from the west and increased vertical leakage would be induced to keep the Deep Aquifer in equilibrium. There would be no physical depletion of the aquifer.
- **Subsidence.** While the potential impacts cannot be accurately quantified, the potential exists for impacts and costs associated with increased risk of localized flooding and damage to existing nearby wells. Continued monitoring of land elevations in the Davis area by the Yolo County Subsidence Network and ongoing review of the results by the City should be sufficient to determine the amounts of subsidence to be expected as additional deep wells are constructed. If necessary, subsidence impacts could be partially mitigated by upgrades to stormwater conveyance facilities.
- **Water Quality Degradation.** The deep wells at UC Davis have shown very little water quality degradation over several decades. New City deep wells could show very gradual water quality degradation over time. New deep wells would not be expected to induce any additional degradation of water quality in existing intermediate depth wells.

In the Draft Well Capacity Replacement EIR (DEIR, 2004), the City proposed to construct 4 to 6 deep wells (in addition to the 4 deep wells that were in service at that time). The wells were intended to offset the capacity of intermediate depth wells that had been removed from service since 1987. Each well was expected to produce between 1,200 and 1,800 gpm and provide a total additional production capacity of about 6,770 gpm. Table 6-2 shows how the necessary additional well capacity was determined.

Table 6-2. Summary of Calculated Well Capacity Required, From 2005 Draft EIR

Well Capacity Removed From Service Since 1987	(-) 6,050 gpm
Well Capacity To Be Removed From Service In Next 2 Years	(-) 3,200 gpm
Total Well Capacity Lost Since 1987	**(-) 9,250 gpm**
Additional Well Capacity Constructed Since 1987	(+) 5,650 gpm
Total Well Capacity Deficit Since 1987	**(-) 3,600 gpm**
Peak Demand Increase Due To New Demand Since 1987	(-) 5,670 gpm
Total Peak Demand Required	**(-) 9,270 gpm**
Booster Pump Station Firm Capacity	(+) 2,500 gpm
Replacement Well Capacity Proposed in DEIR	(-) 6,770 gpm

Eight potential and two back-up well sites were evaluated in the DEIR. The sites were prioritized, with the greatest priority given to well sites in the eastern and southern portions of the City's service area where the City had experienced the greatest loss of well capacity since 1987. The only potentially significant and unavoidable impact identified in the DEIR was that there is an increased potential for land subsidence as a result of additional groundwater extraction.

For the Final Well Capacity Replacement EIR (July 2005), the Project Description was modified to incorporate changes discussed between the City and UC Davis during the DEIR comment period. The project was scaled down from the original proposal because of concerns over well interference and long-term aquifer depletion by UC Davis. The revised proposed project included installation of 2 to 3 deep aquifer wells (instead of 4 to 6 as originally proposed) with a combined maximum design pumping capacity of approximately 4,500 gpm. In addition, Sandy Motley Park was deleted from consideration as a potential well location, and the most southern and eastern sites were identified as high priority since that is where the replacement well capacity was needed. A total of seven sites were identified as high priority and three were designated as backup potential sites.

The sites identified as high priority were:

- A parcel located at 3608 Chiles Road at the south end of the Dave Pelz Bicycle Overcrossing (City-owned)
- A parcel located on the northeastern quadrant of the Mace Boulevard/Highway 80 interchange adjacent to the Park 'N Ride lot (City-owned)
- Within the community garden area at 1819 Fifth Street, east of the City Public Works Corporation Yard (City-owned)
- The El Macero Golf Course, south of the corporation yard at approximately 1050 Mace Boulevard
- A parcel located at 5448 Cowell Boulevard near a greenbelt on extreme eastern edge of the City (City-owned)

- The extreme eastern end of the Cowell Research Park parcel located at 2626 Cowell Boulevard (City-owned)
- An open-space area located adjacent to 4323 Almond Lane (City-owned)

Additionally, the following two back-up locations were identified:

- The southwest corner of Slide Hill Park at 1414 Tulip Lane (City-owned)
- The southern edge of Community Park at 1405 F Street (City-owned)

6.1.3 Groundwater Management Plan

The California Water Code (CWC) provides the authority to adopt a groundwater management plan. The 1992 Groundwater Management Act, AB 3030, established provisions by which local water agencies could develop and implement groundwater management plans (GWMPs). GWMPs are generally designed to prevent local and regional aquifer overdrafting, which reduces available groundwater resources and which, under certain conditions, can lead to degradation of water quality and to land subsidence. The City has been, and continues to be, involved in both regional and local groundwater management efforts.

On October 4, 2005, the City and UC Davis formally approved Resolution 05-278 directing the City Public Works Department to proceed with the development of an AB 3030 GWMP. The development of a GWMP was the next phase in a series of projects, described above, that focus on the sustainability of the groundwater yield and water quality of the local groundwater basin.

The City and UC Davis are within the jurisdictional boundary of the Yolo County Flood Control and Water Conservation District (YCFCWCD). The YCFCWCD was also developing a GWMP for areas within its jurisdiction. Under mutual agreement, the City and UC Davis GWMP was developed to address groundwater management needs specific to the City and UC Davis service areas, and these areas are not directly included or managed under the YCFCWCD GWMP. The City and UC Davis will continue to closely collaborate with YCFCWCD during plan implementation.

The GWMP incorporates information from the Phase I and Phase II Deep Aquifer Studies and other regional groundwater investigations into a plan for managing and monitoring the effects of groundwater utilization. The GWMP includes all mandatory and suggested components outlined in CWC §10750 et seq. and §10753.7. Compliance with these sections is required for eligibility for public funds administered by the California Department of Water Resources (DWR) for construction of groundwater projects. The statutes apply to funds authorized or appropriated after September 1, 2002. Adoption of the GWMP is not otherwise required under California law. The final Plan has been adopted by both the City and UC Davis, and filed with the DWR.

The City and UC Davis have been formally partnering in groundwater management activities since 1996. In the last several years, the City and UC Davis have increased groundwater level and quality monitoring, and have worked with other entities to collect and disseminate water quality and quantity data for the Davis area. Additionally, the City and UC Davis collaborate with other entities within the region on locally-driven groundwater management activities. The GWMP documents the City and UC Davis planned groundwater management activities, and explains potential future actions to increase the effectiveness of groundwater management in the Davis area.

A copy of the GWMP is included in Appendix B.

Excerpts from the GWMP including a summary of the basin description are provided below.

6.1.3.1 Basin Description

This section describes the Yolo Sub-basin, including its water-bearing formations, water levels, and water quality. Much of the following information has been incorporated from the City's GWMP.

The Sacramento Valley in the vicinity of the City and UC Davis is filled by a thick sequence of marine sedimentary rock of Late Jurassic (159 million years [MY] before present) to Eocene (34 MY) age, unconformably overlain by a relatively thin sequence of continental sedimentary deposits of Pliocene (5 MY) and younger age.

A generalized geologic cross section for the Sacramento Valley is shown in Figure 6-3.

The older, deeper marine rocks contain saline water. The freshwater aquifers in the vicinity of the City and UC Davis occur in the overlying continental sedimentary deposits, which are presented from oldest to youngest in the following discussion. Figure 6-4 is a geologic map encompassing the City, UC Davis, and vicinity.

Shallow groundwater in the Davis area occurs under unconfined conditions in the Holocene stream channel deposits, except where these units are overlain by Holocene Basin Deposits, creating confined conditions. At greater depths, groundwater occurs under mostly semiconfined to confined conditions in a single heterogeneous aquifer system, composed of predominantly fine-grained sediments enclosing discontinuous lenses of sand and gravel. The aquifer properties, including hydraulic conductivity, vertical leakance and degree of confinement are dependent on the properties of the fine grained units. The geologic formations comprising the freshwater aquifer are listed from oldest to youngest in the following list.

- Tehama Formation
- Riverbank and Modesto Formations
- Holocene Stream Channel and Basin Deposits
- Tectonic Effects

The Tehama Formation is the primary water-bearing stratigraphic unit in the area (Figure 6-2). The permeability of the Tehama Formation is highly variable but generally less than the overlying Quaternary alluvium. Because of the relatively large thickness, wells can yield up to several thousand gpm. The majority of irrigation and public supply wells in the Davis area are completed in the Tehama Formation. Based on these constraints, deposition of the Tehama Formation began about 3.4 MY and ended about 1.09 MY, which is equivalent to a Pliocene to Pleistocene age.

The Tehama and Red Bluff Formations are unconformably overlain by the late Pleistocene age Riverbank and Modesto Formations. These formations consist of up to 200 feet of loose to moderately compacted silt, silty clay, sand, and gravel deposited in alluvial depositional environments during periods of world-wide glaciation. In the Davis area, the Riverbank and Modesto Formation are not directly related to glacial activity, because glaciers were generally not present in the Coast Ranges. Instead, the formations were deposited in response to changes in base level and increased precipitation during the glacial periods. The increased stream gradients and precipitation resulted in greater stream discharge and competency than at the present time. The greater competency of the streams led to scouring of stream channels in pre-existing geologic deposits, followed by transport, deposition and burial of sands and gravels in the channels as the glacial cycles progressed. The age of the Riverbank Formation ranges from 0.13 to 0.45 MY and corresponds to the Illinoisan and older glacial stages. The age of the Modesto Formation ranges from approximately 0.01 to 0.042 MY and correlates to the Wisconsin glacial stage. Wells penetrating the sand and gravel units of the Riverbank and Modesto Formations produce up to about 1,000 gpm. The majority of the private, domestic wells in the Davis area are completed in the Riverbank and Modesto Formations.

Holocene stream channel and basin deposits are the youngest sediments in the region, with ages of 10,000 years or less. The stream channel deposits consist of up to 80-foot sections of unconsolidated clay, silt, sand, and gravel reworked from older formations by streams. Some of the shallower domestic wells in the Davis area may be screened in Holocene stream channel deposits. Because of their low permeability, limited extent, and generally poor water quality, Holocene flood basin deposits are typically not used for groundwater production.

Tectonism related to changing dynamics of the north-northwest trending San Andreas fault plate boundary along the California coast continued to uplift and deform the Coast Ranges after the deposition of the Tehama Formation.

Faults may affect groundwater flow by bringing geologic materials with different hydraulic properties into contact across the fault plane or by fracturing the materials, which could either increase or decrease permeability, depending on the degree of fracturing and other geologic processes, such as mineralization, active within the fault zone. A fault might, therefore, act as a boundary or barrier affecting the lateral flow of groundwater between adjacent areas, and might act as a conduit allowing vertical or lateral flow within the fault zone. At present the effect of the known faults in the area on groundwater flow is unknown, but easterly flow of groundwater beneath the Dunnigan Hills appears to be impeded.

Folds may also affect groundwater conditions because the folds cause the elevation of geologic units to vary from place to place.

The information summarized above is provided in greater detail in the City's GWMP (Appendix B).

6.1.3.2 Groundwater Movement and Storage

As described in the Groundwater Management Plan, generally, groundwater flow is from the margins of the Sacramento Valley toward the Sacramento River and then southward towards the Sacramento-San Joaquin Delta. Locally, near the losing stretches of Putah Creek east of the

Plainfield Ridge, groundwater flow is northeast or southeast away from the creek. Groundwater pumping in several areas has created cones of depression that disrupt this pattern.

In the vicinity of Davis and UC Davis, the base of fresh groundwater occurs at a depth of approximately 2,800 feet below mean sea level, implying that the fresh water aquifer is about 2,800 feet thick. However, it has only been practical thus far to construct wells less than 2,000 feet deep.

6.1.3.3 Groundwater Levels

Groundwater elevation measurements have been recorded in the Davis area for over 50 years and are available through the DWR Water Data Library at http://wdl.water.ca.gov. Historically, groundwater elevations in the region have ranged from roughly -40 feet to 50 feet above mean sea level (msl). Representative hydrographs for wells in the Davis Area are shown in the Groundwater Management Plan. The figures show that groundwater elevations declined through the 1950s and 1960s. Groundwater elevations increased thereafter, in response to regional water supply projects implemented by Solano County Water Agency and YCFCWCD.

In addition to groundwater elevations resulting from variation in land and water use practices over time, the hydrographs also show that groundwater elevations have fluctuated in response to changes in precipitation. The area experienced multiple years of below normal precipitation in 1976 through 1977 and 1988 through 1991. These periods are apparent in the hydrographs. Groundwater elevations in the falls of 1977 and 1992 were near the historical minima recorded in the mid-1960s. The maximum groundwater elevation measurements were recorded in spring 1983, the same year that the maximum annual precipitation was recorded.

6.1.3.4 Groundwater Quality

Groundwater in the Davis area is of moderate quality for municipal and agricultural water supply. Major groundwater production zones have traditionally been divided into the “Intermediate Aquifer” and “Deep Aquifer” based on general water chemistry, even though both are geologically part of the larger Tehama Formation. The “Intermediate Aquifer” begins at about 200 feet below ground surface, transitioning to the “Deep Aquifer” at about 700 feet below ground surface. Groundwater is characterized as dominated by calcium-magnesium bicarbonate in the “Intermediate Aquifer” and sodium bicarbonate in the “Deep Aquifer”. Groundwater from the “Deep Aquifer” is more desirable for household use, having low concentrations of nitrate and selenium, and moderate hardness. Groundwater from the “Intermediate Aquifer” is more desirable for irrigation, having lower relative concentrations of sodium. Boron is found throughout all zones at concentrations that can have some adverse effects when used for irrigation of sensitive plants. Arsenic concentrations are relatively higher in some of the “Deep Aquifer” zones than in other zones, though still generally below drinking water limits.

Because of the better acceptability for household use, new drinking water supply wells for the City and UC Davis have been completed into the “Deep Aquifer”. Water quality will be monitored in the future to determine if and when recharge from shallower sources is reaching deep wells. Concerns about water quality have been one of the driving forces for the pursuit of supplemental surface water.

6.1.4 Historical Groundwater Use

As discussed previously, the City currently operates 21 groundwater extraction wells (Table 6-1) completed in both the intermediate depth and deep aquifer zones.

Historically, groundwater has accounted for 100 percent of the City's annual water supply. Between 1995 and 2010, the City's groundwater use has varied from a 15-year low of 11,908 acre-feet in 1998 to a high 15,112 acre-feet in 2002. The City's groundwater use in 2010 was 11,955 acre-feet, just above the 15-year low.

Potential increases in the City's water demand due to growth have been offset in part by the City's water conservation program. The City's groundwater production over the last six years is provided in Table 6-3.

Table 6-3. Historical Groundwater Production

	2005	2006	2007	2008	2009	2010
Total Groundwater Production, af/yr	14,452	14,333	14,762	14,219	12,835	11,955

Source: Table 3-2. Groundwater – Volume Pumped (DWR Table 18), City of Davis 2010 UWMP, July 2011.

6.1.4.1 Projected Future Groundwater Use

With the completion of Well DDW-34, the City has reached its new groundwater supply limit documented in the final Davis Well Capacity Replacement EIR (July 2005). Future increases in deep groundwater production would likely require a CEQA process. The City may replace existing deep well pumping to maintain its current capacity.

As discussed below, the City is planning on completing a project to deliver treated surface water from the Sacramento River to City potable water customers. This project is anticipated to be placed into service between 2015 and 2020. This surface water project will allow the City to scale back its future groundwater extractions during normal years. For example, at buildout of the General Plan, groundwater production capacity in normal years is anticipated to be approximately 6,000 af/yr, according to the 2010 UWMP. The City will continue to rely on groundwater for demand peaking, drought, and emergency supplies, during single dry or multiple dry years, as needed, to meet demands when surface water supplies may be limited.

Table 6-4. Projected Groundwater Production Capacity

	2015	2020	2025	2030	2035
Projected Potable Groundwater Production Capacity, af/yr	15,000	6,000	6,000	6,000	6,000

Source: Table 4-5. Water Supplies – Current and Projected (DWR Table 16), City of Davis 2010 UWMP, July 2011.
(a) Assumes surface water deliveries, discussed below, beginning in 2016.

In the future, the City will construct new production and emergency supply wells, as needed, to replace existing, aging production wells and to provide supply reliability in the event of a drought or other emergency situation.

The City's potential uses of groundwater during droughts are consistent with its Groundwater Management Plan (discussed above). By reducing groundwater extraction on an average annual basis to approximately 6,000 af/yr or less, the City will:

- Increase the overall quality of its drinking water, thus increasing customer satisfaction and reducing system maintenance and repair caused by the lower-quality groundwater;
- Allow the underlying aquifer to recharge, effectively increasing the availability of groundwater during a drought or emergency condition (*i.e.*, the City will effectively be "banking" its groundwater); and
- Reduce salts in the City's wastewater which will help the City comply with wastewater discharge requirements.

If the City decreases future groundwater extraction during normal and wet years, current groundwater levels, groundwater flow directions and gradients, and groundwater quality would be expected to change correspondingly. Further, as the City moves ahead with its proposed future surface water project, and if the City introduces an aquifer storage and recovery program (see discussion below), changes in groundwater flow patterns associated with the injection of treated surface water into the confined aquifer zone may occur. Groundwater quality would be expected to improve as a result of the introduction of higher quality surface water into the aquifer.

6.1.4.2 Groundwater Sufficiency

The City's 2010 UWMP addressed the sufficiency of the City's groundwater supplies, in conjunction with the City's other existing and additional water supplies, to meet the City's existing and planned future uses. Based on the information provided above and that included in the City's 2010 UWMP, the City's groundwater supply is sufficient to meet the water demands of the Project, in addition to the City's existing uses. As discussed above, the City's use of groundwater over the last few years has significantly declined, primarily due to water conservation programs. In the future, the City's use of groundwater is anticipated to decrease even further, as high-quality surface water supplies become available. As shown in Table 6-4, in the future, assuming normal year hydrologic conditions, annual groundwater use is anticipated to be as low as 6,000 af/yr by 2020, as indicated in the 2010 UWMP. This anticipated future groundwater pumpage is significantly below the City's historical groundwater pumpage (see Table 6-3), the average annual operational deep well capacity of 8,000 to 9,000 af/yr, and the projected pumping discussed below under Dry Year Water Supplies.

By reducing groundwater extraction on an average annual basis, the City will: (1) recharge the underlying aquifer, effectively increasing the availability of groundwater during a drought or emergency condition (*i.e.*, the City will effectively be "banking" its groundwater); and (2) increase the overall quality of its drinking water, thus increasing customer satisfaction and reducing system maintenance and repair caused by the lower-quality groundwater.

6.2 ADDITIONAL (FUTURE) POTABLE WATER SUPPLIES

The City is currently anticipating additional potable water supplies in the future to be surface water delivered through the Woodland-Davis Clean Water Agency for direct consumption or to serve an aquifer storage and recovery (ASR) program.

Each of these additional water supply opportunities is described below. Summary tables listing the City's existing and additional water supplies, and historical and anticipated future quantities are provided at the end of this section.

6.2.1 Davis Woodland Water Supply Project

The City is participating in the Davis Woodland Water Supply Project. Most of the description below is from the Woodland-Davis Clean Water Agency website and the City's 2010 UWMP.

In September 2009, the Cities of Woodland and Davis established the Woodland-Davis Clean Water Agency (WDCWA), a joint powers authority, to implement and oversee a regional surface water supply project.

The regional project will replace deteriorating groundwater supplies with safe, more reliable surface water supplies from the Sacramento River. Once complete, the project will serve more than two-thirds of the urban population of Yolo County. It will also likely serve UC Davis, a project partner.

Primary Project Goals:

- Provide a new water supply to help meet existing and future needs
- Improve drinking water quality
- Improve the quality of treated wastewater

Project plans include a jointly-owned and operated intake on the Sacramento River with RD 2035, raw water pipelines connecting the intake to a new regional water treatment plant, and separate pipelines delivering treated water to Woodland, Davis, and UC Davis. Improvements to existing water supply systems will vary for Woodland and Davis and will include facilities such as distribution pipelines, water storage tanks and booster pump stations.

The regional water supply project is scheduled for design between now and 2013, for construction between 2013 and 2015, and for operation in 2016.

Under the project's first phase, approximately 17.6 to 18.4 million gallons per day (mgd) of treatment and delivery capacity and an annual volume of up to 20,131 af/yr will be reserved for the City through 2030, with an additional 5.4 to 5.5 mgd treatment and delivery capacity (for a total of approximately 23 mgd) when the water treatment facility is expanded to treat 51.8 mgd. This expansion is currently anticipated between 2030 and 2035.

The City is currently evaluating the possibility of altering the proposed surface water project capacity and phasing, likely reducing its capacity request for the first phase of the project.

The project will ultimately divert up to 45,000 acre-feet of water per year from the Sacramento River. Appropriative water rights were granted in March 2011, and will be subject to conditions imposed by the state. Water diversions will be limited by Term 91 during summer and other dry periods. A more senior water right for 10,000 acre feet was purchased from Conaway Preservation Group (CPG) to provide a summer water supply. Groundwater will continue to be used by Davis when demand for water cannot be met with surface water supplies alone.

Amendment 1 (signed September 29, 2011) to the Joint Power Authority (JPA) Agreement that established the WDCWA (signed September 15, 2009) changed the proposed allocation of cost and water rights among the project participants. UC Davis has an option to participate in the project. The dedicated capacity listed in Amendment 1 is shown in Table 6-5.

Table 6-5. Initial Dedicated Capacity of WDCWA Surface Water Project

	With UC Davis			Without UC Davis		
	Percent	WTP Capacity, mgd	Annual Limit, acre-feet per year	Percent	WTP Capacity, mgd	Annual Limit, acre-feet per year
Davis	43.9	17.6	20,131	46.1	18.4	21,053
Woodland	51.6	20.6[a]	24,006	53.9	21.6[a]	25,084
UC Davis	4.5	1.8	2,000	—	—	—
Total	100	40	46,137	100	40	46,137

(a) Davis capacity would increase to 23 mgd and 23.9 mgd with and without UC Davis, respectively, when the WTP capacity is increased to 51.8 mgd.

Projected surface water deliveries are expected to be close to the values reported in the City's 2010 UWMP (approximately 13,000 af/yr).

Details of the two WDCWA surface water rights are discussed below.

6.2.1.1 Agency Water Right

The WDCWA holds appropriative water right Permit 20281, which authorizes the WDCWA to divert up to 45,000 acre-feet per year from the Sacramento River. Potable water demands for the entire WDCWA (Woodland, Davis, and UC Davis) are not expected to exceed the 45,000 acre-foot annual diversion limit before 2050.

The WDCWA's rights to divert water under Permit 20281 are subject to curtailments under State Water Resources Control Board (SWRCB) Term 91. Specifically, when the diversion prohibition in Term 91 is in effect, surface water may not be diverted from the Sacramento River under this water right permit. Because some Term 91 curtailments can be expected almost every year, there is a need for supplemental surface water during those periods.

6.2.1.2 CPG Water

The WDCWA has purchased appropriative rights for 10,000 af/yr of water from the CPG. Under this purchase agreement, portions of two of the CPG water right licenses will be assigned to the WDCWA, and a portion of the CPG Bureau of Reclamation (Bureau) Sacramento River water rights settlement contract will also be assigned to the WDCWA. Because these CPG water rights have fairly high priorities, and the resultant settlement contract with the Bureau recognizes those priorities, water may be diverted under these water rights during periods when Term 91 is in effect. Nevertheless, the CPG water is subject to the following limitations:

1. Water may not be diverted under the CPG water right permit or Bureau settlement contract during the months of November through March.
2. Total annual diversion is limited to a maximum of 10,000 acre-feet during the period from April through October.
3. Total annual diversion is further limited to a maximum of 7,500 acre-feet during July through September.
4. Total annual diversion can be reduced by as much as 25 percent during Lake Shasta critical years to a maximum of 7,500 acre-feet in April through October, and to a maximum of 5,625 acre-feet during July through September.

6.2.2 Aquifer Storage and Recovery

The City is considering the potential benefits of an ASR program that would allow the City to optimize the conjunctive use of its water supplies through injection of treated (potable) drinking water into selected aquifer zones within the groundwater sub-basin for storage when surplus supplies are available, and recovery of that potable water from the aquifer to optimize water quality and meet seasonal peak demands during drought periods, or when emergency or disaster scenarios preclude the use of imported water supplies.

6.3 NON-POTABLE WATER SUPPLIES

The Cannery may use an existing non-potable irrigation well to offset the use of potable water for non-potable landscape irrigation. However, at this time, no firm plans are in place for use of non-potable water. The use of non-potable water for irrigation could reduce the Project's potable water demand by up to 140 af/yr, based on a projected irrigable area of 32.5 acres and an annual water use of 4.3 af/acre/yr, as indicated in Table 2-3.

6.4 SUMMARY OF EXISTING AND ADDITIONAL WATER SUPPLIES

Table 6-6 provides a summary of the City's existing and additional water supply entitlements. A discussion of the future anticipated availability of these existing and additional water supplies during dry years is provided in the next section.

Table 6-6. Summary of Existing and Additional Water Supplies

Supply	Water Right or Available Supply Quantity, af/yr	Supply Ever Used by City
Existing Water Supplies		
Groundwater[(a)]	15,000	Yes
Additional Water Supplies		
WDCWA Surface Water Supply	13,000	No
Aquifer Storage and Recovery[(b)]	Unknown	No

(a) The City is planning to decrease groundwater use to 6,000 af/yr by the year 2020. However, studies described in this WSA have indicated 8,000 af/yr or more of groundwater would be available to the City to make up for shortfalls in the event of a severe drought or other water shortage.
(b) Supplies from ASR are assumed to be dry year supplies. As such, during normal years, supplies from these sources are assumed to be 0 af/yr.

6.5 DRY YEAR WATER SUPPLY AVAILABILITY AND RELIABILITY

Water Code section 10910 (c)(4) requires that a WSA include a discussion with regard to *"whether total projected water supplies, determined to be available by the city or county for the project during normal, single dry, and multiple dry water years during a 20-year projection, will meet the projected water demand associated with the proposed project, in addition to existing and planned future uses, including agricultural and manufacturing uses."* Accordingly, this WSA addresses these three hydrologic conditions through the year 2035.

The reliability of each of the City's existing and additional water supplies and their projected availability during normal, single dry, and multiple dry years, is described below and summarized in Table 6-7.

Table 6-7. Water Supply Reliability in Normal, Single Dry, Multiple Dry Years[(a)]

Supply Source	Anticipated Reliability (% of Entitlement)		
	Normal Years	Single Dry Years	Multiple Dry Years
Existing Water Supplies			
Groundwater[(b)]	100	100	100
Additional Water Supplies			
WDCWA Surface Water Supply[(c)]	84	49	72
Aquifer Storage and Recovery[(d)]	—	100	100

(a) The City's 2010 UWMP Update Tables 7-1 through 7-3 Supply and Demand Comparison - Normal Year, Single Dry Year and Multiple Dry Year Events (DWR Tables 32, 33, and 34) indicates 100% reliability of the City projected conjunctive use water supply through 2035, but does not indicate the reliability of the individual water supply sources.
(b) The City is planning to decrease groundwater use to 6,000 af/yr by the year 2020. However, studies described in this WSA have indicated 8,000 af/yr or more of groundwater would be available to the City to make up for shortfalls in the event of a severe drought or other water shortage.
(c) Some degree of impairment could be expected due to Term 91 restrictions, the restriction would be compensated for by using the purchased surface water right and available deep well groundwater capacity.
(d) Supplies from ASR are assumed to be dry year supplies. As such, during normal years, supplies from these sources are assumed to be 0 af/yr.

The City's Water Shortage Contingency Plan was established in 1992, consistent with Water Code section 10632, and includes five stages of action to respond to a water shortage with up to a 50 percent reduction in available water supplies. Each stage of action includes specific water consumption reduction measures, water use prohibitions, and penalties for excessive water use. The Water Shortage Contingency Plan also includes a Catastrophic Supply Interruption Plan, prepared in accordance with Water Code section 10632(c), which addresses actions to be taken by the City during and immediately following an emergency. The City's Water Shortage Contingency Plan and Catastrophic Supply Interruption Plan are further described in the City's 2010 UWMP.

6.5.1 SWRCB Term 91

As indicated above, Term 91 is a State Water Resources Control Board (SWRCB) standard water right permit term that has been in effect since 1984. Term 91 prohibits certain Sacramento River water right diversions during low-flow conditions in the Sacramento River watershed, and is therefore reflective of snowpack and reservoir conditions throughout the Sacramento Basin. Lake Shasta critical years, on the other hand, are determined by inflows into Lake Shasta, and are therefore more reflective of snowpack and river flows in the Siskiyou Mountains and the McCloud and Pit River watersheds. As a result, prolonged Term 91 conditions and Lake Shasta critical years are not always concurrent.

Dry year water supply analysis requires knowledge and information about probable Term 91 curtailments and Lake Shasta critical year occurrences over the 2016–2050 simulation period. However, because both factors are largely dependent on wet season weather patterns, future Term 91 and Lake Shasta conditions cannot be predicted with certainty. Because of the time-varying nature of both parameters, a stochastic approach was used in an analysis by West Yost (West Yost January 10, 2012) to project Term 91 curtailments and Lake Shasta critical year occurrences over the 2016–2050 simulation period.

Because Term 91 has been in effect since 1984, actual Term 91 curtailments are available for fewer than three decades. Moreover, the criteria for imposing Term 91 curtailments have changed over time. Therefore, Term 91 curtailments in the 1980s and early 1990s do not necessarily reflect current or expected future Term 91 curtailments.

For these reasons, a synthesized historical Term 91/Lake Shasta record has been developed using the hydrologic record in conjunction with the use of the CalSim-II model. The details of that analysis, plus an in-depth explanation of Term 91 and Shasta critical years, are presented in a separate document titled "Estimate of Future SWRCB Term 91 Curtailments" (MBK Engineers, April 2011).

The synthesized Term 91/Lake Shasta historical record for the period of 1922–2002 is shown in Figure 6-5. As indicated, Lake Shasta critical year reductions coincide with all occurrences of Term 91 curtailments of six months or greater, but also occasionally happen during relatively normal Term 91 years.

The frequency of Term 91 curtailments by duration are summarized in Table 6-8. As indicated, three-month Term 91 curtailments are the most common, representing 38 percent of all years in the synthesized record. Two-month and four-month curtailments are also common, while curtailments of six months or longer represent only five percent of the synthesized record.

Term 91 is almost always in effect in July and August, with curtailments in June and September also being relatively common. In addition, Term 91 curtailments are in effect during November for 16 percent of the years in the synthesized record. This result is significant because neither the Permit 20281 supply nor the CPG supply is available in November when the Term 91 diversion prohibition is in effect, as discussed above. Therefore, in the absence of an additional supplemental surface water supply, no surface water would be available under those conditions, and the City would need to rely on a combination of municipal groundwater and previously-stored ASR water (if an ASR program is implemented by the City).

Table 6-8. Frequency of Occurrence of Term 91 Curtailments

Term 91 Duration, months	Frequency of Occurrence, percent	Frequency of Indicated Duration or Shorter, percent	Frequency of Indicated Duration or Longer, percent
0	4	4	100
1	5	9	96
2	16	25	91
3	38	63	75
4	26	89	37
5	6	95	11
6	1	96	5
7	4	100	4

6.5.2 Normal Years

Normal or wet water years are those water years that match or exceed median rainfall and runoff levels. The following describes the availability and reliability of the City's existing and additional water supplies under normal year conditions:

- The City's firm deep well groundwater capacity of 9,200 gpm would be available under all hydrologic conditions.
- The Term 91 analysis, discussed above, indicates that three months is the median (50 percent exceedence) number of months with interrupted surface water supply.
- The CPG water right would be subject to the restrictions described above. During a Normal year, 7,500 acre-feet would be available for all the project partners (approximately 3,300 acre-feet for the City), assuming the three month curtailment occurred during July, August, and September. The remaining 2,500 acre-feet (approximately 1,100 acre-feet for the City) would be available in months other than July, August, and September.

The results of the stochastic analysis indicate that approximately 84 percent of the City's water supply could be available from all the WDCWA surface water entitlements in 2030 under Normal hydrologic conditions, whether because of Term 91 curtailments or because of the need to provide a supplemental supply during maximum demand periods. The value of 84 percent is being used in this WSA as the reliability, although additional surface water would be available outside of Term 91 curtailment months for use in an ASR program. The remaining water supply would be from groundwater.

The reliability of each of the City's existing and additional water supplies and their projected availability during normal and wet years is shown in Table 6-9.

6.5.3 Single Dry Years

Single Dry Years are defined as the 100 percent exceedence years (driest year on record). The following describes the availability and reliability of the City's existing and additional water supplies under single dry year conditions:

- The City's firm deep well groundwater capacity of 9,200 gpm would be available under all hydrologic conditions.
- The Term 91 analysis, discussed above, indicates that seven months is the maximum (100 percent exceedence) number of months with interrupted surface water supply.
- The CPG water right would be subject to the restrictions described above. During a Single Dry Year, 7,500 acre-feet would be available for all the project partners (approximately 3,300 acre-feet for the City), over the seven month period, with a maximum of 5,625 acre-feet (approximately 2,500 acre-feet for the City) available during July through September.

The results of the stochastic analysis indicate that approximately 49 percent of the City's water supply could be available from the WDCWA surface water in 2035 under Single Dry Year hydrologic conditions, whether because of Term 91 curtailments or because of the need to provide a supplemental supply during maximum demand periods. The value of 49 percent is being used in this WSA as the reliability, although additional surface water would be available outside of Term 91 curtailment months for use in an ASR program. The remaining water supply would be from groundwater

The reliability of each of the City's existing and additional water supplies and their projected availability during a single dry year is shown in Table 6-10.

Table 6-9. Projected Existing and Additional Water Supplies Available in Normal Years

Supply	Anticipated Reliability (% of Entitlement)	Projected Future Available Supply, af/yr					
	Normal Years		2015	2020	2025	2030	2035
Existing Water Supplies							
Groundwater[(a)]	100		13,095	6,000	6,000	6,000	6,000
Additional Water Supplies							
WDCWA Surface Water Supply	84		0	11,943	12,342	12,714	13,104
Aquifer Storage and Recovery[(b)]	—		—	—	—	—	—
Total Projected Potable Water Supply			**13,095**	**17,943**	**18,342**	**18,714**	**19,104**
% Cutback from Normal Year			0	0	0	0	0

(a) The City is planning to decrease groundwater use to 6,000 af/yr by the year 2020. However, studies described in this WSA have indicated that up to 8,500 af/yr of groundwater is available to the City to make up for shortfalls in the event of a severe drought or other water shortage.

(b) Assumed to be zero in normal years, as ASR is considered to be dry year supplies.

Table 6-10. Projected Existing and Additional Water Supplies Available in Single Dry Years

Supply	Anticipated Reliability (% of Entitlement)	Projected Future Available Supply, af/yr					
	Single Dry Years		2015	2020	2025	2030	2035
Existing Water Supplies			13,095	8,500	8,500	8,500	8,500
Groundwater[(a)]	100						
Additional Water Supplies							
WDCWA Surface Water Supply	49		0	7,043	7,233	7,433	7,642
Aquifer Storage and Recovery[(b)]	100		—	—	—	—	—
Total Projected Potable Water Supply			**13,095**	**15,543**	**13,733**	**15,933**	**16,142**
% Cutback from Normal Year			0	0	0	0	0

(a) The City is planning to decrease groundwater use to 6,000 af/yr by the year 2020. However, studies described in this WSA have indicated that up to 8,500 af/yr of groundwater is available to the City to make up for shortfalls in the event of a severe drought or other water shortage.

(b) The volume of water to be stored and recovered from the potential ASR program has not yet been determined.

6.5.4 Multiple Dry Years

Multiple Dry Years are frequently defined as the 80 to 90 percent exceedence value. The following describes the availability and reliability of the City's existing and additional water supplies under multiple dry year conditions:

- The City's firm groundwater capacity of 9,200 gpm would be available under all hydrologic conditions.
- The Term 91 analysis, discussed above, indicates that a curtailment of four or five months would be expected (80 to 90 percent exceedence).
- The CPG water right would be subject to the restrictions described above. A multiple dry year is also assumed to be a Shasta Critical Year and therefore 7,500 acre-feet would be available for all the project partners (approximately 3,300 acre-feet for the City), over the seven month period, with a maximum of 5,625 acre-feet (approximately 2,500 acre-feet for the City) available during July through September.

The results of the stochastic analysis indicate that approximately 72 percent of the City's water supply could be available from the WDCWA surface water in 2035 under Multiple Dry Year hydrologic conditions, whether because of Term 91 curtailments or because of the need to provide a supplemental supply during maximum demand periods. The value of 72 percent is being used in this WSA as the reliability, although additional surface water would be available outside of Term 91 curtailment months for use in an ASR program. The remaining water supply would be from groundwater.

The reliability of each of the City's existing and additional water supplies and their projected availability during a single dry year is shown in Table 6-11.

Table 6-11. Projected Existing and Additional Water Supplies Available in Multiple Dry Years

Supply	Anticipated Reliability (% of Entitlement)	Projected Future Available Supply, af/yr					
	Single Dry Years		2015	2020	2025	2030	2035
Existing Water Supplies							
Groundwater[(a)]	100		13,095	6,000	6,000	6,000	6,000
Additional Water Supplies							
WDCWA Surface Water Supply	72		0	10,294	10,595	10,910	11,242
Aquifer Storage and Recovery[(b)]	100		—	—	—	—	—
Total Projected Potable Water Supply			**13,095**	**16,294**	**16,595**	**16,910**	**17,242**
% Cutback from Normal Year			0	0	0	0	0

(a) The City is planning to decrease groundwater use to 6,000 af/yr by the year 2020. However, studies described in this WSA have indicated that up to 8,500 af/yr of groundwater is available to the City to make up for shortfalls in the event of a severe drought or other water shortage.
(b) The volume of water to be stored and recovered from the potential ASR program has not yet been determined.

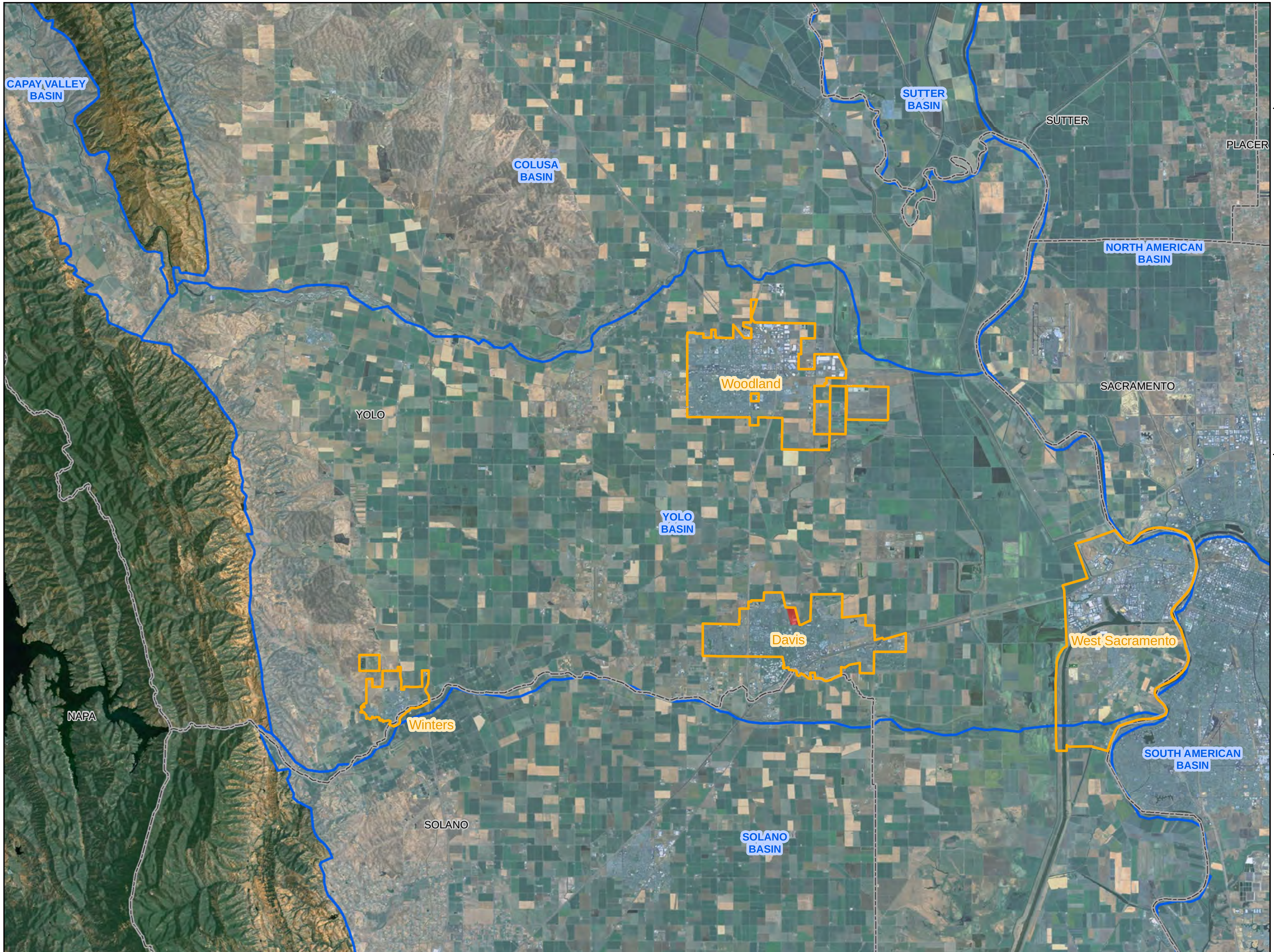


FIGURE 6-1

The Cannery
Water Supply Assessment

GROUNDWATER SUB BASINS

N

0 1.5 3 Miles

LEGEND

- The Cannery Project Area
- City Limits
- County
- CA Bulletin 118 Groundwater Sub Basins

WEST YOST ASSOCIATES
Consulting Engineers

N:\Clients\487 De Novo Planning Group\00-12-02 DavisCanneryEIR\GIS\Figures\Figure 6-2 Davis Wells.mxd 6/25/2012

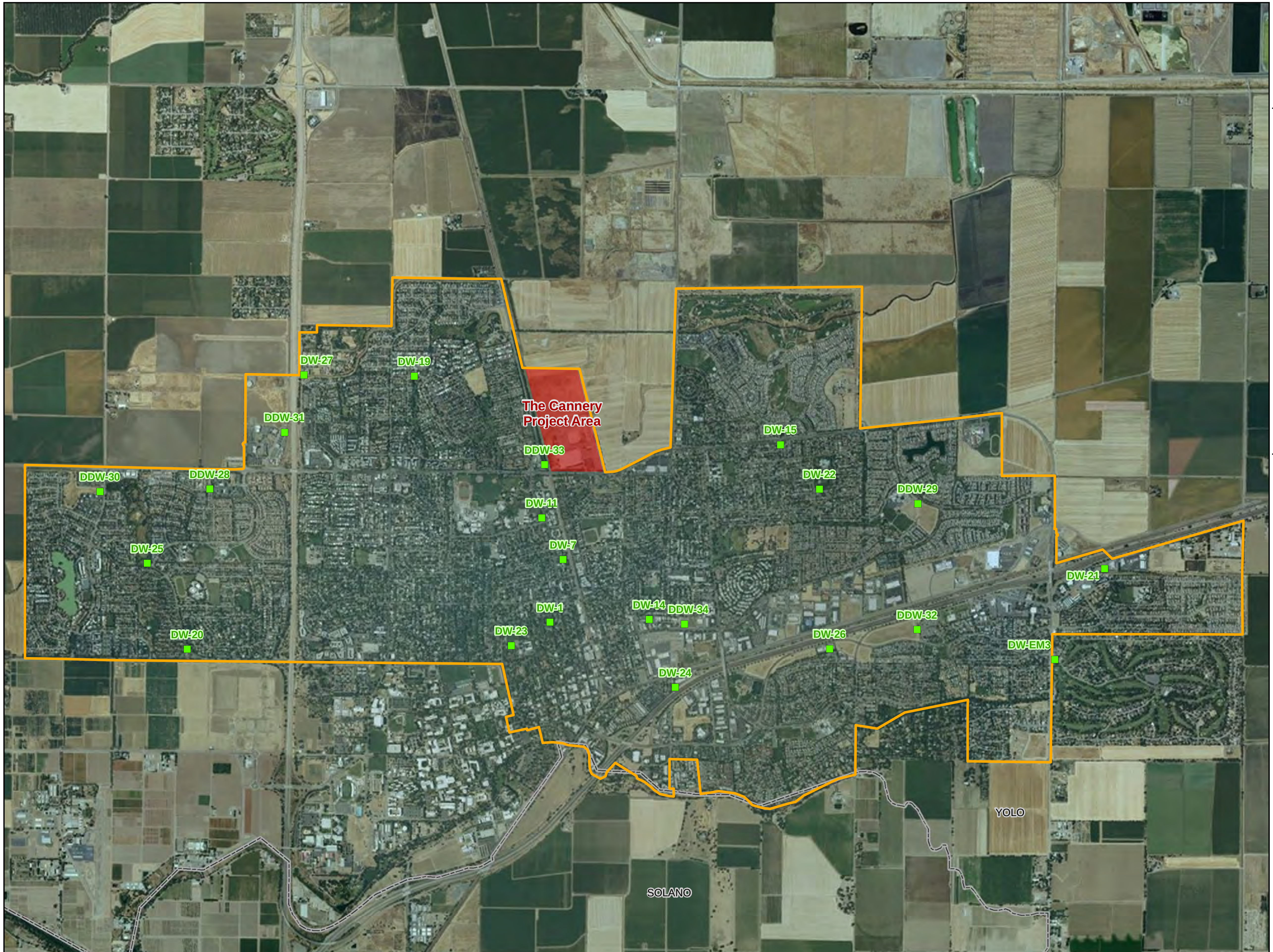


FIGURE 6-2

The Cannery
Water Supply Assessmentt

EXISTING CITY OF DAVIS GROUNDWATER WELLS

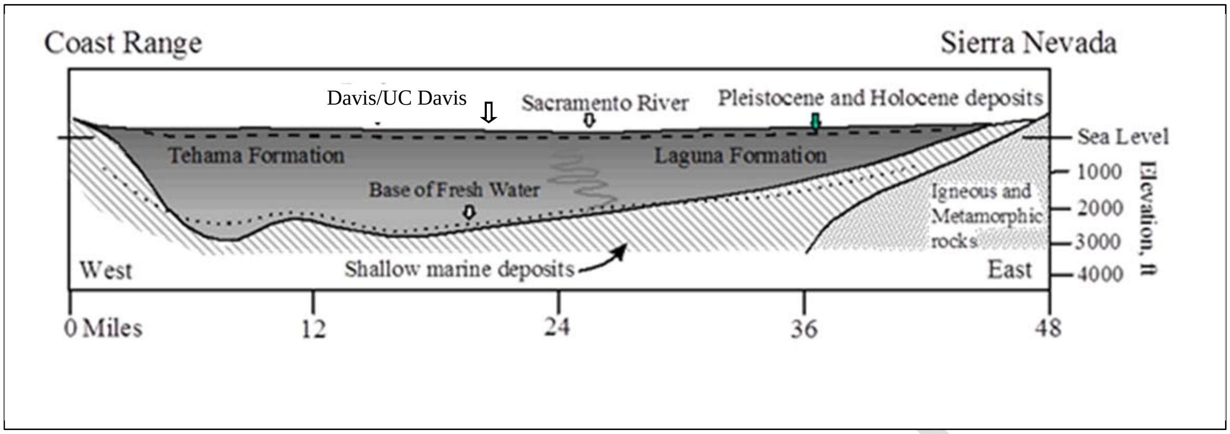
N

0 0.25 0.5 Miles

LEGEND
- The Cannery Project Area
- City Limits
- County

WEST YOST ASSOCIATES
Consulting Engineers

Figure 6-3. Sacramento Valley Geologic Cross Section



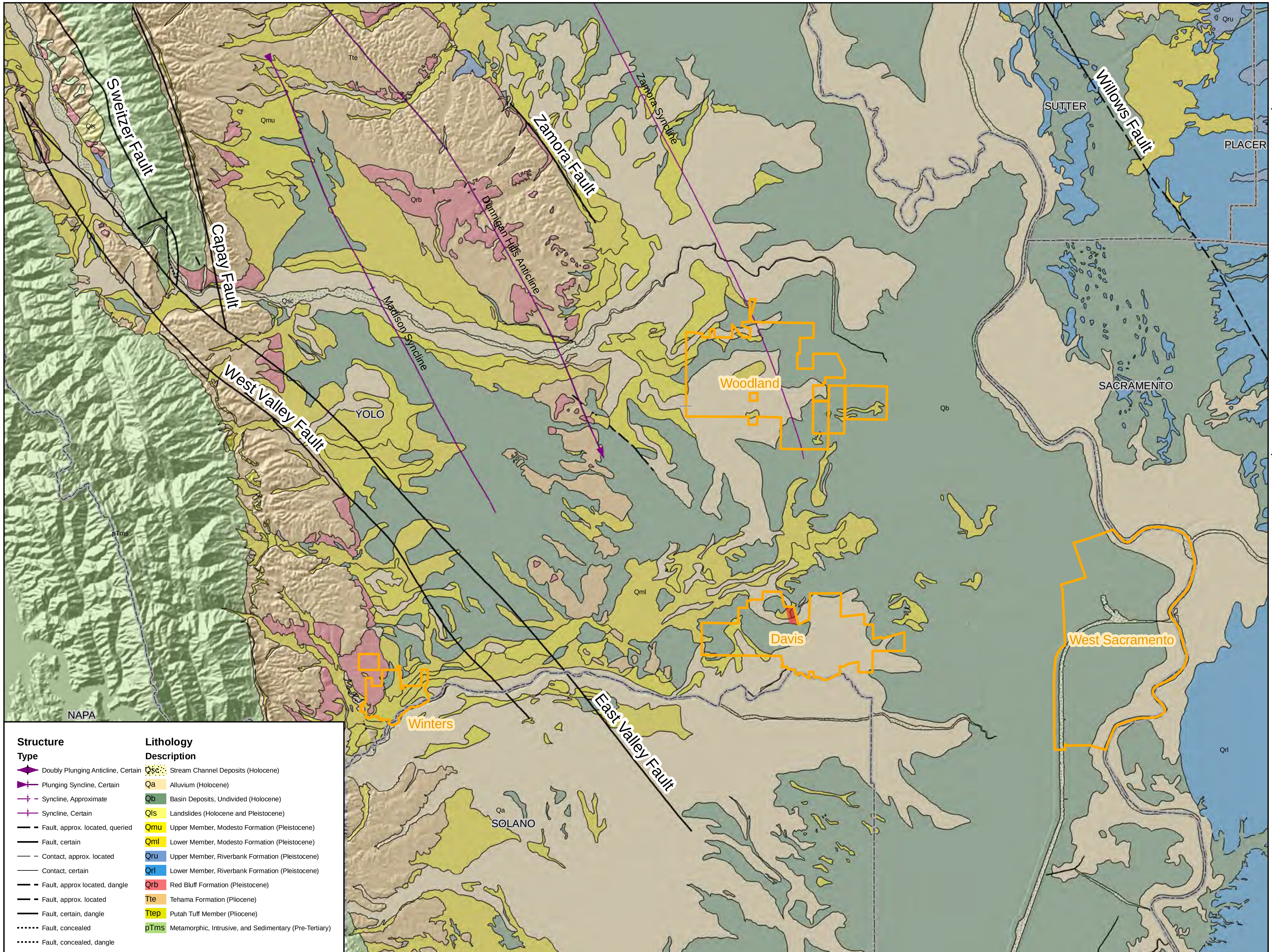
Source: California Department of Water Resources, 1978

N:\Clients\487 De Novo Planning Group\00-12-02 DavisCanneryEIR\GIS\Figures\Figure 6-4 Geologic Map.mxd 6/25/2012

FIGURE 6-4

The Cannery Water Supply Assessment

GEOLOGIC MAP



N

0 1.5 3 Miles

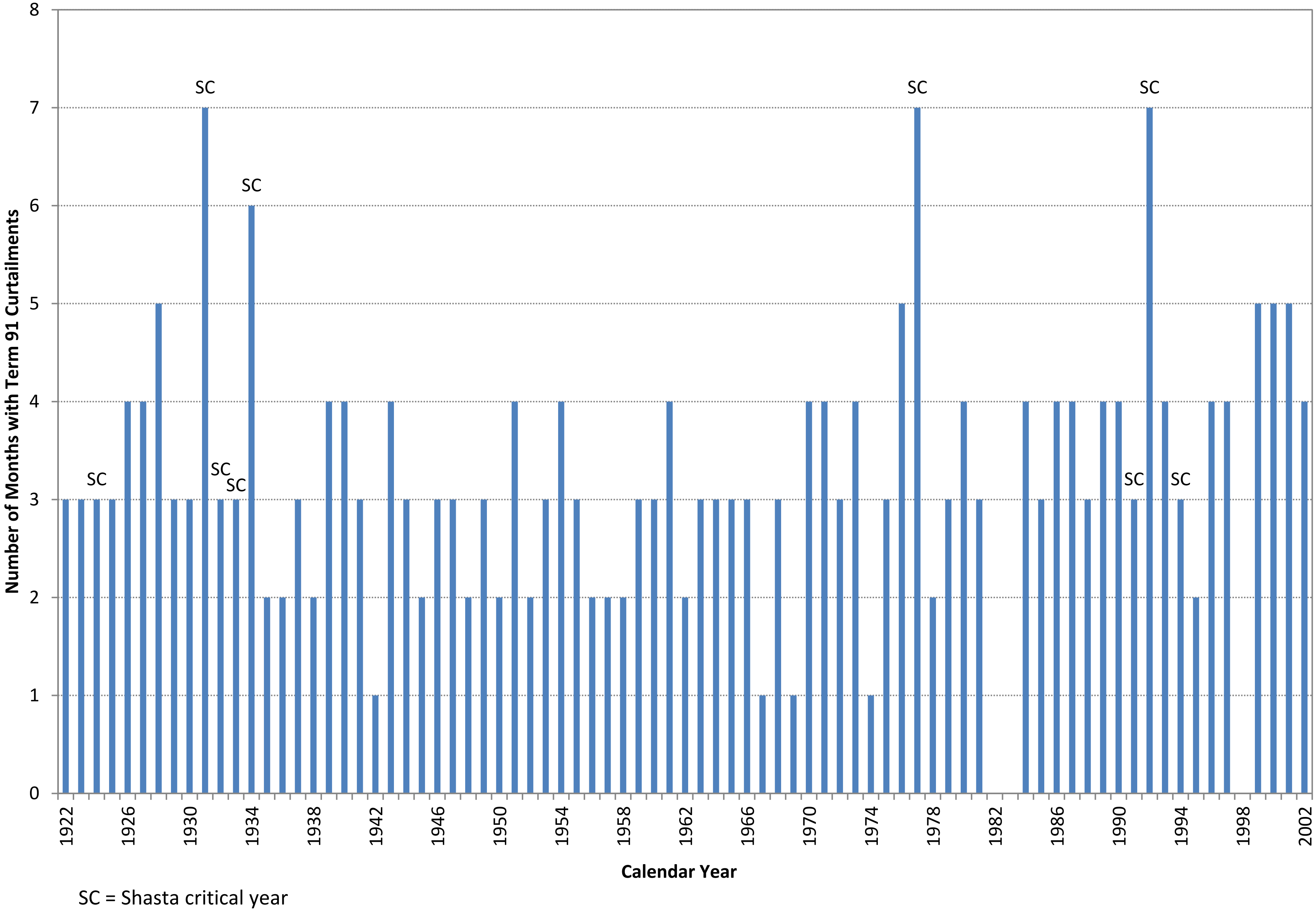
LEGEND

- The Cannery Project Area
- City Limits
- County

WEST YOST ASSOCIATES

Consulting Engineers

Figure 6-5. Synthesized Term 91 Curtailments and Lake Shasta Critical Years, 1922–2002



CHAPTER 7
Determination of Water Supply Sufficiency

10910(c)(4) If the city or county is required to comply with this part pursuant to subdivision (b), the water supply assessment for the project shall include a discussion with regard to whether the total projected water supplies, determined to be available by the city or county for the project during normal, single dry, and multiple dry water years during a 20-year projection, will meet the projected water demand associated with the proposed project, in addition to existing and planned future uses, including agricultural and manufacturing uses.

10911 (a) If, as a result of its assessment, the public water system concludes that its water supplies are, or well be, insufficient, the public water system shall provide to the city or county its plans for acquiring additional water supplies, setting forth the measures that are being undertaken to acquire and develop those water supplies. If the city or county, if either is required to comply with this part pursuant to subdivision (b), concludes as a result of its assessment, that water supplies are, or will be, insufficient, the city or county shall include in its water supply assessment its plans for acquiring additional water supplies, setting forth the measures that are being undertaken to acquire and develop those water supplies. Those plans may include, but are not limited to, information concerning all of the following:

(1) The estimated total costs, and the proposed method of financing the costs, associated with acquiring the additional water supplies.

(2) All federal, state, and local permits, approvals, or entitlements that are anticipated to be required in order to acquire and develop the additional water supplies.

(3) Based on the consideration set forth in paragraphs (1) and (2), the estimated timeframes within which the public water system, or the city or county if either is required to comply with this part pursuant to subdivision (b), expects to able to acquire additional water supplies.

7.1 FINDINGS

Based on the analysis described above, this WSA demonstrates that the City's existing and additional potable water supplies are sufficient to meet the City's existing and projected future potable water demands, including those future water demands associated with the Project, to the year 2035 under all hydrologic conditions. This finding is based on the following points:

1. The Water Well Agreement was perfected with the construction of Well DDW-33 and conveying title of that well to the City in 2008.
2. The projected water demand of the Cannery Project is substantially less than the projected growth of water demand and supplies as documented in the City's 2010 UWMP.
3. The proposed surface water supply project will be sized to serve projected growth in the City.
4. The City currently has sufficient groundwater capacity available to serve the Project's projected water demand, even without the proposed surface water project.

The following discussion and associated tables demonstrate this sufficiency.

7.1.1 Current Conditions including the Project

Table 7-1 summarizes the City's current water supplies and water demands in normal, single dry and multiple dry years based on existing demands, development projects with approved water supply and the Project. As shown, for all of the hydrologic conditions, the City's existing water supplies are sufficient to meet the City's existing water demands, in addition to the Project.

Table 7-1. Existing Water Supply and Demand (Existing Demands + Proposed Project)

Supply	Current Dry Year Water Supply Availability, af/yr[a]		
	Normal Years	Single Dry Year	Multiple Dry Years
Existing Water Supplies			
Groundwater[b]	15,000	15,000	15,000
Total Potable Water Supply	15,000	15,000	15,000
Existing Potable Water Demand (2010)	11,955	11,955	11,955
Existing Potable Water Demand (2010) plus the Project[c]	12,393	12,393	12,393
Potable Water Supply Surplus (Deficit)	2,607	2,607	2,607

(a) See Dry Year Water Supply Availability and Reliability discussion in Section 6.
(b) The City is planning to decrease groundwater use 6,000 af/yr or less by the year 2015 (based on normal year supply conditions). However, studies described in this WSA have indicated that up to 8,500 af/yr of groundwater is available to the City to make up for shortfalls in the event of a severe drought or other water shortage.
(c) Existing water demand includes projected water demand for the Project.

With the City's existing supplies, no water supply shortages are anticipated for any of the hydrologic conditions, based on existing water demands, in addition to those projected water demands associated with development projects with approved water supply, including the Project.

7.1.2 2035 Conditions

Table 7-2 summarizes the City's Year 2035 water supplies and water demands in normal, single dry and multiple dry years. The projected water demands shown include the projected water demands for the Project. As shown, for all hydrologic conditions, the City's existing and additional water supplies are sufficient to meet the City's Year 2035 water demands. No water supply shortages are anticipated for any hydrologic conditions based on Year 2035 water demands.

Table 7-2. Existing and Additional Year 2035 Water Supply and Demand

Supply	Year 2035 Water Supply Reliability, af/yr[a]		
	Normal Years	Single Dry Years	Multiple Dry Years
Existing Water Supplies			
Groundwater[b]	6,000	8,500	6,000
Additional Water Supplies			
WDCWA Surface Water Project)	13,104	7,642	11,242
Aquifer Storage and Recovery	—	unknown	unknown
Total Potable Water Supply	**19,104**	**16,142**	**17,242**
Projected 2035 Projected Potable Water Demand[c]	15,916	15,916	15,916
Potable Water Supply Surplus (Deficit)	3,188	226	1,326

(a) See Dry Year Water Supply Availability and Reliability discussion in Section 6.
(b) The City is planning to decrease groundwater use 6,000 af/yr or less by the year 2015 (based on normal year supply conditions). However, studies described in this WSA have indicated that up to 8,500 af/yr of groundwater is available to the City to make up for shortfalls in the event of a severe drought or other water shortage.
(c) Projected 2035 water demand includes projected water demand for the Project.

7.2 ADDITIONAL WATER SUPPLIES

The foregoing is based on an evaluation of both existing and additional (not yet subject to a firm assurance) water supplies. Both the existing water supply source and the proposed future water supply sources are sufficient to serve the Project. Based on the conclusion that sufficient water supply exists, the additional supplies analysis of Water Code 10911(a) is not required.

As described previously in this WSA, the City is currently anticipating surface water from WDCWA surface water project to be used for direct consumption, or in an aquifer storage and recovery program.

Each of these additional water supplies has been described above.

CHAPTER 8
Water Supply Assessment Approval Process

10910 (g)(1) Subject to paragraph (2), the governing body of each public water system shall submit the assessment to the city or county not later than 90 days from the date on which the request was received. The governing body of each public water system, or the city or county if either is required to comply with this act pursuant to subdivision (b), shall approve the assessment prepared pursuant to this section at a regular or special meeting.

10911 (b) The city or county shall include the water supply assessment provided pursuant to Section 10910, and any information provided pursuant to subdivision (a), in any environmental document prepared for the project pursuant to Division 13 (commencing with Section 21000) of the Public Resources Code.

The Davis City Council must approve this WSA at a regular or special meeting. Furthermore, the City must include this WSA in the Draft EIR being prepared for the Project.

The Project, with its 610 proposed residential dwelling units, is also subject to the requirements of SB 221 (Government Code section 66473.7). SB 221 applies to residential development projects of more than 500 dwelling units and requires that the water supplier (the City) provide a written verification that the water supply for the project is sufficient. Such a written verification must be provided before a final subdivision map for the Project may be approved.

APPENDIX A

Water Well Agreement

Recording requested by and Mail to:

City of Davis
Attn: Robert Weir
23 Russell Blvd.
Davis, CA 95616

WATER WELL AGREEMENT
("Agreement")

PARTIES: This Agreement is made this 1st day of November 2005 by and between the City of Davis ("City") and Pole Line Road Holding Company, LLC, a Delaware limited liability company ("Lewis")

RECITALS:

A. Lewis owns certain property ("Lewis Property") located within the City. The Lewis Property is depicted on the map attached as Exhibit "A."

B. City and Lewis have previously entered into a Potable Water Supply Service Agreement, dated July 27, 2004 (the "Existing PWSSA") whereby the City has produced water from a well on the Lewis Property for use in the City's municipal water distribution system (the "Existing Well"). The Existing Well, however, has deteriorated with age and its production volume has been reduced. City and Lewis desire that a replacement well be constructed to replace the Existing Well.

C. Lewis and City wish to make provision for the testing, design, construction, use and operation of a replacement water well (the "Replacement Well") on the Lewis Property, and the abandonment of the Existing Well.

I. REPLACEMENT WELL SITE and WATER FACILITIES.

A. The Replacement Well Site ("Site") shall consist of the Well Parcel, and Easements, as set forth below. The Site shall remain the property of Lewis until the Site and the Water Facilities (defined below) are conveyed to the City according to Sections VII or VIII herein. City shall have the right to use the Site and the Water Facilities according to the terms of a new Potable Water Supply

Service Agreement in the form of Exhibit "B" hereto (the "New PWSSA") and as provided in Section VI hereof. City and Lewis hereby stipulate, for purposes of this Agreement only, that the reasonable value of the Site is $100,000.00 (the "Site Value"). In the event all or any portion of the Property, Site, or Water Facilities is the subject of a condemnation action, neither this Agreement, nor the Site Value may be used as evidence of valuation of the property which is the subject of that action.

1. WELL PARCEL: The Replacement Well shall be constructed within a parcel of land approximately 100' X 100' located within the Lewis Property as shown on Exhibit B attached hereto (the "Well Parcel"). The actual size and configuration of the Well Parcel will be determined during the Testing Phase, as set forth in Section III, A, with consideration given to existing pipeline access and right of way access for future maintenance and operation of the Replacement Well, as well as taking into consideration the future needs, requirements, and constraints, of Lewis for development of the Lewis Property under Section VII. Lewis shall retain ownership of the Well Parcel until title is conveyed to City according to Sections VII or VIII hereof.

2. EASEMENTS/ACCESS: If the Well Parcel and Water Facilities, are conveyed by Lewis to City, as provided herein, the conveyance shall include easements necessary for the City's use and enjoyment of the Water Facilities (the "Easements") to be located in a manner that will provide the least interference with the future development, use and enjoyment of the Lewis Property by Lewis and Lewis' successors in interest. The Easements shall include easements for the use, maintenance, repair and replacement of the pipelines and utilities constructed as part of the Water Facilities, and for access to the Water Facilities over the Property within rights of way designated by Lewis. The location and size of the Easements shall be included by Lewis as part of the design of the Water Facilities provided Lewis shall retain the exclusive right to relocate such Easements (and the Water Facilities within the Easements) as necessary to permit the future use and development of the Lewis Property at Lewis' cost and expense. Such relocation of Easements and Water Facilities shall be subject to City's reasonable approval, and shall not impair materially the City's ability or right to use the Water Facilities.

B. The Water Facilities shall consist of the Replacement Well, pumping plant and appurtenances, including a separate power supply, metering equipment and related utility line and connection, and the outlet pipelines. Subject to the terms of the New PWSSA, the Water Facilities shall remain the property of LEWIS until they are conveyed to the City as provided herein.

1. The Replacement Well, pumping plant, and appurtenances shall consist of a completed and fully operational water well and pumping plant certified by the Department of Health Services ("DHS"), together with a pump

house, perimeter fencing and landscape screening to be compatible with future land uses on the Lewis Property.

2. The outlet pipelines shall consist of a buried water main and buried flush line, together with valving and appurtenances from the Water Well to connections to the City's municipal water distribution and storm drain systems in Covell Road and/or flood control channel located west of the Property boundary.

II. REGULATORY COMPLIANCE.

CITY shall, with the cooperation of Lewis, complete any and all documentation and take all other actions necessary to (i) comply with the California Environmental Quality Act (ii) comply with all requirements of DHS, including all testing and permitting requirements, and (iii) comply with all requirements of the State and Regional Water Quality Control Board, including all NPDES requirements, all with respect to execution and implementation of this Water Well Agreement, the abandonment of the Existing Well, and the design, construction and operation of the Water Facilities. City shall be responsible for the payment of costs associated with ensuring regulatory compliance of the Water Facilities.

III. TESTING, DESIGN AND CONSTRUCTION.

A. TESTING PHASE. The parties acknowledge that drilling and equipping the Replacement Well requires the drilling of a pilot hole and conducting tests (the "Pilot Tests") to determine the depths, yields and quality of the subterranean water bearing strata underlying the Well Parcel. The Pilot Tests shall be conducted by Lewis at its expense, provided City shall collect all groundwater samples from the Pilot Well and analyze these samples as necessary to determine the water quality at City's expense. City and Lewis shall, during the Testing Phase, and consistent with sound engineering and well development practices, mutually approve the final location of the Replacement Well, Well Facilities, Well Parcel and Easements (the "Testing Phase Approval"). From and after the Testing Phase Approval, the City shall assume all risk of water yield and water quality from the selected Site and shall be required to lease and/or purchase the Site and Water Facilities as set forth in Sections VI and VIII notwithstanding such water yield or water quality. If the parties determine, following the pilot hole boring, that the water yield or water quality from the selected Site is not suitable, they shall meet and confer in good faith to determine whether (1) to proceed with development of the Replacement Well at the selected location, subject to such remedial measures as the parties shall agree; or (2) to relocate the pilot well and the Site to another location on the Lewis Property. In the event Lewis and City cannot reach agreement on either (1) or (2) above, then, upon thirty (30) days prior written notice to the other party, either party may elect to abandon the Replacement Well project and cancel this Agreement. Lewis shall maintain a complete record of the costs incurred by Lewis to complete the Testing Phase. In the event that the parties decide on options (1) or (2) above, the costs associated therewith shall be treated as a Project Cost according to Section V hereof. In the event that the parties decide to abandon the Replacement Well Project , City shall pay to Lewis 50% all costs incurred to that date by Lewis; provided, City shall bear 100% of all sampling and testing costs, Neither party shall unreasonably withhold concurrence in regard to groundwater production zones, the design of the water well and pumping plant, or the suitability of the Site and pilot hole for development of the replacement water well.

B. DESIGN PHASE. Lewis shall contract for the design of the Water Facilities and all utilities and appurtenances necessary for the operation thereof. Said design shall meet City's generally applicable design standards and generally accepted engineering standards and shall be subject to review and approval by CITY, which approval shall not be withheld unreasonably. Lewis shall maintain a complete record of the cost to design the Water Facilities and all utilities and appurtenances necessary for the operation thereof.

C. CONSTRUCTION PHASE. Lewis shall contract for the construction of the Water Facilities and all utilities, including a separate power connection and meter, and appurtenances necessary for the operation thereof, according to the approved design. City shall have the opportunity for reasonable observation and verification of proper construction. Lewis shall require its contractor to pay prevailing wages according to Labor Code §§ 1720, *et seq.* Lewis shall (i) require its contractors and subcontractors to submit certified copies of payroll records to Lewis; (ii) maintain complete copies of such certified payroll records; and (iii) make such records available to the City and its designees for inspection and copying during regular business hours at the Property or at another location within the City. Lewis shall indemnify and hold harmless City and its officers, employees, agents and representatives from and against any and all present and future liabilities, obligations, orders, claims, damages, fines, penalties and expenses (including attorneys' fees and costs), arising out of or in any way connected with Lewis's obligation to pay prevailing wages in accordance with Labor Code §§1720, *et seq.*, including all claims that may be made by contractors, subcontractors or other third party claimants pursuant to Labor Code Sections 1726 and/or 1781, as amended and added by Senate Bill 966. Lewis shall maintain a complete record of the costs to construct the Water Facilities and all utilities and appurtenances necessary for the operation thereof. Construction shall be complete when Lewis has recorded a notice of completion.

C. SELECTION OF CONTRACTORS. In selecting contractors for the testing, design and construction phases of this project, Lewis shall solicit proposals from not less than three separate contractors for each phase of the work, and shall contract with the lowest responsible bidder for said work. Lewis shall, until completion of the Water Facilities and acceptance by the City for use, indemnify and hold harmless City and its officers, employees, agents and representatives from and against any and all present and future liabilities, obligations, orders, claims, damages, fines, penalties and expenses (including attorneys' fees and costs), arising out of or in any way connected with work conducted by Lewis or its contractors as contemplated in this Agreement, excepting any claims arising from negligence or willful misconduct City or it's contractors.

D. SCHEDULE. The parties agree, subject to any Force Majeure Event (as defined below), to use their commercially reasonable efforts to complete the Testing, Design and Construction phases in accordance with the schedule attached hereto as Exhibit "D".

IV. TERMINATION EXISTING PWSSA/ABANDONMENT OF EXISTING WELL.

When the Water Facilities are complete as provide in Section III, C hereof, the Existing PWSSA shall terminate and the Existing Well and related appurtenances shall be abandoned, destroyed, and/or removed in accordance with all applicable laws (the "Abandonment"). Lewis shall contract for and complete such Abandonment consistent with the existing and future uses and development of the Lewis Property by Lewis. The Abandonment of the Existing Well shall be completed at Lewis's sole cost and expense.

V. PROJECT COSTS.

Project Costs shall consist of sum total of all of the following as generally identified below and more specifically described in Exhibit "E" attached hereto (the "Project Cost Schedule"), except that the total Project Cost shall not exceed $1,500,000, unless the parties mutually agree in writing to the amount and purpose of any cost overruns. Lewis shall notify City in writing of any anticipated cost overrun and seek agreement from City prior to incurrence of any cost overrun. City shall provide a written response to Lewis stating the City's consent to or refusal to consent to the cost overrun within 30 days of receipt of written notification from Lewis. In the event that Lewis incurs costs of greater than $1,500,000 without written consent of the City provided in accordance with this Paragraph, Lewis shall be solely responsible for the payment of all amount due in excess of $1,500,000; provided Lewis may elect to terminate this Agreement, including the Existing PWSSA and the New PWSSA if the City does not agree to increase the $1,500,000 cap wherever such cap exists in this Agreement by the amount of such cost overruns. In the event that Lewis terminates the Agreement under the terms of this Section, Lewis shall convey the Site and all improvements located on or made to the Site at the time of termination to the City for the Project Costs incurred as of the date of such termination, inclusive of the Site Cost, and, following conveyance of the Site and improvements to City, Lewis shall cease to have any further obligation to City under this Agreement except as provided in Section VI.A for the Existing PWSSA or under Section I.A(2). This conveyance shall occur through escrow in accordance with Section VIII. The Project Cost Schedule shall be updated by Lewis as necessary:

1. SITE: The fair market value of the Site as determined in Section I, A hereof.

2. TESTING: The cost to drill and test the pilot well (excepting sampling costs paid by the City) as provided in Section III, A hereof.

3. WATER FACILITY DESIGN: The cost to design the Water Facilities as provided in Section III, B hereof.

4. WATER FACILITY CONSTRUCTION: The cost to construct the Water Facilities as provided in Section III, C hereof.

5. ABANDONMENT OF EXISTING WELL: The costs to abandon the Existing Well under Section IV.

VI. EXTENSION OF EXISTING PWSSA/NEW PWSSA:

A. The term of the Existing PWSSA shall be extended by the parties from July 27, 2005 to the earlier of (i) completion of the Replacement Well, or (ii) July 27, 2007. For purposes of this Section, the Replacement Well shall be deemed complete at such time that the Replacement Well is fully permitted, connected to the City water system and pumping water.

B. FORM OF AGREEMENT: Concurrently with the completion of the Replacement Well, the parties shall execute the New Potable Water Supply Service Agreement in the form attached hereto as Exhibit C.

C. EFFECTIVE DATE: The New PWSSA shall be effective upon the date when the notice of completion of the Water Facilities is recorded as required by Section III, C hereof (the "Effective Date").

D. TERM: The term of the New PWSSA shall be for two years from the Effective Date.

E. PWSSA PRICE: Lewis shall invoice City and City shall pay to Lewis, quarterly in advance, a sum equal to two and one-half percent (2½%) of the total Project Costs as determined in Section V hereof as consideration for the New PWSSA.

F. OPERATION AND MAINTENANCE: CITY shall be solely responsible for all costs of operating and maintaining the Water Facilities and City shall maintain and deliver to Lewis quarterly (the "Quarterly Report") a complete record of the quantity of water produced by the Water Facilities the prior quarter.

G. PERMITS: CITY, at its sole cost, shall obtain any and all permits and comply with all laws associated with operating the Water Facilities as part of City's municipal water supply system.

H. EXTENSION OF TERM: If, at the end of the two year term of the New PWSSA, Lewis has not either (1) dedicated the Site and Water Facilities to City under Section VII hereof; or (2) exercised its right to sell under Section VIII hereof, the term of the New PWSSA shall extend for successive one year periods subject to Lewis' right to terminate the New PWSSA upon one hundred eighty (180) days prior written notice to City. If the term is extended, the City shall pay, in addition to the amounts required by Section VI, E hereof, a volumetric charge of $175 per acre foot water produced by City from the Water Facilities. The Volumetric Charge shall be paid quarterly based upon the Quarterly Report.

VII. FUTURE DEVELOPMENT OF THE LEWIS PROPERTY; DEDICATION OF WATER FACILITES TO CITY.

Without making any commitment to Lewis or providing any assurances for development approvals for future land uses on the Lewis Property, City acknowledges that Lewis may seek future land use approval(s) from City for proposed development of the Lewis Property. A material consideration for Lewis to develop the Water Facilities is to assure an adequate source of water for any such future land use development on the Lewis Property. If (1) the production volume of the Water Facilities exceeds the total projected demand of the development proposed for the Lewis Property; and (2) Lewis has conveyed or offers to convey the Water Facilities to the City in accordance with the terms of either Section V or VIII of this Agreement, then City shall not require Lewis to demonstrate the sufficiency of or to provide any additional source of water supply to serve the development proposed for the Lewis Property under the Subdivision Map Act or after applicable regulations. Nothing in this Agreement shall limit in any way Lewis's obligation to pay all applicable impact fees levied in accordance with all applicable laws against any development projects that are approved on the Lewis Property.

VIII. LEWIS SALE:

A. At anytime not less than one year following completion of construction and issuance of all permits and approvals required for the operation of the Water Facilities, Lewis, in its sole discretion may deliver a written notice of sale to the City, whereupon the City shall, purchase the Site and Water Facilities for an amount equal to the Project Costs as provided in Section V hereof (subject to the $1,500,000 cap or any increase thereto approved by the City under Section V) (the "Purchase Price"). Lewis shall open escrow for this sale at Chicago Title Company, 2901 K Street, Suite 390, Sacramento, California 95816, Attn: Sue Heimbichner, by delivering escrow a copy of the Notice of Sale. City shall deposit the Purchase Price into escrow within sixty (60) days after opening of escrow and Lewis shall deposit the deed to the Well Parcel which shall include the Easements the next business day after City deposits the Purchase Price.

IX. GENERAL PROVISIONS:

A. NOTICES. No notice, request, demand, instruction, or other document to be given hereunder to any party shall be effective for any purpose unless personally delivered to the person at the appropriate address set forth below (in which event such notice shall be deemed effective only upon such delivery), delivered by air courier next-day delivery (e.g. Federal Express), delivered by mail, sent by registered mail or certified mail, return receipt requested, or telecopied, as follows:

To Lewis:	Pole Line Road Holding Company, LLC Attn: William B. Mellerup 9216 Kiefer Blvd. Sacramento, CA 95826 Fax: 916.364.9353
Copy to:	Lewis Operating Corp.

Attn: General Counsel
1156 N. Mountain Ave.
Upland, CA 91786-3633
909.949.6725

To City:

City of Davis
Attn: Robert Weir
23 Russell Blvd.
Davis, CA 95616
Fax: 530.758.4738

Notices delivered by air courier shall be deemed to have been given the next business day after deposit with the courier and notices mailed shall be deemed to have been given on the second business day following deposit of same in any United States Post Office mailbox in the stat to which the notice is addressed or on the third business day following deposit in any such post office box other tan in the state to which the notice is addressed, postage prepaid, addressed as set forth above. Notices telecopied shall be deemed delivered the same business day received. The addresses, addressees, and telecopy number for the purpose of this Paragraph, may be changed by giving written notice of such change in the manner herein provided for giving notice. Unless and until such written notice of change is received, the last address and addressee and telecopy number stated by written notice, or provided herein if no such written notice of change has been received, shall be deemed to continue in effect for all purposes hereunder.

B. TIME: Time is of the essence for each provision of this Agreement of which time is a factor.

C. ATTORNEYS' FEES: In the event of any action or proceeding brought by either party against the other under this Agreement, inclusive of all appeals of any such actions or proceedings, the prevailing party shall be entitled to recover, as determined by the Court, reasonable costs and expenses, including, without limitation, attorneys' fees, expert witness fees, and court costs, incurred for prosecution, defense, consultation, or advise in such action or proceeding.

D. MERGER/AMENDMENT: It is agreed that all understandings and agreements heretofore had between the parties respecting the transactions contemplated by this Agreement are superseded by this Agreement, which fully and completely expresses the agreement of the Parties. There are no representations, warranties, or agreements, as between the parties hereto, concerning the subject matter of this transaction except as specifically and expressly set forth in this Agreement. This Agreement may only be amended, modified, or supplemented by a written document executed by Lewis and City.

E. CHOICE OF LAW: This Agreement shall be governed and construed in accordance with the laws of the State of California.

F. COUNTERPARTS: This Agreement, and any amendments hereto, may be signed in multiple counterparts, which together shall constitute the complete Agreement.

G. SEVERABILITY: If any term, provision, condition, or covenant of this Agreement, or the application thereof to any party or circumstance shall, to any extent, be held invalid or unenforceable, the remainder of this Agreement or the application of the term, provision, condition, or covenant to persons or circumstances other than those as to whom or which it is held invalid or unenforceable, shall not be affected thereby. Each term and provision of this Agreement shall be valid and enforceable to the fullest extent permitted by law.

H. NO THIRD PARTY BENEFICIARY: This Agreement is between City and Lewis only and no third party is intended expressly or by implication to be benefited hereby.

I. NO REPRESENTATIONS OR WARRANTIES: Lewis makes no representations or warranties, including any warranties of reliability or fitness, relating to the Site, the Existing Well, the Replacement Well, or the water, and City acknowledges that it will use the Replacement Well in its "as is, where is" condition.

J. NO WATER RIGHTS: City acknowledges and agrees that Lewis is not granting to City any water rights owned by Lewis except the nonexclusive right to pump water from the subject wells during the terms of the Existing and New PWSSAs which right shall terminate upon termination of each PWSSA unless the Site and Water Facilities are dedicated or sold to City under Sections VII or VIII in this Agreement.

K. FORCE MAJEURE EVENT: If either party is delayed at any time in meeting the obligations herein undertaken by any act or neglect of the other Party, or by changes ordered or approved by the other, or by labor disputes, fire, unusual delay in transportation, adverse weather conditions not reasonably anticipatable, unavoidable casualties, or any causes beyond the party's reasonable control, then the time for completion shall be extended for such reasonable time as may compensate for such occurrences.

CITY OF DAVIS,
A Municipal Corporation,
State of California

James W. Antonen
City Manager

APPROVED AS TO FORM:

Harriet A. Steiner
City Attorney

WBF:km\949\G2355A-DavisWaterWellAgmt
101905

POLE LINE ROAD HOLDING COMPANY, LLC, a Delaware limited liability company

By: NORTH MOUNTAIN CORPORATION, a California corporation – Its Sole Manager

By: William B Mellerup
Authorized Agent

By: Douglas V. Mull
Authorized Agent

EXHIBIT A

LEWIS PROPERTY

LEWIS PLANNED COMMUMITIES

CITY OF DAVIS CALIFORNIA

OCTOBER 2005

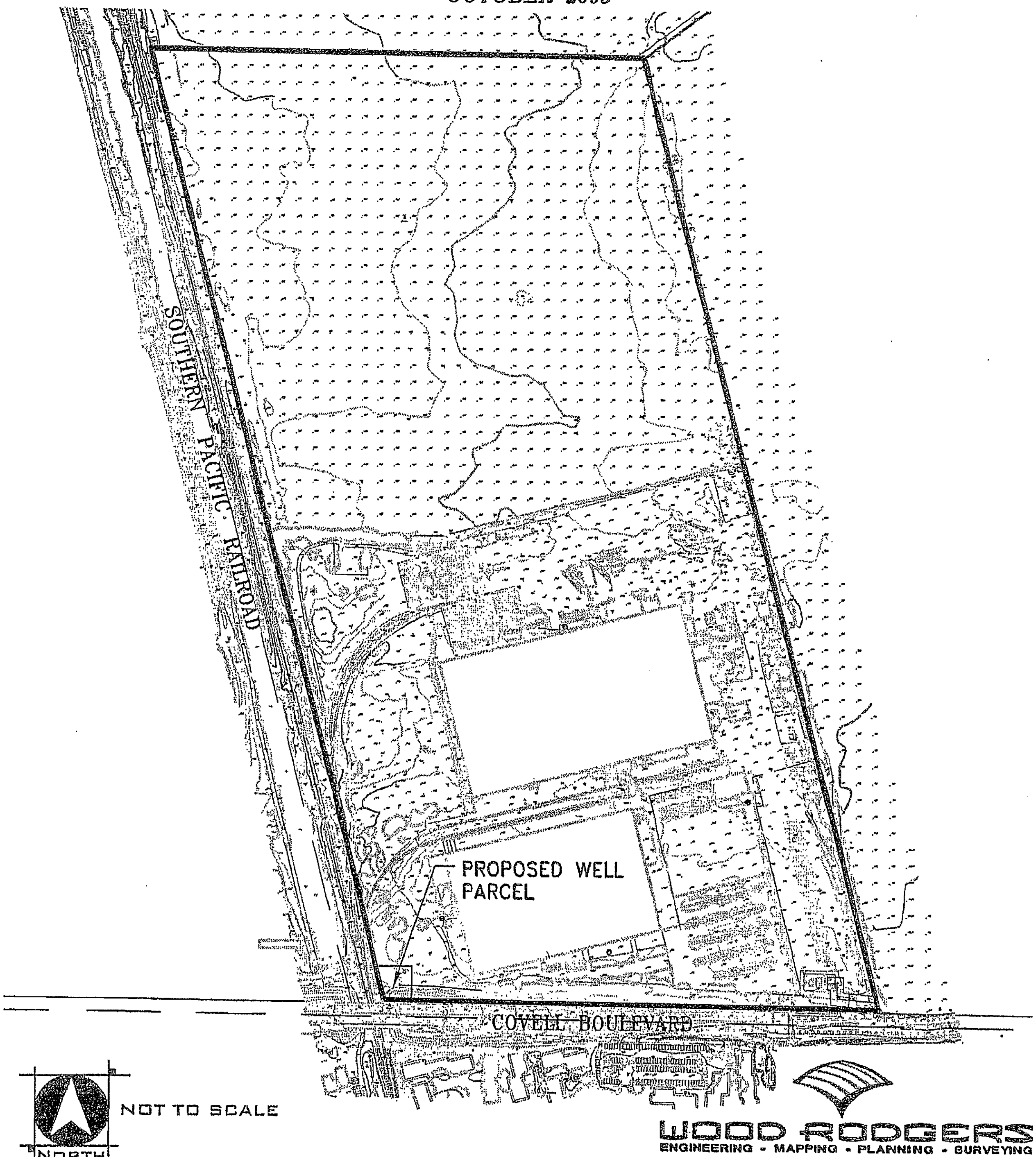


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Exhibit B
Potable Water Supply Service Agreement
Between the City of Davis and Pole Line Road Holding Company, LLC

This Potable Water Supply Service **Agreement** ("**Agreement**") is made and entered into this ___ day of _______________, ________, (the "Effective Date") by and between Pole Line Road Holding Company, LLC, a Delaware limited liability company ("Lewis"), and the **City of Davis**, a Municipal Corporation.

In consideration of mutual promises herein contained, it is hereby agreed as follows:

1. **City** and **Lewis** agree that **City** will have access to and the right to pump and use water from **Lewis's** Deep Well ("LDW") depicted in Exhibit A, without restrictions as set forth in this **Agreement**. Lewis shall invoice City and City shall pay to Lewis, quarterly in advance, a sum equal to two and one-half percent (2½%) of the total Project Costs as determined in Section V of that certain Water Well Agreement, dated_______________, by and between Lewis and City, a copy of which is attached as Exhibit B, Water Well Agreement.

2. **City's** use is a temporary use only during the effective period of this agreement and there is no express or implied relinquishment of any **Lewis** water rights, if any, to the **City**.

3. The **City** shall be solely responsible for all expenses associated with operating and maintaining LDW. This includes any testing, monitoring, replacement of equipment, replacement and maintenance of service connections between the **City's** and **Lewis's** water systems, and any other related tasks and responsibilities associated with maintaining and operating a water system and water service in accordance with standard practices and procedures as recognized by AWWA and regulators of the water system and all in accordance with the Water Well Agreement.

4. **City** shall provide a chlorine contingency plan including MSDS disclosures, emergency response and containment plan, and **City** shall be responsible for any and all chlorine handling and emergency situations.

5. **City** will be solely responsible for any special California Department of Health Services (DHS) requirements placed on the **City** as a condition of permitting the **City** to use LDW in accordance with the conditions of this agreement and the Water Well Agreement.

6. Only authorized trained **City** water system operators and staff shall have access to the **City/Lewis** water system connection and operations. All site visits shall be coordinated between designated **City** and **Lewis** representatives, generally with at least 24 hours notice. No notice shall be required in the event of an emergency; however, **City** shall give notice to **Lewis** of the emergency and the actions taken to remedy the emergency.

7. The **City** shall operate LDW using only qualified operators. All operational maintenance will be performed as required by **City** staff. If LDW fails to operate for any reason, the **City** will contact the designated **LDW** representative before any corrective action is taken; provided that **City** shall take any action required to stabilize the situation, if necessary.

8. The **City** will comply with all applicable federal, state and local laws, ordinances, and regulations relating to the **City's** use of the premises, well and water for a municipal potable water supply including but not limited to the handling any chemicals for treatment of water or well equipment at the site. The **City** shall not release or dispose of any hazardous materials on the premises provided, however, that the parties understand and agree that **City** may chlorinate the water at the well, as set forth above. The **City** is solely responsible for making sure the water is at all times safe for human consumption.

9. The **City** shall indemnify **Lewis** against all liability, claims or damages arising from **City's** use of the well and water and the treatment and delivery of the same for human consumption. **City** shall also indemnify **Lewis** against liability, claims or damages resulting from **City's** failure to comply with this agreement and injuries suffered by City's employees or contractors while on the well site, including but not limited to, failure of the well site work area to comply with OSHA. **Lewis** acknowledges that **City** is self-insured for general liability insurance, worker's compensation, and employer's liability coverage. **City** shall provide **Lewis** with a description and proof of **City's** self-insurance coverage program prior to execution of this **Agreement**.

10. **Lewis** may terminate this agreement at any time if **City** fails to cure any default within 15 days after notice of same. Otherwise, this agreement shall remain in effect until the earlier of (i) such time that either or both parties desire to terminate this agreement with 90-day written notice, or (ii) two years from the Effective Date, unless **Lewis** and **City** agree on an extension, in writing .

11. No party to this **Agreement** may assign any right or obligation pursuant to this **Agreement**. Any attempted or purported assignment of any right or obligation pursuant to this **Agreement** shall be void and of no effect.

12. The **City's** designated representative for the purposes of this agreement shall be Robert Weir. **LIC's** representative for the purposes of this **Agreement** shall be William B. Mellerup. The parties may change their respective representatives by giving notice to the other party.

13. Any notice, demand, request, consent, approval, or communication that either party desires or is required to give to the other, shall be in writing and either served personally or sent by United Stated certified mail, return receipt requested or faxed (receipt of all faxed notices shall be acknowledged by the receiving party, addressed as follows:

To LIC: Pole Line Road Holding Company, LLC
Attn: William B. Mellerup
9216 Kiefer Blvd.
Sacramento, CA 95826
Fax: 916-364-9353

Copy to: Lewis Operating Corp.
Attention: General Counsel
1156 N. Mountain Ave
Upland, CA 91786
Fax: 909-949-6725

To City: City of Davis
Attn: Robert Weir
23 Russell Boulevard
Davis, California 95616
Fax: 530-758-4738

14. No Representations or Warranties: Lewis makes not representations or warranties, including any warranties of reliability or fitness, relating to the well, the well equipment, or the water, and City acknowledges that it is using the well in its "as is, where is" condition.

15. No Water Rights: City acknowledges and agrees that Lewis is not granting to City any water rights owned by Lewis except the nonexclusive right to pump water from the subject well during the term of this Agreement which right shall terminate in accordance with Paragraph 10 above

Executed as of the day first above stated.

City of Davis
A Municipal Corporation,
State of California

____
Jim Antonen
City Manager

Approved As To Form:

____
Harriet A. Steiner
City Attorney

POLE LINE ROAD HOLDING COMPANY, LLC, a Delaware limited liability company

By: NORTH MOUNTAIN CORPORATION,
a California corporation – Its Sole Manager

By: ______________________

Name: ______________________
Its: Authorized Agent

By: ______________________

Name: ______________________
Its: Authorized Agent

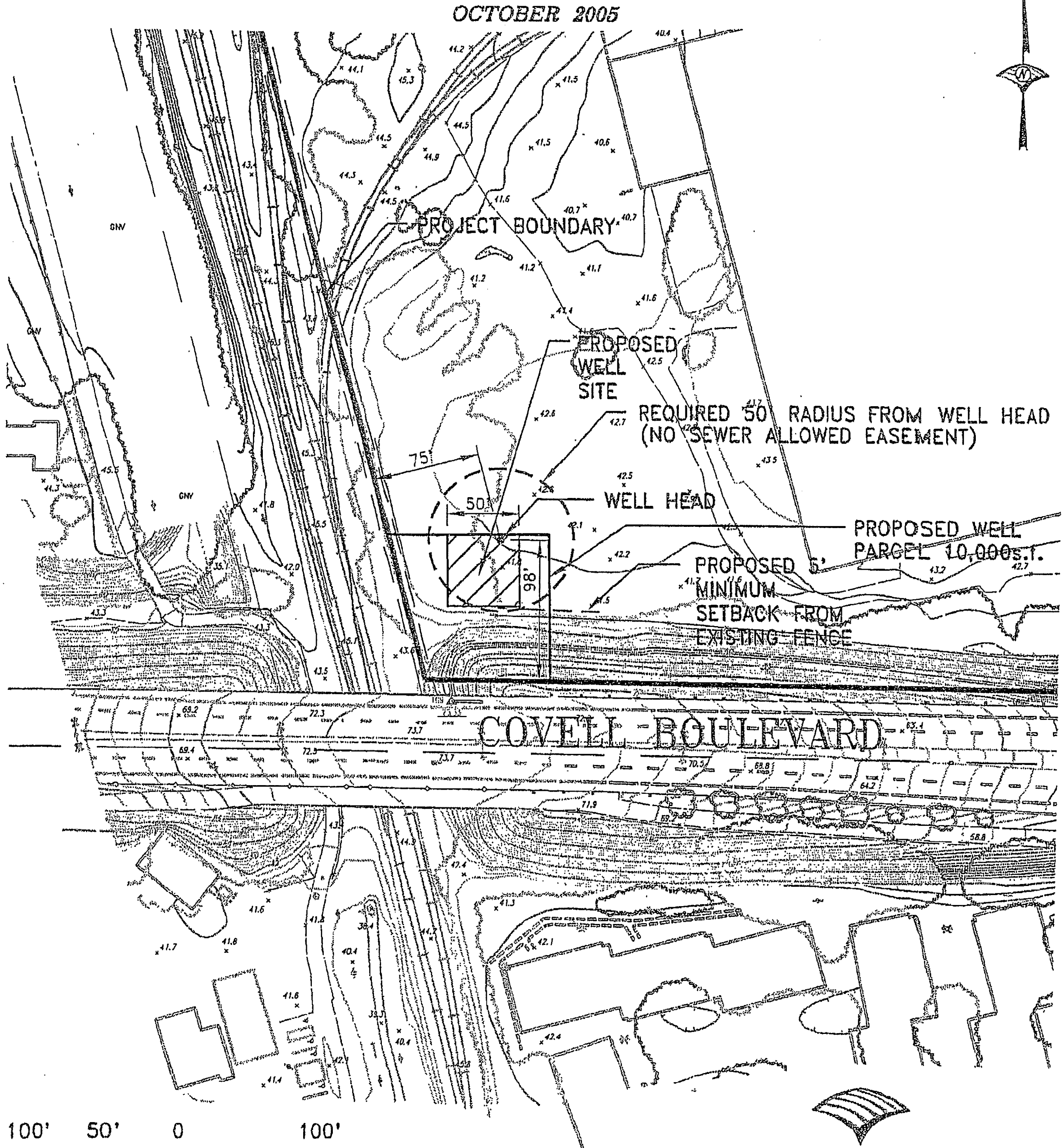
EXHIBIT C

LEWIS PROPERTY

LEWIS PLANNED COMMUMITIES

CITY OF DAVIS CALIFORNIA

OCTOBER 2005



100' 50' 0 100'

SCALE: 1" = 100'

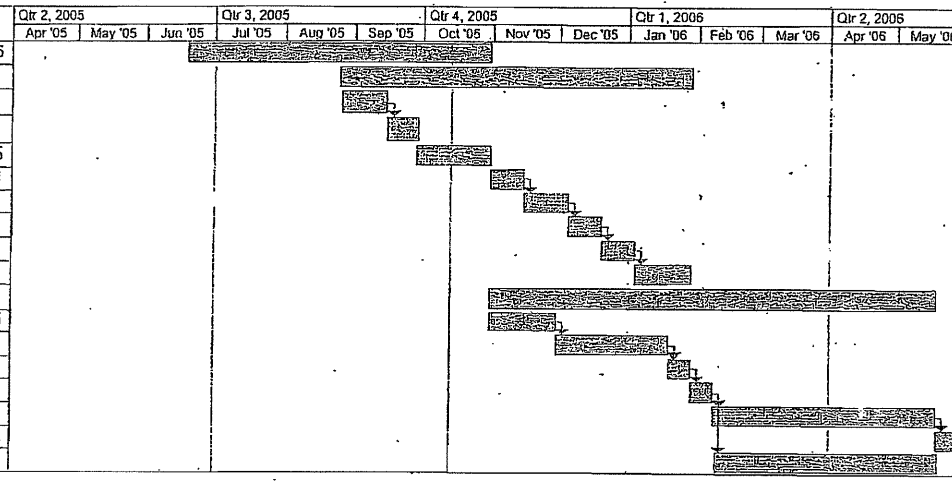
WOOD RODGERS
ENGINEERING • MAPPING • PLANNING • SURVEYING
3301 C St, Bldg. 100-B Tel 916.341.7760
Sacramento, CA 95816 Fax 916.341.7767

\\Socfile01\Jobs\Jobs\1417-Hunt_Wesson\1417-Hunt_Wesson Property\Hunt_Wesson OA\Civil\Exhibits\EXH-well site.dwg 10/13/05 4:11pm jholt

Exhibit D

Lewis Property - Replacement Well Schedule

ID	Task Name	Duration	Start	Finish
1	Negotiate Agreement w/City	134 days	Sun 6/19/05	Mon 10/31/05
2	REPLACEMENT WELL	157 days	Thu 8/25/05	Sun 1/29/06
3	Prepare well specs/site & work plan/acquire City/DHS approvals	20 days	Thu 8/25/05	Wed 9/14/05
4	Acquire well construction proposals	14 days	Wed 9/14/05	Wed 9/28/05
5	Establish drilling contractor contract	33 days	Wed 9/28/05	Mon 10/31/05
6	Drilling contractor mobilization	15 days	Mon 10/31/05	Tue 11/15/05
7	Pilot hole drilling/logging	20 days	Tue 11/15/05	Mon 12/5/05
8	Depth-specific water quality sampling	15 days	Mon 12/5/05	Tue 12/20/05
9	Lab reports/well design/acquire City/DHS approvals	15 days	Tue 12/20/05	Wed 1/4/06
10	Construct, develop, and test replacement well	25 days	Wed 1/4/06	Sun 1/29/06
11	PUMP STATION	200 days	Mon 10/31/05	Fri 5/19/06
12	Develop site plan/acquire City/DHS approvals	30 days	Mon 10/31/05	Wed 11/30/05
13	Develop pump station plans/specs/acquire City/DHS approvals	50 days	Wed 11/30/05	Thu 1/19/06
14	Acquire pump station construction proposals	10 days	Thu 1/19/06	Sun 1/29/06
15	Establish pump station contractor contract	10 days	Sun 1/29/06	Wed 2/8/06
16	Build pump station	100 days	Wed 2/8/06	Fri 5/19/06
17	Facility testing and final permitting	10 days	Fri 5/19/06	Mon 5/29/06
18	Offsite piping and PG&E Service	100 days	Wed 2/8/06	Fri 5/19/06



Project: Project1
Date: Thu 10/13/05

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

EXHIBIT E
ESTIMATED PROJECT COSTS

ITEM OF WORK	ESTIMATED COST
SITE	$100,000
REPLACEMENT WELL COSTS	
a) Mobilization/demobilization	$57,750
b) Test hole, geophysical logging, and depth-specific water sampling	$177,650
c) Well drilling and construction	$399,001
d) Well development	$34,650
d) Well development	$6,710
subtotal	$675,761
REPLACEMENT WELL PUMPING PLANT COSTS	
a) Site work (clear/grub, grade, clean up, etc.)	$16,500
b) Concrete structures (facility pad, pedestals, access, etc.)	$33,000
c) Well pump and facility piping and valves	$125,400
d) Motor control center and facility electrical	$110,000
e) Painting, fencing and gate	$15,400
f) Well disinfection, operational testing, contingency	$29,700
subtotal	$330,000
REPLACEMENT WELL OFF SITE PIPING COSTS (DISTRIBUTION SYSTEM)	
a) Est. 1,500' of 12" ductile iron pipe @ $105/linear foot	$157,500
b) Less 1,500' of 8" ductile iron pipe @ $64/linear foot (1)	-$96,000
subtotal	$61,500
REPLACEMENT WELL COSTS ASSOCIATED WITH NEW ELECTRICAL SERVICE	
Electrical distribution and service	$50,000
OLD FACILITIES REMOVAL / ABANDONMENT	
Well destruction costs	$60,000
REPLACEMENT WELL - CONSULTING & ENGINEERING	
a) Engineering design, project coordination, and construction management costs (Brown and Caldwell, Reece Consulting, other Engineering/Consultants)	$200,000
PROJECT TOTAL	$1,477,261
PROJECT CONTINGENCY AT 10%	$147,726
ESTIMATED GRAND TOTAL	**$1,624,987**

APPENDIX B

Groundwater Management Plan

CITY OF DAVIS / UC DAVIS

GROUNDWATER MANAGEMENT PLAN

April 2006

Prepared by:

BROWN AND CALDWELL
202 Cousteau Place, Suite 170
Davis, California 95616
(530) 747-0650

In Association with:

West Yost & Associates, Inc.
1260 Lake Blvd, Suite 240
Davis, California 95616

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

APPENDICES

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS (continued)

LIST OF FIGURES (continued)

SECTION 1
INTRODUCTION

1.1 Plan Authority and Administration

On October 4, 2005, the City of Davis formally approved Resolution 05-278 directing the City of Davis Public Works Department to proceed with the development of an AB 3030 Groundwater Management Plan (GWMP or Plan). The resolution is included in Appendix A. The development of a GWMP for the City of Davis (City) and the University of California at Davis (UC Davis) is the next phase in a series of projects that focus on the sustainability of the groundwater yield and water quality of the local groundwater basin.

The California Water Code (CWC) provides the authority to adopt a groundwater management plan. The City and UC Davis are within the jurisdictional boundary of the Yolo County Flood Control and Water Conservation District (YCFCWCD). The YCFCWCD is currently developing a GWMP for areas within its jurisdiction. Under mutual agreement, the City and UC Davis GWMP was developed to address groundwater management needs specific to the City and UC Davis service areas, and these areas are not directly included or managed under the YCFCWCD GWMP. The City and UC Davis will continue to closely collaborate with YCFCWCD during plan implementation.

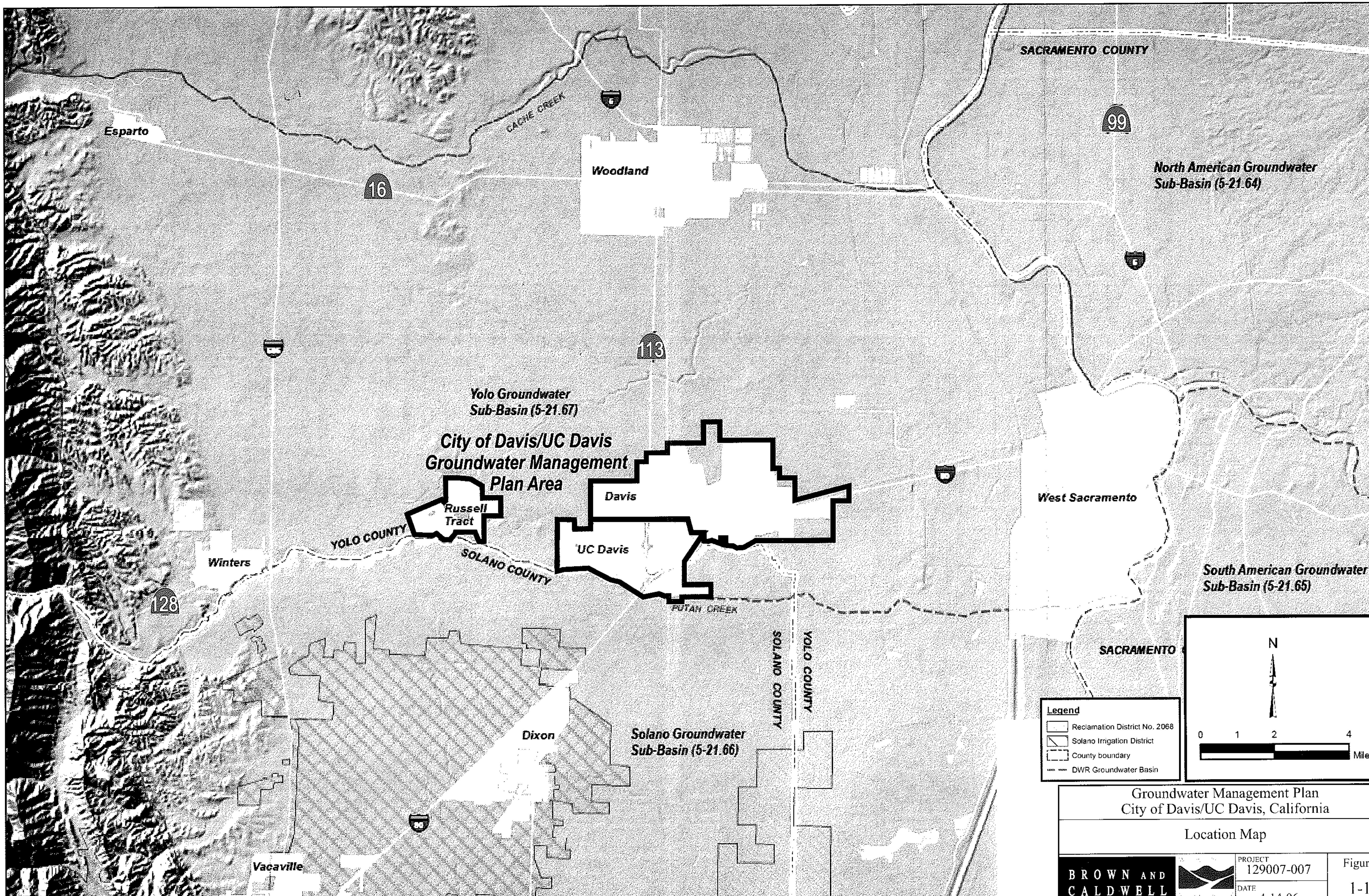
The GWMP incorporates information from the Phase I and Phase II Deep Aquifer Studies and other regional groundwater investigations into a plan for managing and monitoring the effects of groundwater utilization (Brown and Caldwell, 2005). The GWMP includes all mandatory and suggested components outlined in CWC §10750 *et seq.* and §10753.7. Compliance with these sections is required for eligibility for public funds administered by the California Department of Water Resources (DWR) for construction of groundwater projects. The statutes apply to funds authorized or appropriated after September 1, 2002. Adoption of the GWMP is not otherwise required under California law. The final Plan has been adopted by both the City and UC Davis, and filed with the DWR. Plan adoption resolutions are included in Appendix A.

The City and UC Davis have been formally partnering in groundwater management activities since 1996. In the last several years, the City and UC Davis have increased groundwater level and quality monitoring, and have worked with other entities to collect and disseminate water quality and quantity data for the Davis area. Additionally, the City and UC Davis collaborate with other entities within the region on locally-driven groundwater management activities. This GWMP documents the City and UC Davis planned groundwater management activities, and explains potential future actions to increase the effectiveness of groundwater management in the Davis area.

The area covered by the GWMP is described in Section 1.2, and Section 1.3 discusses the GWMP's objectives. The overall Plan development process, as described in the CWC, is presented in Section 1.4, and the public involvement process is described in Section 1.5. Components of the GWMP are outlined in Section 1.6.

1.2 Area Covered by Plan

The area covered by this Plan includes the combined City and UC Davis service areas. These service areas overlie the Yolo sub-basin and a small portion of the Solano sub-basin. The Davis/UC Davis GWMP area is shown in Figure 1-1.



Groundwater Management Plan
City of Davis/UC Davis, California

Location Map

BROWN AND CALDWELL

PROJECT 129007-007

DATE 4-14-06

Figure 1-1

P:\129000\129007 - Davis UC Davis GWMP\figs

1.3 Plan Objectives

The GWMP goal is to maintain or enhance local groundwater quantity and quality, resulting in as reliable a groundwater supply as possible for beneficial uses and avoidance of adverse subsidence. The proposed GWMP includes all required and recommended components and all applicable voluntary components per CWC§10750 *et seq.* as described in DWR's Bulletin 118, California Groundwater – Update 2003 (DWR, 2003). Specifically, the GWMP endeavors to:

- Minimize the long-term drawdown of groundwater levels;
- Protect groundwater quality such that it remains viable for public water supply;
- Prevent adverse inelastic land surface subsidence from occurring as a result of groundwater pumping;
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality;
- Minimize the effect of groundwater pumping on surface water flows and quality in sensitive areas of Putah Creek;
- Develop, plan, and implement groundwater replenishment and cooperative management projects; and
- Work collaboratively with and understand the goals and objectives of entities engaged in groundwater management in surrounding areas.

1.4 Plan Development Process

There are five main steps in the development of a GWMP as defined under CWC § 10753.2 through 10753.6; these are summarized below.

Step 1- Provide public notification of a hearing on whether or not to adopt a resolution of intention to draft a GWMP and subsequently complete a hearing on whether or not to adopt a resolution of intention to draft a GWMP. Following the hearing, draft a resolution of intention to draft a GWMP.

Step 2 - Adopt a resolution of intention to draft a GWMP and publish the resolution of intention in accordance with public notification (6066 gov. code). Upon written request, provide copy of resolution of intention to interested persons. The Davis City Council adopted the resolution of intention to develop a GWMP on October 4, 2005. This resolution can be found in Appendix A. UC Davis senior administrative management authorized UC Davis staff to participate in the development and implementation of the GWMP.

Step 3 - Prepare draft GWMP within two years of resolution of intention adoption. Provide to the public a written statement describing the manner in which interested parties may participate in developing the GWMP, as discussed in Section 1.5 below. This may also include appointing a Technical Advisory Committee (TAC).

Step 4 - Provide public notification (6066 gov. code) of a hearing on whether or not to adopt the GWMP, followed by the hearing on adopting the GWMP.

Step 5 - If protests are received for less than 50 percent of the assessed value of property in the Plan area, the GWMP may be adopted within 35 days after completion of Step 4 above. If protests are received for greater than 50 percent of the assessed value of the property in the Plan area, the Plan will not be adopted.

1.5 Public Outreach and Education

A public involvement strategy including scheduled public and stakeholder inputs, policy establishment for notifying public/stakeholders of project meetings or plan reviews, and policy establishment for public/stakeholder input documentation was developed.

Public outreach and education are a focus of the City and UC Davis' resource and conservation goals. The City and UC Davis encourage two-way dialogue, characterized by information dissemination and requests for suggestions and feedback on both City and UC Davis activities. In addition to public outreach completed during development of the GWMP as required under CWC § 10753.2 through 10753.6, the City and UC Davis have regularly disseminated information on GWMP development as part of their ongoing public outreach effort.

The City and UC Davis have reported on GWMP development during meetings with interested stakeholders. Stakeholder groups include nearby water districts, local governments, and large private well operators near the plan area. Most Yolo County stakeholders are represented through the Water Resources Association of Yolo County (WRA) and the YCFCWCD. Individuals attending these meetings typically represent a wide range of organizations, including watershed groups, water agencies, independent groundwater users, and interest groups. Future GWMP public outreach and education will focus on GWMP implementation activities.

In particular, the GWMP team presented information on GWMP development and on the draft GWMP report at meetings of the City's Natural Resources Commission (NRC) and the WRA Technical Advisory Committee (WRA TAC), with opportunity for the public to provide comment directly to Natural Resource Commission and WRA representatives. The Notice of Intention to adopt the GWMP and the draft GWMP were also presented at Davis City Council meetings, with opportunities given for comments by stakeholders and the public. Meeting dates are listed in Table 1-1. Additional details on stakeholder involvement and interagency planning are provided in Sections 3.7 and 3.8, respectively.

Table 1-1. Stakeholder and Public Meetings

Date	Meeting Group
10/4/05	Davis City Council
11/16/05	WRA TAC
11/28/05	Davis NRC
3/27/06	Davis NRC
3/29/06	WRA TAC
5/16/06	Davis City Council

1.6 Management Plan Components

This GWMP includes the following CWC required and DWR recommended components (DWR, 2003):

- **Seven mandatory components of CWC § 10750 *et seq.*** CWC § 10750 *et seq.* requires GWMPs to include several components to be eligible for award of funding administered by DWR for the construction of groundwater projects or groundwater quality projects. These amendments to the CWC were included in Senate Bill 1938, effective January 1, 2003. The amendments apply to funding authorized or appropriated after September 1, 2003.

- **Twelve voluntary components of CWC § 10750 *et seq.*** CWC § 10750 *et seq.* includes 12 specific technical issues that could be addressed in GWMPs to manage the basin optimally and protect against adverse conditions.

- **Seven recommended components in DWR Bulletin 118-223**

Table 1-2 summarizes the CWC required and DWR recommended GWMP components pursuant to current guidance and the report section where each component is addressed.

Table 1-2. City and UC Davis GWMP Components

Plan Component Description	GWMP Section
CWC § 10750 *et seq.*, Mandatory Components	
1. Documentation of public involvement statement	1.5
2. Establish basin management objectives	3.2, 3.5.1
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping	3.4
4. Plan to involve other agencies located within groundwater basin	3.7.1
5. Adoption of monitoring protocols by basin stakeholders	3.4, 3.5.3
6. Map of groundwater basin showing area of agency subject to GWMP, other local agency boundaries, and groundwater basin boundary as defined in DWR Bulletin 118	Figure 1-1
7. For agencies not overlying groundwater basins, prepare GWMP using appropriate geologic and hydrogeologic principles.	1.2
CWC § 10750 *et seq.*, Voluntary Components	
8. Control of saline intrusion	3.5.5
9. Identification and management of wellhead protection areas and recharge areas	3.5.4
10. Regulation of the migration of contaminated groundwater	3.5
11. Administration of well abandonment and well destruction program	3.5.2
12. Mitigation of conditions of overdraft	3.6.3
13. Replenishment of groundwater extracted by water producers	3.6.3
14. Monitoring of groundwater levels and storage	3.4.1
15. Facilitating conjunctive use operations	3.6.2, 3.6.3
16. Identification of well construction policies	3.5.1
17. Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects	3.6.4

Table 1-2. City and UC Davis GWMP Components (continued)

Plan Component Description	GWMP Section
CWC § 10750 *et seq.*, Mandatory Components	
18. Development of relationships with state and federal regulatory agencies	3.7.1
19. Review of land use plans and coordination with land use planning agencies to assess activities that create reasonable risk of groundwater contamination	3.5.2
DWR Bulletin 118 Suggested Components	
20. Manage with guidance of advisory committee	3.6.1, 3.7.2
21. Describe area to be managed under GWMP	1.2
22. Create link between BMOs and goals and actions of GWMP	Section 3
23. Describe GWMP monitoring program	3.4
24. Describe integrated water management planning efforts (i.e. Yolo County IRWMP)	3.8
25. Report on implementation of GWMP	3.9.1
26. Evaluate GWMP periodically	3.9.2

1.7 Groundwater Management Plan Organization

This GWMP is organized into four sections:

- Section 1 – Introduction;
- Section 2 – Water Resources (Physical) Setting;
- Section 3 – Plan Implementation; and
- Section 4 – References.

Section 2 provides an overview of existing physical conditions that should be understood and considered when developing and implementing groundwater management activities. The section includes information on topics such as precipitation, hydrology, geology, groundwater levels, groundwater quality, existing well infrastructure, and water demand and supply. The understanding of existing physical conditions helps define groundwater management needs, objectives, and actions.

Section 3 includes the major themes, or components, that will be addressed during Plan implementation. The five groundwater management components included in the Plan are groundwater monitoring, groundwater resource protection, groundwater sustainability, stakeholder involvement, and interagency water resource planning. Nested under each of these components are specific implementation actions that the City and UC Davis will be pursuing.

Section 4 includes Plan references.

SECTION 2
PHYSICAL SETTING

2.1 Introduction

The City of Davis and most of UC Davis are located in the Yolo Subbasin (Subbasin 5-21.67) of the Sacramento Valley Groundwater Basin as defined in the California DWR Bulletin 118 update (DWR, 2003). Figure 1-1 shows the location of the groundwater subbasins. The Yolo Subbasin is bounded by Cache Creek on the north; the Sacramento River on the east; Putah Creek on the south; and the Coast Range on the west (DWR, 2004).

2.2 Topography

Land surface elevations within the Yolo Subbasin range from approximately 0 feet along the southeastern edge to approximately 630 feet along the western edge. Except near the western edge of the basin, where land surface elevations increase with proximity to the Coast Range, the topographic relief is low. Land surface elevations within the City and UC Davis service areas range from approximately 30 to 80 feet above sea level. The Plainfield Ridge, the southern topographic expression of the Dunnigan Hills anticline, is an area of slightly elevated rolling hills located approximately four miles west of Davis. The Yolo Bypass, the flood basin of the Sacramento River, is located approximately three miles east of Davis (Figure 1-1).

2.3 Climate and Precipitation

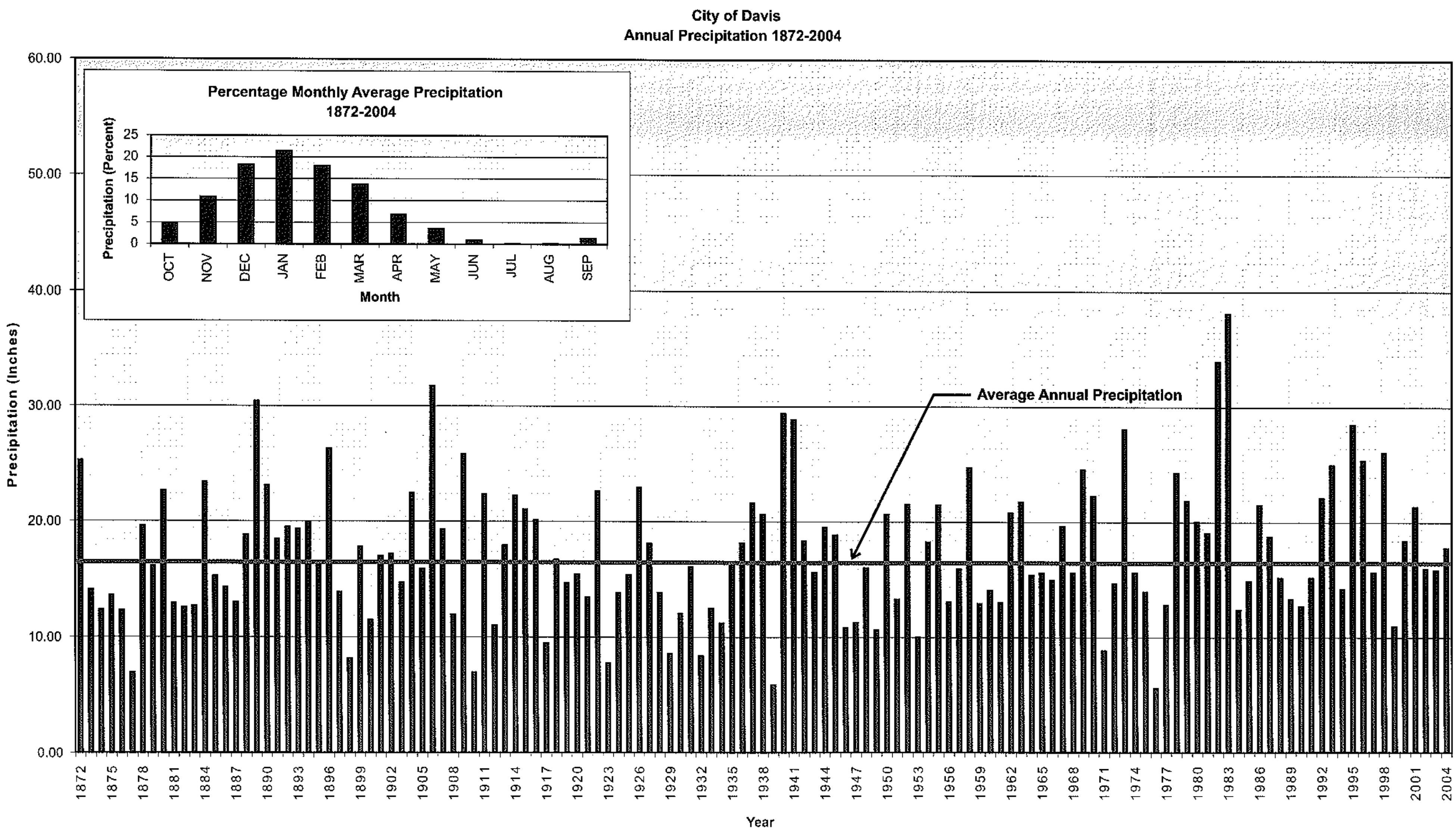
The Yolo Subbasin has a Mediterranean climate with cool, wet winters and hot, dry summers. Regionally, temperature and precipitation vary with elevation, with the lower temperatures and higher precipitation occurring at higher elevations. The region is subject to wide variations in annual precipitation and experiences periodic dry periods. Summers can be hot at times with weekly periods of 100 degree Fahrenheit temperatures, which greatly increase summer irrigation requirements.

Based on the historical data obtained from the Western Regional Climate Center, average monthly temperature ranges from 45 to 75 degrees Fahrenheit. Extreme low and high daily temperatures are 12 and 116 degrees Fahrenheit, respectively.

The average annual precipitation varies from 18 inches near the eastern edge of the subbasin to 24 inches near the western edge (DWR, 2004). However, because of the low topographic relief in the eastern part of the subbasin, temperature and precipitation do not vary greatly within the City and UC Davis.

Figure 2-1 shows the annual precipitation for the Davis area for the period 1872 through 2004. Table 2-1 summarizes the annual precipitation statistics.

P:\29000\129007 - Davis UC Davis GWMP\figs



BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure
	DATE 2-16-06	Historic Precipitation	2-1

Table 2-1. Statistics for City of Davis Precipitation, 1872 through 2004

Statistic	Annual Precipitation, inches	Year
Minimum	5.6	1976
Maximum	38.1	1983
Median	16.1	1931
Mean	17.4	1872-2004

Multi-year dry periods in the Davis area have included:

- 1873-1877
- 1881-1883
- 1885-1887
- 1897-1898
- 1917-1921
- 1923-1925
- 1928-1934
- 1946-1949
- 1959-1961
- 1976-1977
- 1988-1991

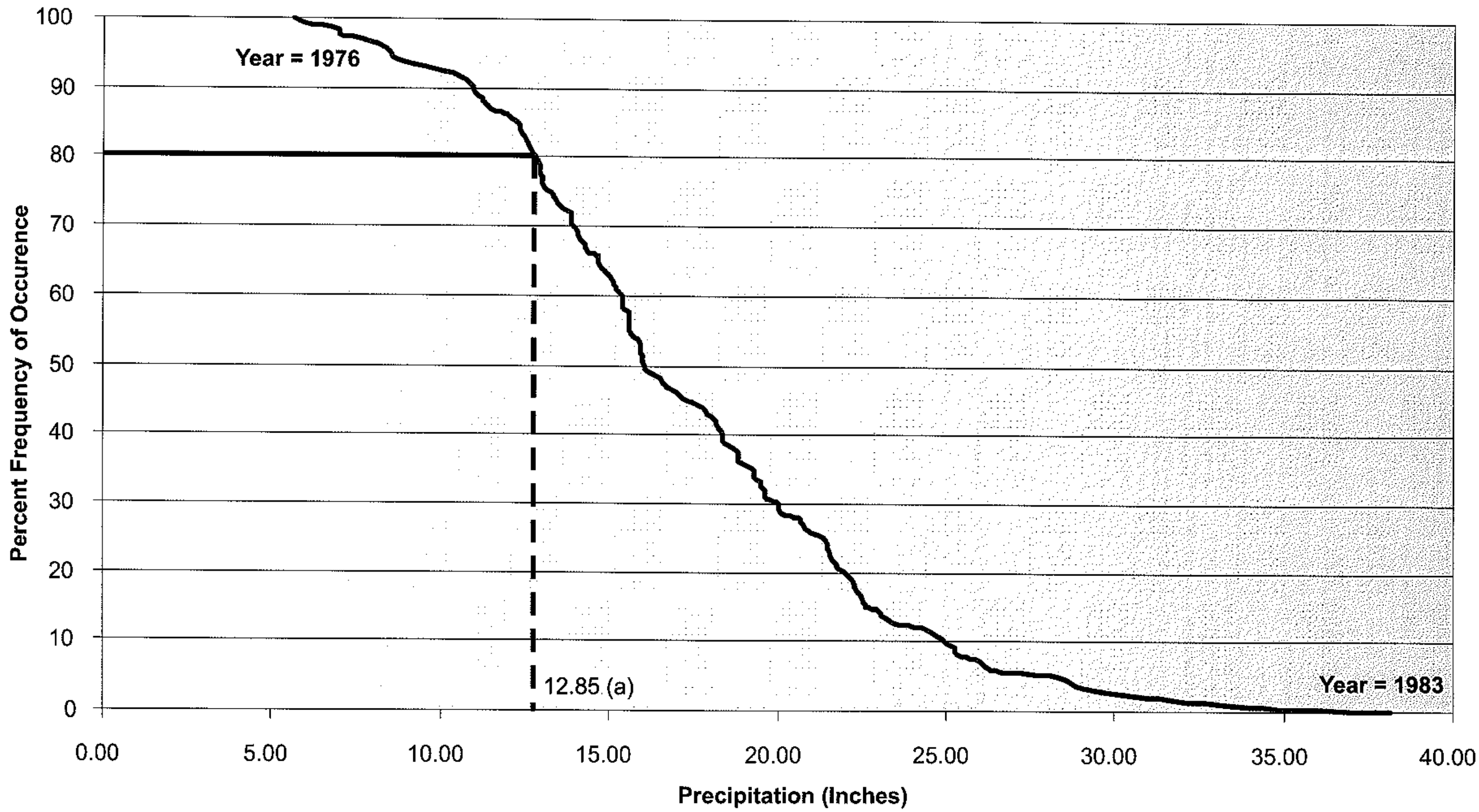
Figure 2-2 is an exceedance curve for Davis area precipitation data. The figure shows the frequency at which a given level of annual precipitation was met or exceeded. The curve can be used to gauge how frequently the precipitation recorded in any given year was equaled or exceeded in the past. For example, the minimum historical precipitation of 5.6 inches in 1976 was equaled or exceeded in 100 percent of all years from 1872 to 2004. The 16.1 median inches of precipitation recorded in 1931 was met or exceeded in 50 percent of past years.

2.4 Surface Water Hydrology

The major surface water features in the vicinity of the City and UC Davis service areas form the Yolo Subbasin's boundaries. These boundaries are Cache Creek on the north, Putah Creek on the south, and the Sacramento River on the east (Figure 1-1). Of these streams, Putah Creek is most significant because of its proximity to the City and UC Davis service areas. Putah Creek is the most southerly of the major tributaries to the Sacramento River originating in the Coast Ranges.

Putah Creek drains approximately 600 square miles beginning in the St. Helena Range south of Clear Lake. The stream flows southeasterly to Lake Berryessa, which inundated the Berryessa Valley beginning in 1959 with completion of Monticello Dam as part of the U.S. Bureau of Reclamation's Solano Project. Releases from Lake Berryessa are controlled at Lake Solano, near Winters. Flows are diverted at the Putah Diversion Dam for use in Solano Project service areas and are also released to Lower Putah Creek. Below the Putah Diversion Dam, the stream flows easterly approximately 20 miles to the Yolo Bypass and eventually discharges to Cache Slough on the Sacramento–San Joaquin River Delta.

P:\29000\129007 - Davis UC Davis GWMP\figs



(a) Example: 80% chance of annual rainfall exceeding 12.85 inches and a 20% chance of annual rainfall less than or equal to 12.85 inches, which is one definition of a dry year in Section 3 of this plan.

BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure 2-2
	DATE 4-14-06	Precipitation Exceedance Curve, 1872-2004	

There are no natural surface water inflows to Lower Putah Creek east of Winters, and, because the stream occupies a channel ridge, precipitation falling outside of the channel does not enter the stream (Tomasson, et. al., 1960). The stream channel forks about three miles southwest of Davis. The south fork was reportedly excavated beginning in the 1890's and follows a section line for nearly four miles (Tomasson, et. al., 1960). The former north fork, which passes through the UC Davis service area, is separated from the south fork by a flood control levee. All flow is along the south fork.

Following a series of legal actions beginning in 1990, a settlement known as the Putah Creek Accord was negotiated in 2000 to resolve disputes involving the Putah Creek Council, the City of Davis, UC Davis (Yolo parties), the Solano County Water Agency (SCWA), Solano Irrigation District (SID), Maine Prairie Water District and the Cities of Vacaville, Fairfield, Vallejo and Suisun City (Solano parties). The settlement agreement provides for instream flows required for maintenance and enhancement of aquatic and related resources in Lower Putah Creek, with provisions for reducing these flows when storage in Lake Berryessa is low. The settlement agreement also includes a process for addressing illegal surface water diversions from Putah Creek. The Yolo and Solano parties formed the Lower Putah Creek Coordinating Committee and established a streamkeeper position to implement the settlement agreement.

The settlement agreement requires SCWA and SID to maintain certain instream flows measured at the Putah Diversion Dam, the Interstate 80 Bridge over Putah Creek, and the western side of the Yolo Bypass. Releases must be sufficient to maintain flows from Old Davis Road Bridge to the western boundary of the Yolo Bypass throughout the year except in certain years when reservoir storage is low. During years of low reservoir storage, flow must be maintained to the Interstate 80 Bridge.

SCWA has established the Lower Putah Creek Riparian Water Program (PRWP) to differentiate riparian and non-riparian water downstream of the Putah Diversion Dam. SCWA defines riparian water as any water derived from precipitation or rising groundwater that would exist in Lower Putah Creek in the absence of the Solano Project. Under the PRWP, Lower Putah Creek is divided into five reaches:

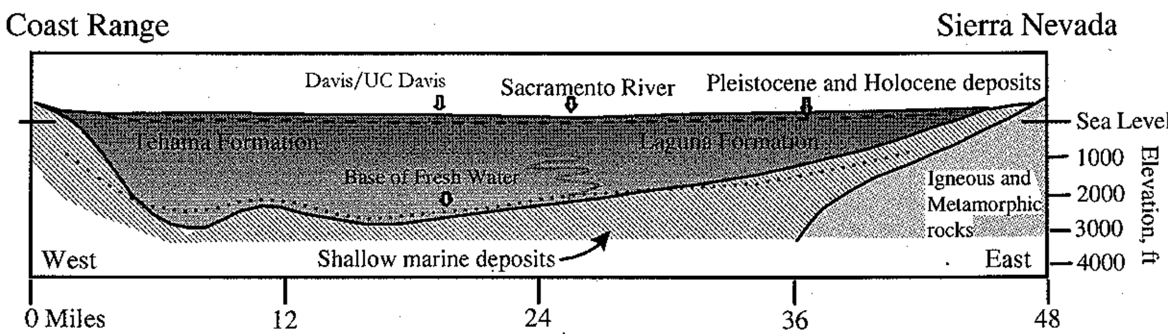
a) Putah Diversion Dam to Interstate 505 Bridge (a losing reach)
b) Interstate 505 Bridge to Stevenson Bridge (a gaining reach)
c) Stevenson Bridge to Interstate 80 Bridge (a losing reach)
d) Interstate 80 Bridge to Mace Boulevard (a losing reach)
e) Mace Boulevard to Yolo Bypass (a losing reach).

Only the reach from Interstate 505 Bridge to below Stevenson Bridge is gaining due to groundwater seepage into the creek. The gaining characteristics may be attributable to geologic factors related to the Dunnigan Hills Anticline and Plainfield Ridge. Along all other reaches, seepage occurs from the creek to the underlying aquifer. The net stream loss or gain is the net total of groundwater seepage, precipitation, and evapotranspiration under the PRWP. Groundwater elevation measurements are used to calculate seepage to or from Putah Creek.

2.5 Hydrogeology

The Sacramento Valley in the vicinity of City and UC Davis is filled by a thick sequence of marine sedimentary rock of Late Jurassic (159 million years [my] before present) to Eocene (34 my) age, unconformably overlain by a sequence of continental sedimentary deposits of Pliocene (5 my) and younger age Pliestocene and Holocene deposits (Harwood and Helley, 1987).

A generalized geologic cross section for the Sacramento Valley is shown in Figure 2-3.

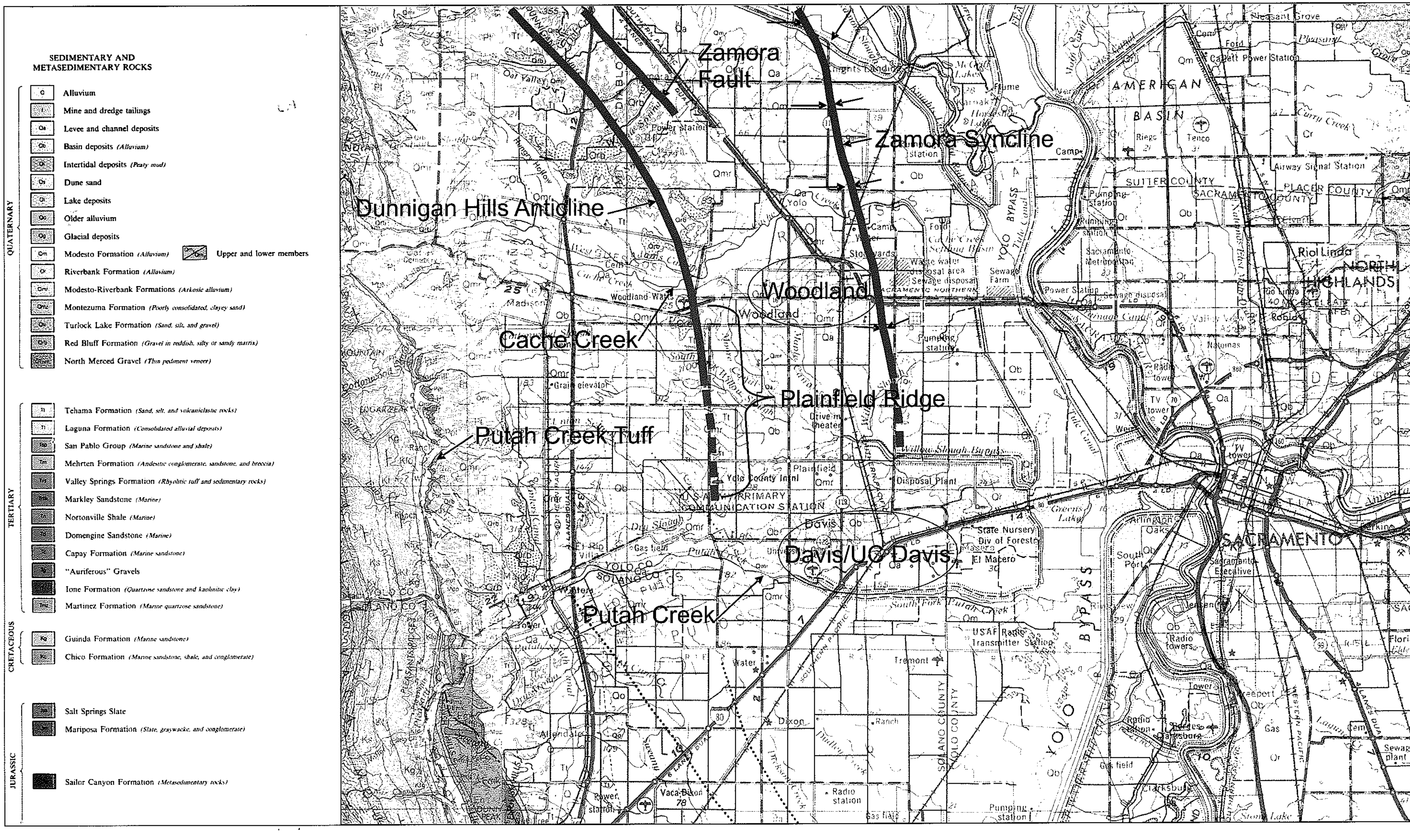


Source: California Department of Water Resources, 1978

Figure 2-3. Sacramento Valley Geologic Cross Section

The older, deeper marine rocks contain saline water. The freshwater aquifers in the vicinity of City and UC Davis occur in the overlying continental sedimentary deposits. Figure 2-4 is a geologic map encompassing the City, UC Davis, and vicinity showing the major types of exposed sedimentary deposits and important structural features in the area (CGS, 1981). Figure 2-5 is a geologic column that provides a conceptual overview of the freshwater portion of the aquifer in the Davis area.

Shallow groundwater in the Davis area generally occurs under unconfined conditions in the recent Holocene stream channel deposits (DWR, 1978). At greater depths, groundwater occurs under mostly semiconfined to confined conditions in a heterogeneous aquifer system, composed of predominantly fine-grained sediments enclosing discontinuous lenses of sand and gravel. The aquifer properties, including hydraulic conductivity, vertical leakance and degree of confinement are dependent on the properties of the fine grained units (Williamson, et. al., 1989; Bertoldi, et. al., 1991). The geologic formations comprising the freshwater aquifer are discussed from oldest to youngest in the following sections.



References:
California Geological Survey, 1981, Geologic Map of the Sacramento Quadrangle, compiled by D.L. Wagner, C.W. Jennings, T.L. Bedrossian and E.J. Bortugno, 1:250,000, second printing 1987.

California Geological Survey, 1982, Geologic Map of the Santa Rosa Quadrangle, compiled by D.L. Wagner and E.J. Bortugno, 1:250,000, second printing 1999.

Harwood, D.S. and E.J. Helley, 1987, U.S. Geological Survey Professional Paper 1359, Late Cenozoic Tectonism of the Sacramento Valley

Groundwater Management Plan
City of Davis/UC Davis, California

Geologic Map

BROWN AND CALDWELL

PROJECT 129007-007

DATE 3-17-06

Figure 2-4

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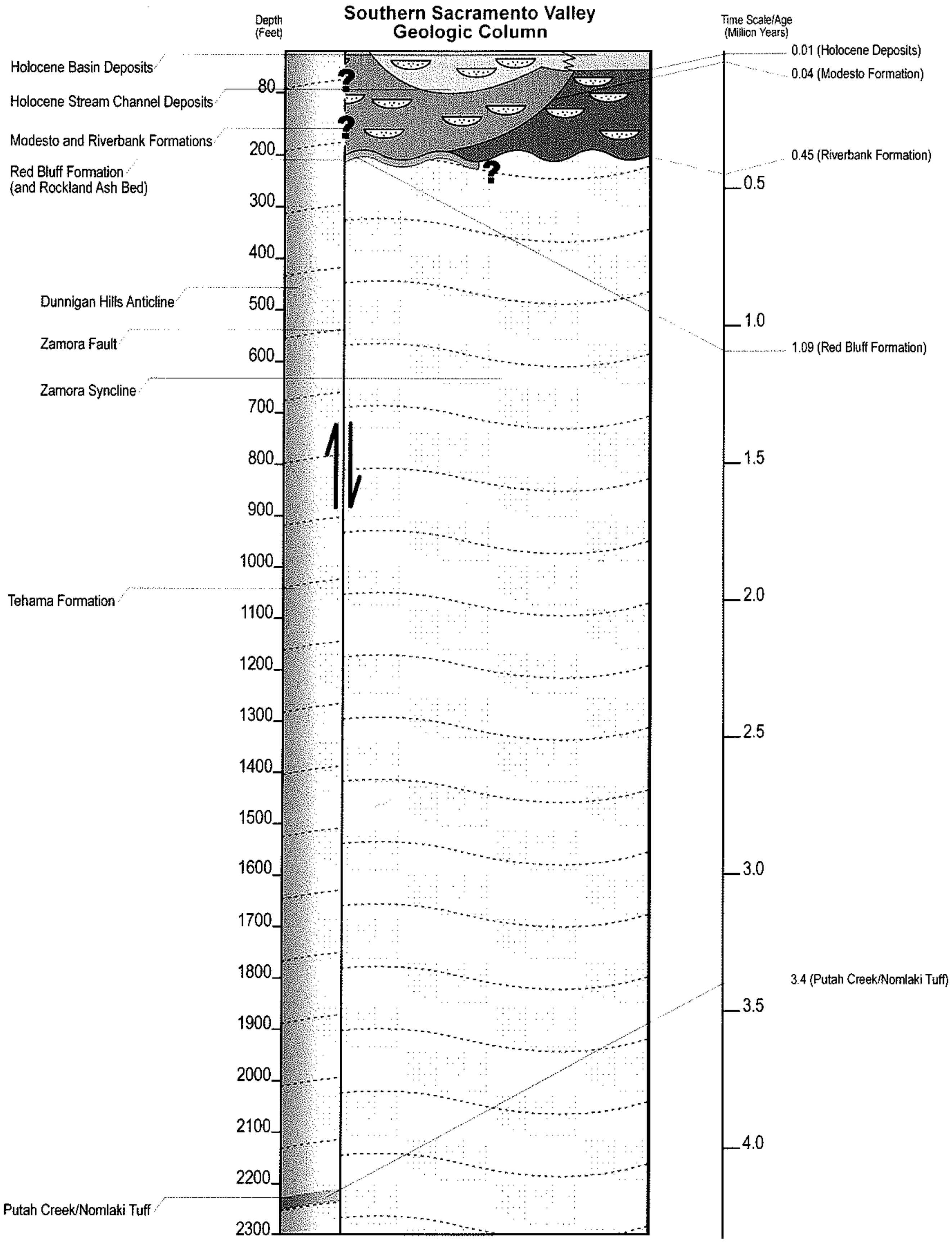

(Approximate Base of Freshwater: 2,800 Feet)

BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan City of Davis/UC Davis, California	Figure 2-5
	DATE 3-9-06	Conceptual Geologic Column of the Sacramento Valley	

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2.5.1 Tehama Formation

The Tehama Formation (Figure 2-5) forms the oldest, deepest and thickest part of the freshwater aquifer in the Davis area. The Tehama Formation consists of up to 2,500 feet of moderately compacted silt, clay, and silty fine sand enclosing thin, discontinuous lenses of sand and gravel, silt and gravel deposited in a fluvial (river-borne) environment. In outcrop, the Tehama Formation consists of pale green, gray, and tan sandstone and siltstone with lenses of crossbedded pebble and cobble conglomerates. Based on the mineralogy of surface exposures, the sediments were derived from erosion of the Coast Ranges and Klamath Mountains (Russell, 1931; DWR, 1978, 2004; Helley and Harwood, 1985). The sediments were distributed by ancestral east-flowing Coast Range drainages, and deposited into the Sacramento Valley, which, at that time, was similar but considerably wider than it is today (Olmsted and Davis, 1961). The overall south-flowing drainage of the Sacramento Valley also distributed and reworked these deposits, as evidenced by the crossbedding seen in the coarser layers of the formation and sourcing of some sediments from the north (Olmsted and Davis, 1961).

The Tehama Formation is exposed at the land surface over extensive areas on the eastern flank of the Coast Range including the Dunnigan Hills and English Hills. Smaller outcrops are present on the Plainfield Ridge. The Tehama Formation is buried beneath younger sediments in most other areas of the Sacramento Valley (Figure 2-4).

The age of the Tehama Formation is constrained by volcanic rock units, which can be time-correlated with rock units deposited near the base and slightly above the top of the Tehama Formation. The Putah Creek/Nomlaki Tuff, which is located near the base of the Tehama Formation has a radiometrically determined age of 3.4 my (Evernden et. al, 1964; Harwood and Helley, 1987). The Putah Creek Tuff is exposed at the land surface in the Capay Hills northwest of the Davis area (Figure 2-4). Figure 2-5 shows the estimated stratigraphic position of the Putah Creek/Nomlaki Tuff in the subsurface, based on the total thickness of the Tehama Formation. The Tehama Formation is unconformably overlain by a thin gravel pediment known as the Red Bluff Formation (Figures 2-4 and 2-5). The age of the Red Bluff Formation is constrained to be 0.45 to 1.09 my by the radiometrically determined ages of the Rockland ash bed and the Deer Creek basalt, respectively (Harwood, et. al., 1981; Harwood and Helley, 1987).

The Tehama Formation is the primary water-bearing stratigraphic unit in the area. The permeability of the Tehama Formation is highly variable but generally less than the overlying Quaternary alluvium. Because of the relatively large thickness, wells can yield up to several thousand gallons per minute (gpm) (DWR, 2004). The majority of irrigation and public supply wells in the Davis area are completed in the Tehama Formation (DWR, 2004).

2.5.2 Riverbank and Modesto Formations

Wells penetrating the sand and gravel units of the Riverbank and Modesto Formations produce up to about 1,000 gpm (DWR, 2004). The majority of the small domestic wells in the Davis area are completed in the Riverbank and Modesto Formations (DWR, 2004).

The Tehama and Red Bluff Formations are unconformably overlain by the late Pleistocene age Riverbank and Modesto Formations. These formations consist of up to 200 feet of loose to moderately compacted silt, silty clay, sand and gravel deposited in alluvial depositional environments during periods of world-wide glaciation (Lettis, 1988; Weissmann, et. al., 2002; DWR, 2004). In the Davis area, the Riverbank and Modesto Formation are not directly related to glacial activity, because glaciers were generally not present in the Coast Ranges. Instead, the formations were deposited in response to changes in base level and increased precipitation during the glacial periods.

Figure 2-4 shows the distribution of the Riverbank and Modesto Formation in the Davis area. The formations are exposed at the land surface along the channels of Cache and Putah Creeks, and along the fringes of the Dunnigan Hills and Coast Range, where they form a series of coalescing alluvial fans, emanating from the mouths of the creeks.

The age of the Riverbank Formation ranges from 0.13 to 0.45 my and corresponds to the Illinoisan and older glacial stages. The age of the Modesto Formation ranges from approximately 0.01 to 0.042 my and correlates to the Wisconsin glacial stage.

2.5.3 Holocene Stream Channel and Basin Deposits

According to DWR, Holocene stream channel deposits form a shallow aquifer of moderate to high permeability, but with limited capacity due to the relatively restricted lateral and vertical extents of the deposits. Some of the shallower domestic wells in the Davis area may be screened in Holocene stream channel deposits (DWR, 2004). Because of their low permeability, limited extent, and generally poor water quality, Holocene flood basin deposits are typically not used for groundwater production (DWR, 2004). Figure 2-4 shows the distribution of stream channel and basin deposits in the Davis area.

Holocene stream channel and basin deposits are the youngest sediments in the region, with ages of 10,000 years or less. The stream channel deposits consist of up to 80-foot sections of unconsolidated clay, silt, sand and gravel reworked from older formations by streams.

Holocene flood basin deposits are very young near-surface deposits formed during flood events when streams overtopped their natural levees flooding the surrounding area. As the floodwater spread, the current velocity decreased, resulting in deposition of silts, clays and fine sands.

2.5.4 General Structure

Tectonism related to changing dynamics of the north-northwest trending San Andreas fault plate boundary along the California coast continued to uplift and deform the Coast Ranges after the deposition of the Tehama Formation (Dickenson and Snyder, 1979; Harwood and Helley, 1987). The formation was uplifted and regionally tilted to the east, and the western edge of the formation was partially eroded, leaving it exposed on the lower east flank of the Coast Ranges. Stresses related to the San Andreas fault system extended to the western margin of the Sacramento Valley after the initial uplift that tilted the formation eastward. These stresses created a set of broad folds expressed geographically as the Dunnigan Hills (Harwood and Helley, 1987) (Figure 2-4). Other structural features are located in the subsurface.

The significant structural features in the Davis area are the Zamora fault, the Dunnigan Hills anticline (Plainfield Ridge), and the Zamora syncline (Figure 2-4). These structural features affect rock units at least as young as the Red Bluff Formation, which indicates that the structural deformation was occurring as recently as 1.09 my – the youngest age of the Red Bluff Formation – and may be continuing at present (Harwood and Helley, 1987).

Folds

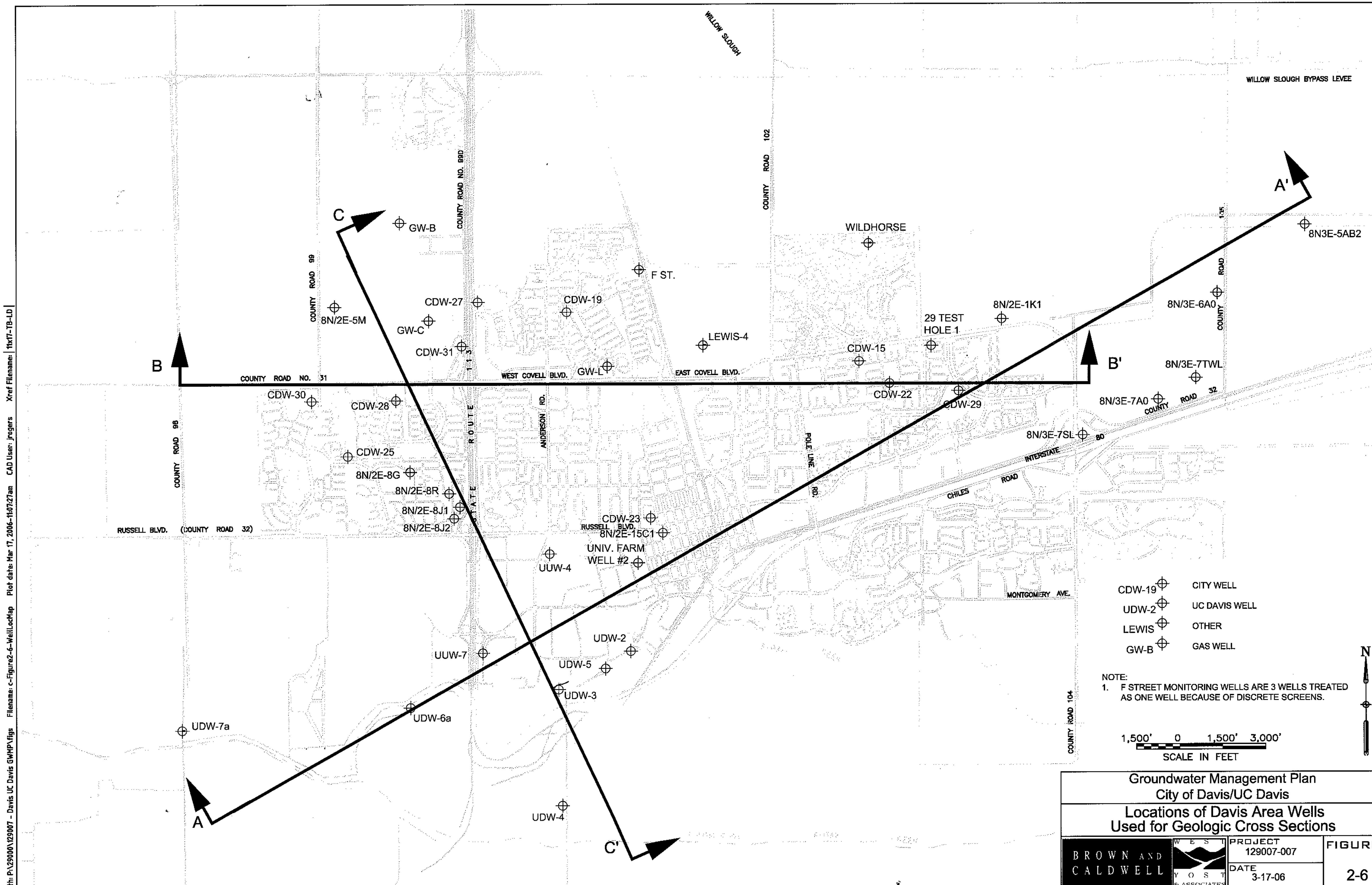
The Dunnigan Hills are the topographic expression of a doubly plunging anticline, a fold in which the central axis is raised relative to the limbs (Figures 2-3, 2-4 and 2-5). The axis of the Dunnigan Hills anticline is oriented northwest and plunges beneath the land surface on both ends of the structure. To the south-southeast the anticline is subtly expressed as the Plainfield Ridge, the alignment of low hills that project into the south-central portion of Yolo County along the western margins of Woodland and Davis (Harris and Brewster, 2005).

The Zamora syncline is a similar structural feature, except that the fold axis is lowered relative to the limbs of the fold and is not doubly plunging. The Zamora syncline is located in the subsurface east of the Dunnigan Hills and Zamora fault (Figure 2-5). The axis of the syncline passes beneath the east side of the City of Davis. The Zamora syncline has no topographic expression, which means that the thickness of post-Cretaceous sediments, including the Tehama Formation, is greater along the axis of the syncline than on the limbs (Figure 2-5). This means that the aquifer thickness is greatest along the axis of the syncline.

Folds may also affect groundwater conditions because the folds cause the elevation of geologic units to vary from place to place. This has two effects. First, since the Dunnigan Hills anticline is expressed at the land surface, erosion of the Tehama Formation has exposed older, lower sections of the formation along axis of the fold. Thus, the folds may affect recharge characteristics where the Tehama Formation is exposed at the land surface or is in contact with overlying formations that transmit recharging water. Second, the Tehama Formation sediments were typically aligned along bedding planes during deposition of the sediments, resulting in higher permeability along than across bedding planes. Typically, this results in a maximum permeability horizontally and a minimum permeability vertically. Subsequent folding of the bedding planes causes a reorientation of the direction of maximum and minimum permeability, which could tend to affect groundwater directions and rates of flow.

2.5.5 Davis Area Detailed Hydrogeologic Cross-Sections

Geologic cross sections were developed for the Davis area based on the Hydrogeologic Conceptualization Report (LSCE; 2003, 2005), Phase I Deep Aquifer Study cross-sections, and a detailed evaluation of water well and gas well logs in the north Davis area (Brown and Caldwell and West Yost & Associates, 2005). The section lines are shown in Figure 2-6. The cross sections including the sand sequence boundaries as defined by LSCE (2005) are shown in Figures 2-7, 2-8, and 2-9.



Groundwater Management Plan
City of Davis/UC Davis

Locations of Davis Area Wells
Used for Geologic Cross Sections

BROWN AND CALDWELL

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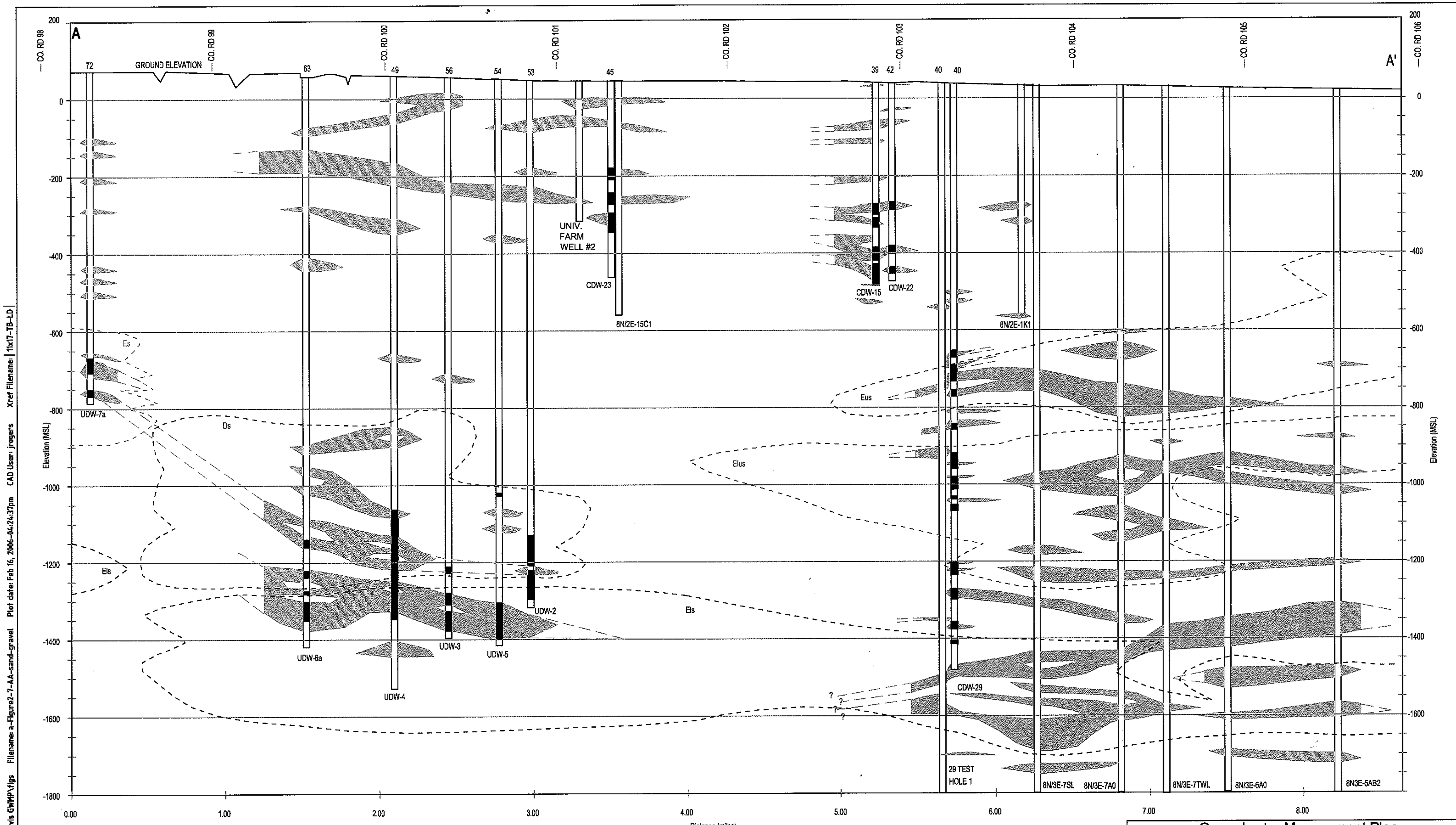
DATE 3-17-06

FIGURE 2-6

Path: P:\29000\129007 - Davis UC Davis GWMP\figs Filename: c-Figure2-6-WellLocMap Plot date: Mar 17, 2006-11:07:27am CAD User: jrogers Xref Filename: 11x17-TB-LD



CDW-	CITY OF DAVIS WELL	■	WELL SCREENS
UDW-	UCD DOMESTIC WELL		SAND AND GRAVEL
UUW-	UCD UTILITY WELL	- - -	SAND SEQUENCE, LSCE 2005

Groundwater Management Plan
City of Davis/UC Davis

Cross-section A-A'
Sand and Gravel Layers

BROWN AND CALDWELL

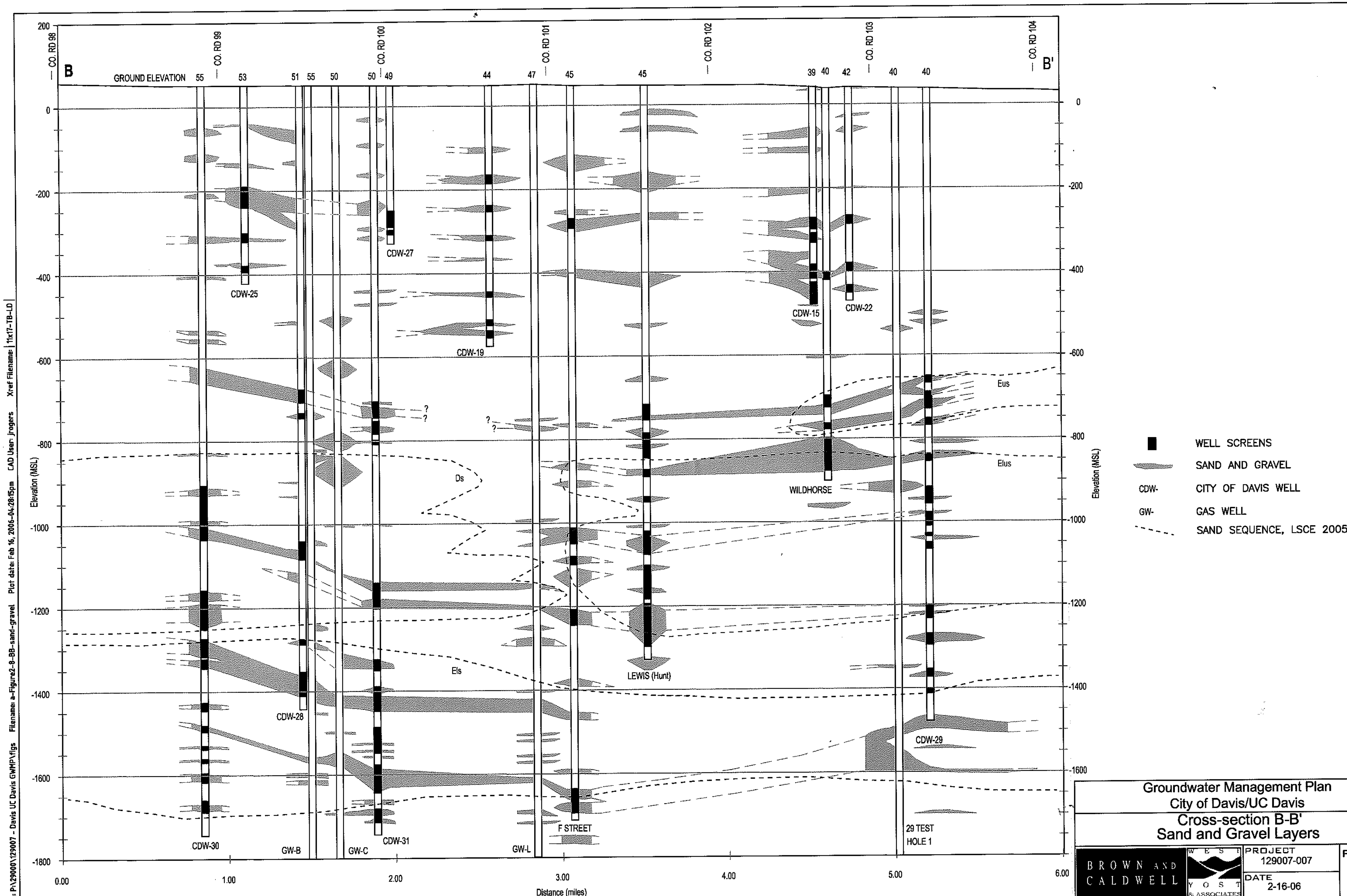
WEST YOST & ASSOCIATES

PROJECT 129007-007

DATE 2-16-06

FIGURE 2-7

Path: P:\29000\129007 - Davis UC Davis GWMP\figs Filename: a-Figure2-7-AA-sand-gravel Plot date: Feb 16, 2006-04:24:37pm CAD User: jrogers Xref Filename: | 11x17-TB-LD |



Groundwater Management Plan
City of Davis/UC Davis

Cross-section B-B'
Sand and Gravel Layers

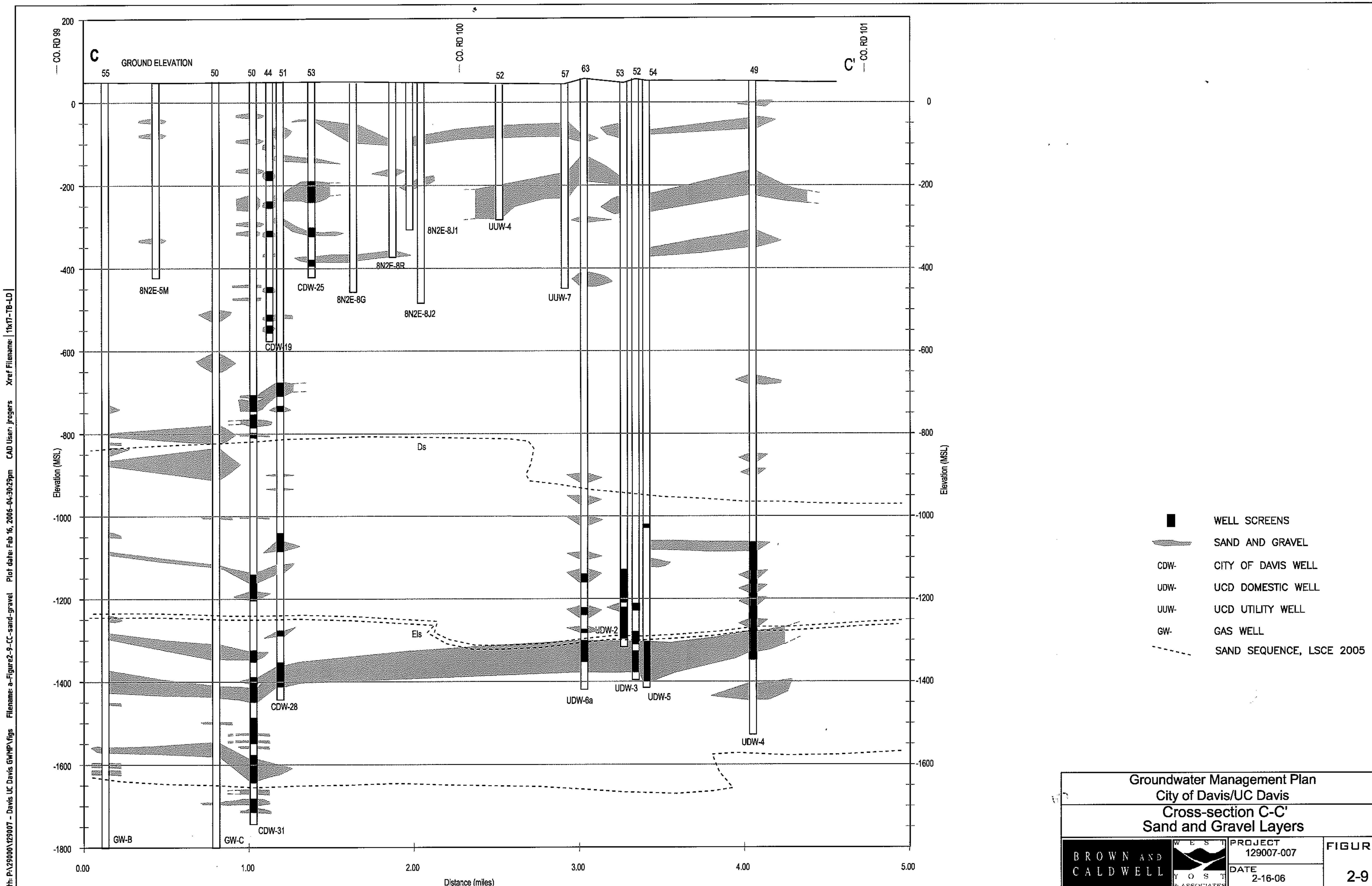
BROWN AND CALDWELL

WEST YOST & ASSOCIATES

PROJECT 129007-007

DATE 2-16-06

FIGURE 2-8



Groundwater Management Plan
City of Davis/UC Davis

Cross-section C-C'
Sand and Gravel Layers

BROWN AND CALDWELL | WEST YOST & ASSOCIATES | PROJECT 129007-007 | DATE 2-16-06 | FIGURE 2-9

2.5.6 Soils

According to DWR (1978), which summarizes work performed by the United States Geological Survey (Bertoldi, 1974), most soils in the Davis area are either 1) "soils containing hardpan or other consolidated horizons that restrict the vertical flow of water, including soils over bedrock", such as in the Dunnigan Hills and other areas in which the Tehama Formation is exposed; or 2) "soils containing clay in sufficient quantities to impede the vertical flow of water", such as occur in most of the lands within the Davis area. Exceptions to this generalization are the soils in the vicinity of Putah and Cache Creeks, which have "few barriers to the vertical flow of water." Areas containing soils with few barriers to vertical flow are more likely to be the recharge areas for underlying aquifers

2.5.7 Groundwater Levels

Groundwater elevation measurements have been recorded in the Davis area for over 50 years and are available through the DWR Water Data Library at http://wdl.water.ca.gov. Representative hydrographs for shallow and intermediate depth wells in the Davis Area are shown on Figures 2-10 and 2-11. The figures show that groundwater elevations declined through the 1950s and 1960s. Groundwater elevations increased thereafter, in response to regional water supply projects implemented by SCWA (Lake Berryessa) and YCFCWCD (Indian Valley Reservoir).

In addition to the groundwater elevation changes resulting from variation in land and water use practices over time, the hydrographs also show that groundwater elevations have fluctuated in response to changes in precipitation. As noted in Section 2.2, the area experienced multiple years of below normal precipitation in 1976 through 1977 and 1988 through 1991. These periods are apparent in the hydrographs (Figure 2-10 and 2-11). Groundwater elevations in the falls of 1977 and 1992 were near the historical minima recorded in the mid 1960s. The maximum groundwater elevation measurements were recorded in spring 1983, the same year that the maximum annual precipitation was recorded (Figures 2-1 and 2-2).

Groundwater elevation contour maps depicting the range of groundwater elevations in the Davis area are shown on Figures 2-12 through 2-15. Near minimum groundwater elevations exemplified by fall 1964 and fall 1976 are shown on Figure 2-12 and 2-13. Figure 2-14 shows the maximum groundwater elevations measured in spring 1983, and Figure 2-15 shows recent groundwater elevations measured in fall 2003. Fall 2003 had near average precipitation (Figures 2-1 and 2-2).

2.5.8 Groundwater Movement

Generally, groundwater flow is from the margins of the Sacramento Valley toward the Sacramento River and then southward towards the Sacramento-San Joaquin Delta. Locally, near the losing stretches of Putah Creek east of the Plainfield Ridge, groundwater flow is northeast or southeast away from the creek. Groundwater pumping in several areas has created cones of depression that disrupt the broad groundwater flow patterns. Historically, groundwater elevations in the region have ranged from roughly -40 feet to 50 feet above mean sea level (msl).

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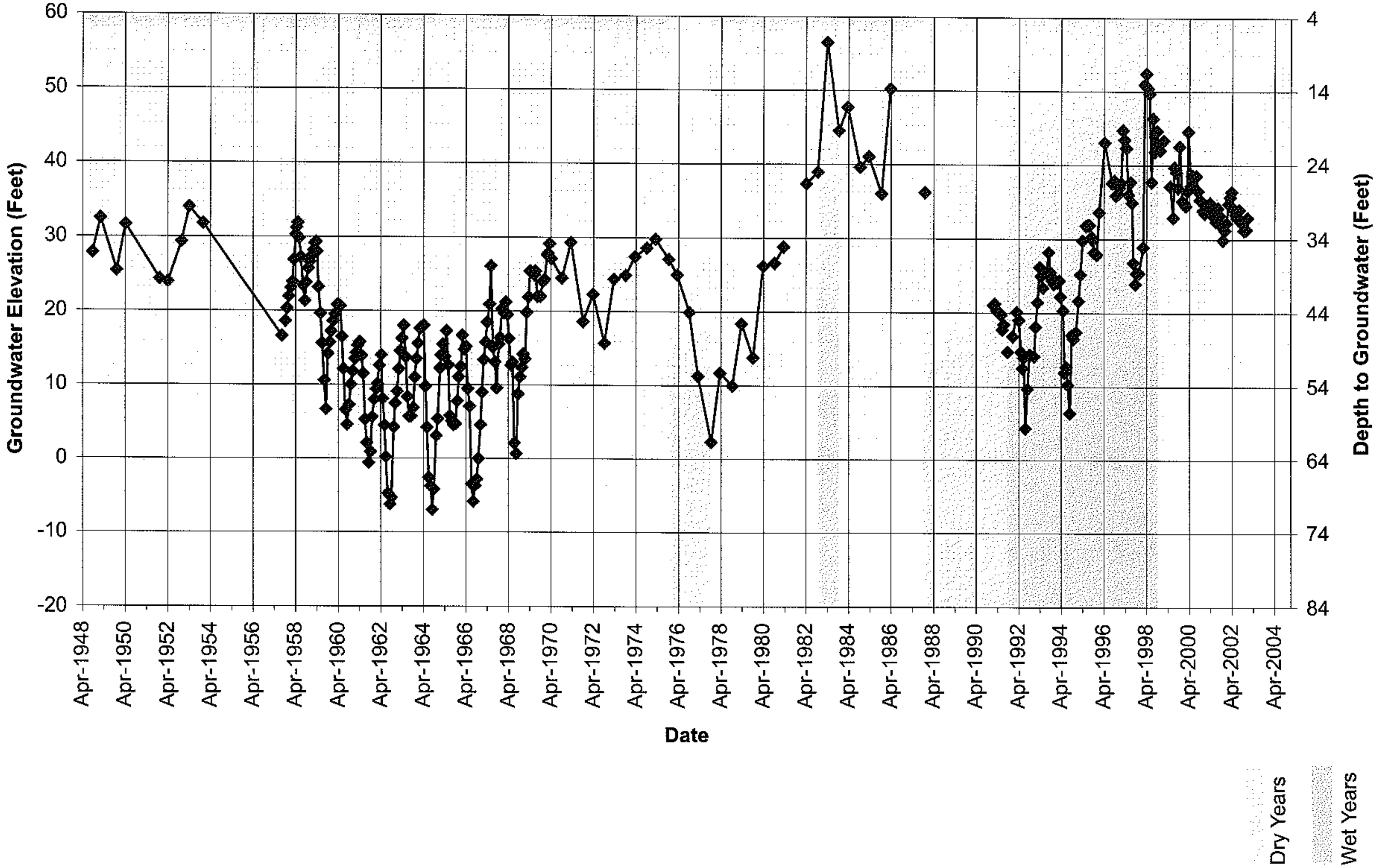

BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure
	DATE 2-16-06	Hydrograph of Department of Water Resources Well No. 08N01E12R003M, Elevation 64 feet	2-10

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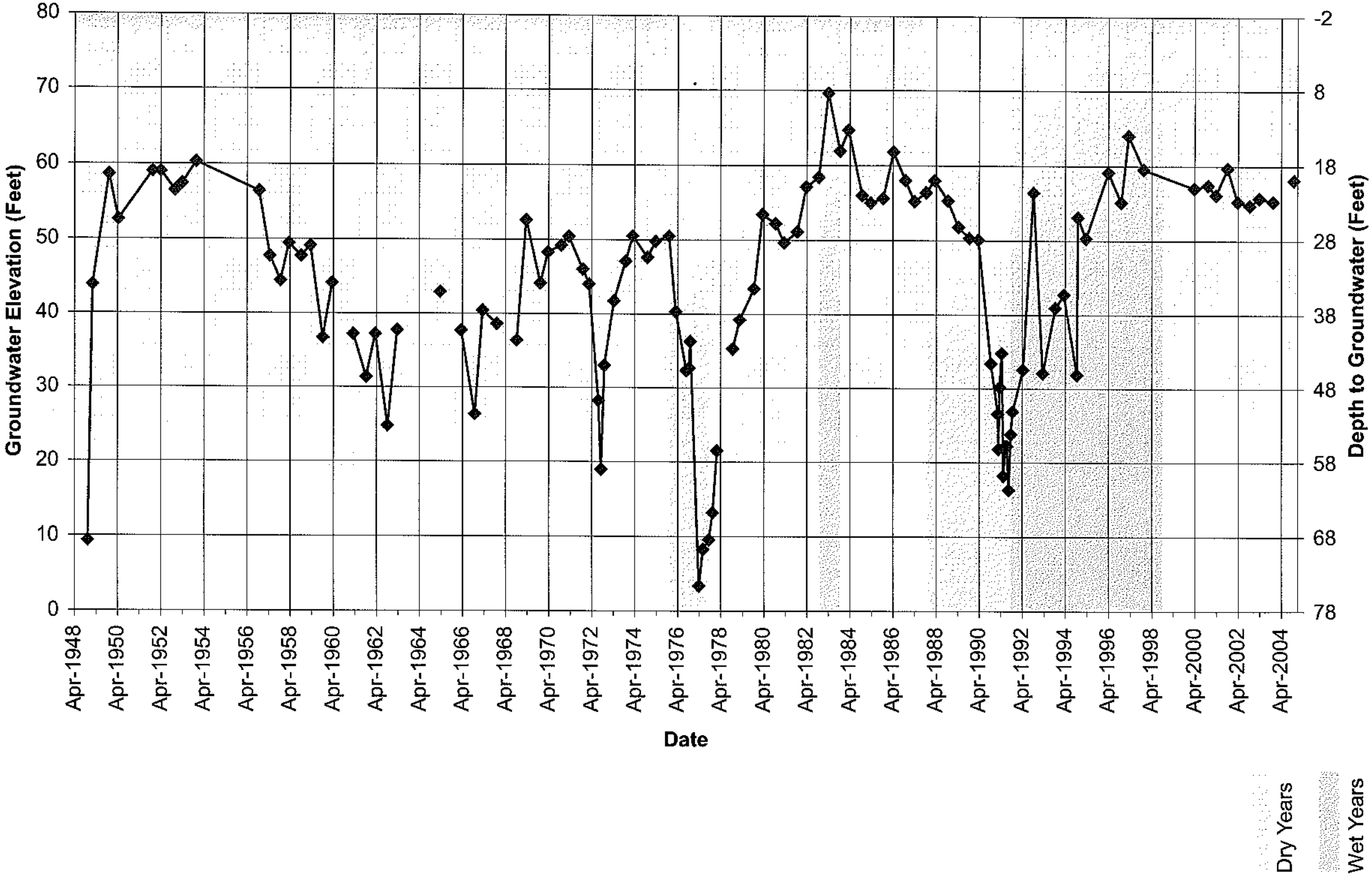
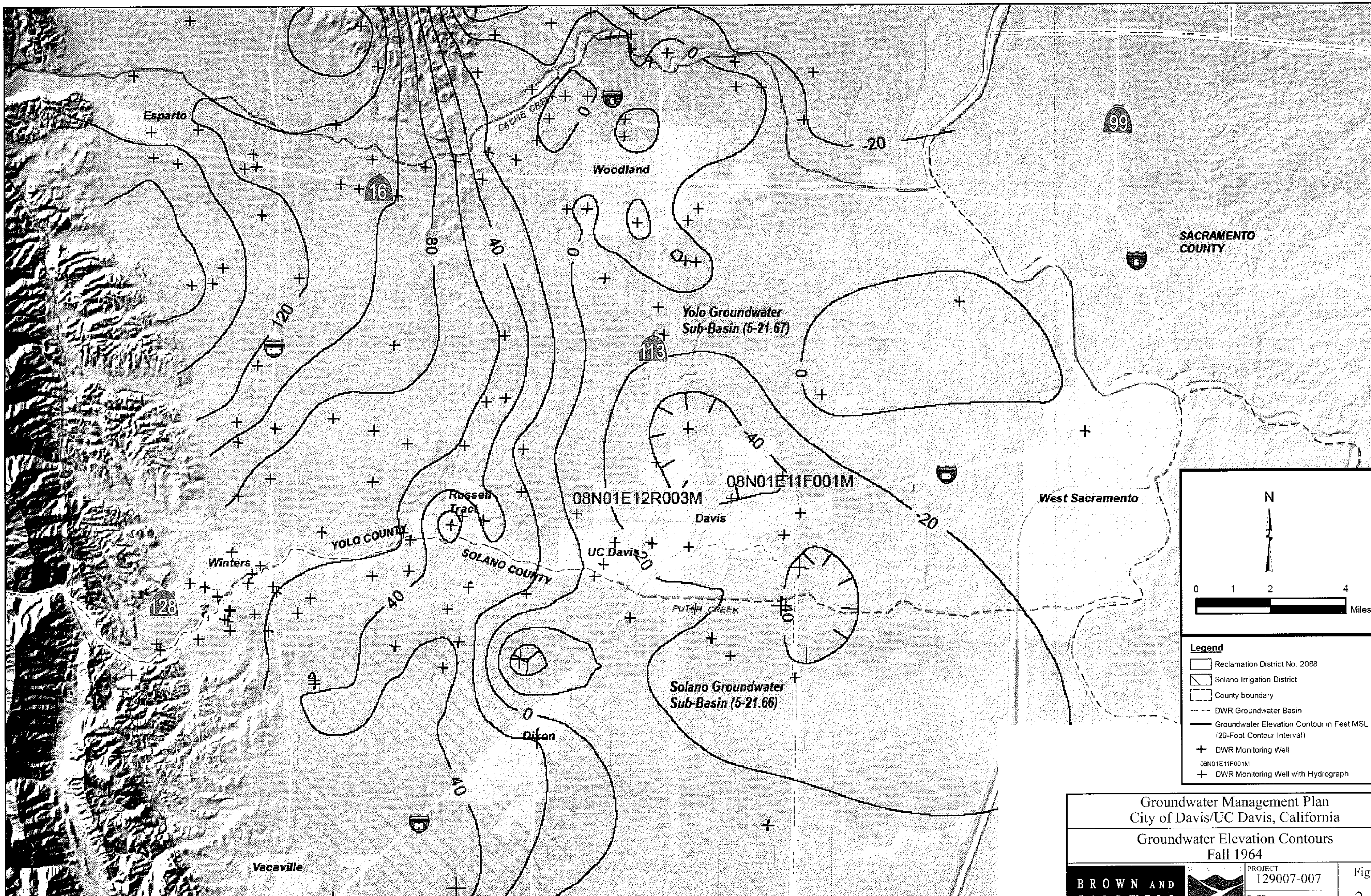


BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure
	DATE 2-16-06	Hydrograph of Department of Water Resources Well No. 08N01E11F001M, Elevation 78 feet	2-11



Groundwater Management Plan
City of Davis/UC Davis, California

Groundwater Elevation Contours
Fall 1964

BROWN AND CALDWELL

PROJECT 129007-007

DATE 3-16-06

Figure 2-12

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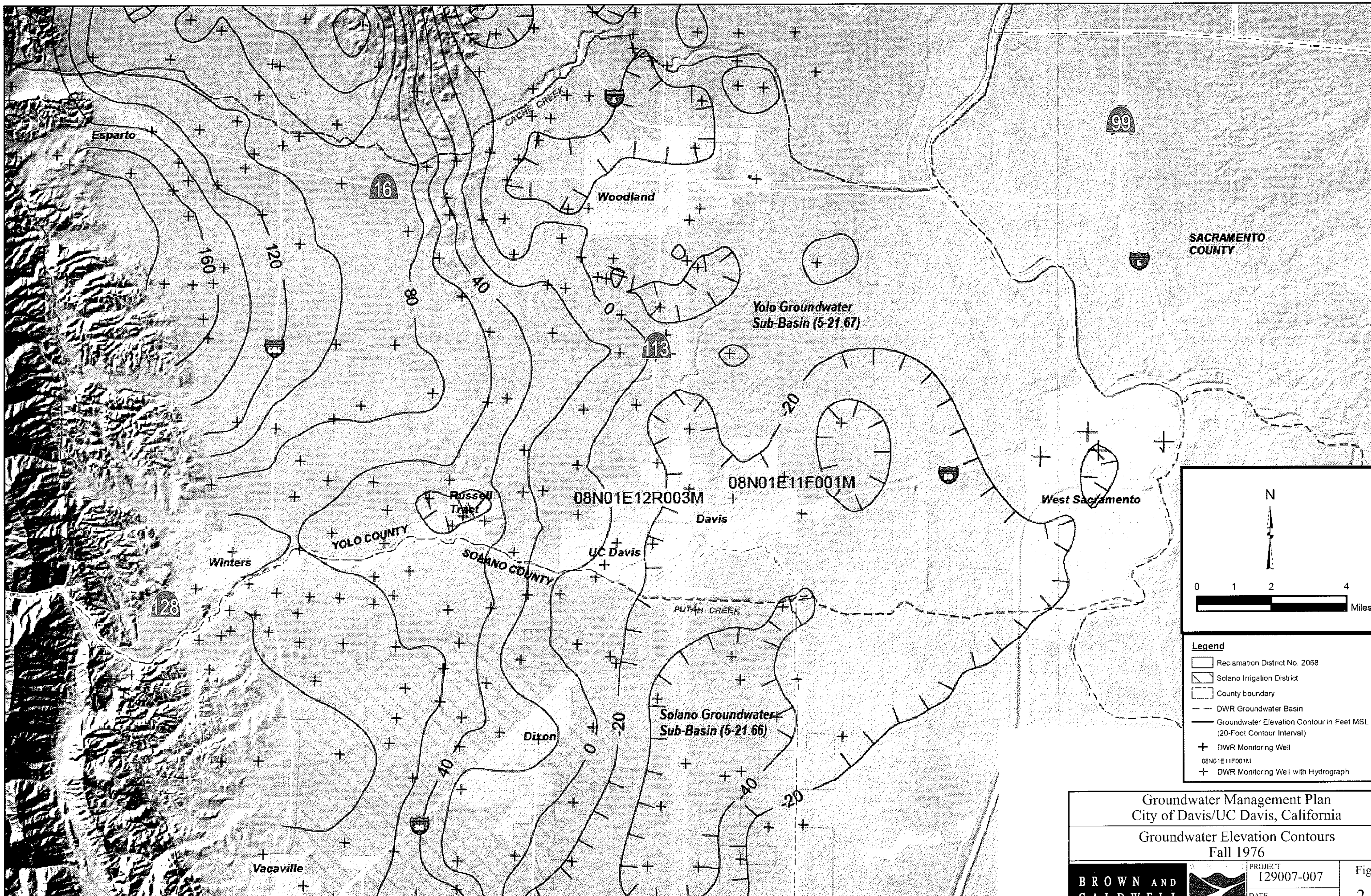

Groundwater Management Plan
City of Davis/UC Davis, California

Groundwater Elevation Contours
Fall 1976

BROWN AND CALDWELL

PROJECT 129007-007

DATE 3-16-06

Figure 2-13

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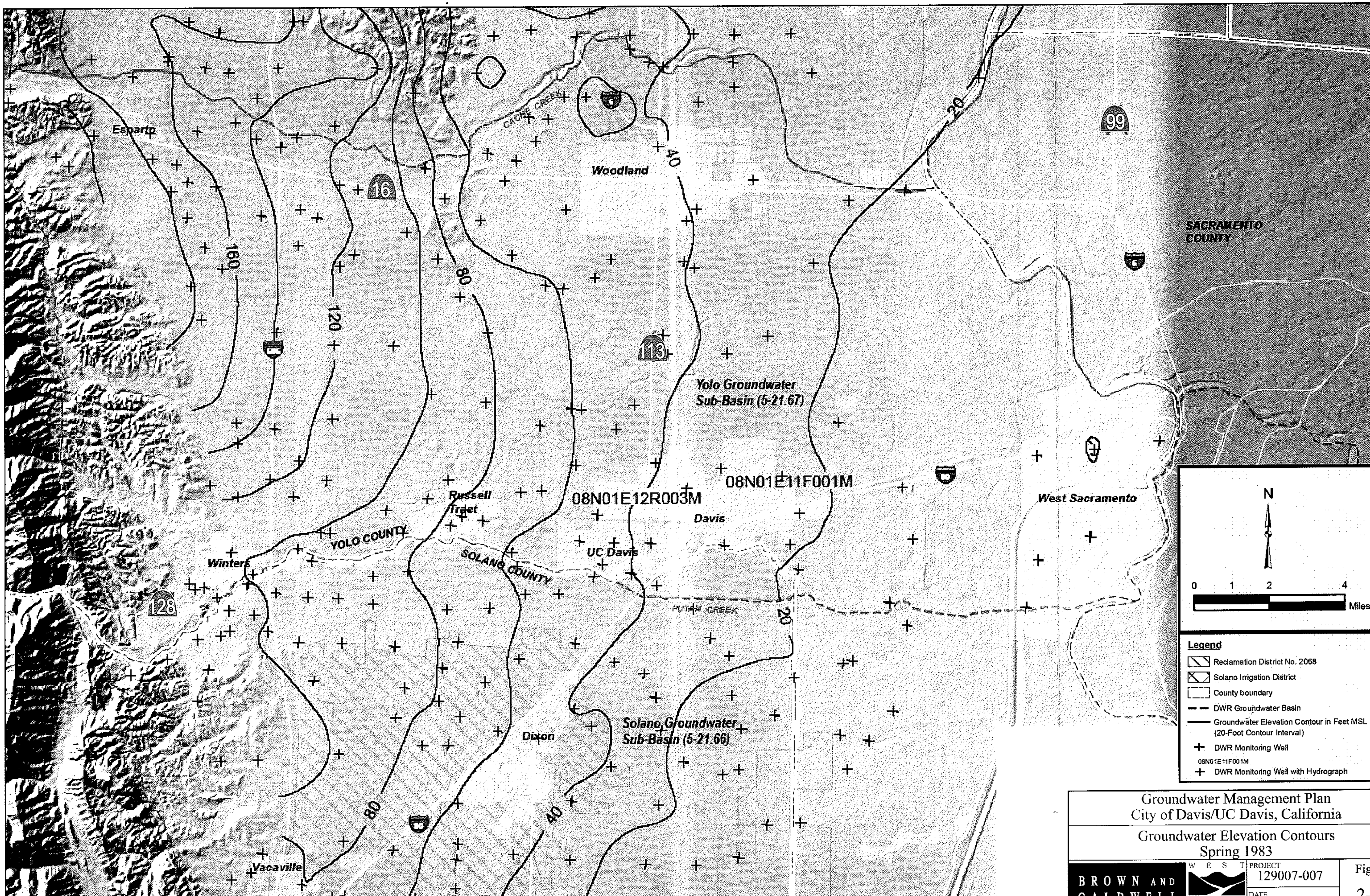

Groundwater Management Plan
City of Davis/UC Davis, California

Groundwater Elevation Contours
Spring 1983

BROWN AND CALDWELL

WEST YOST & ASSOCIATES

PROJECT 129007-007

DATE 3-16-06

Figure 2-14

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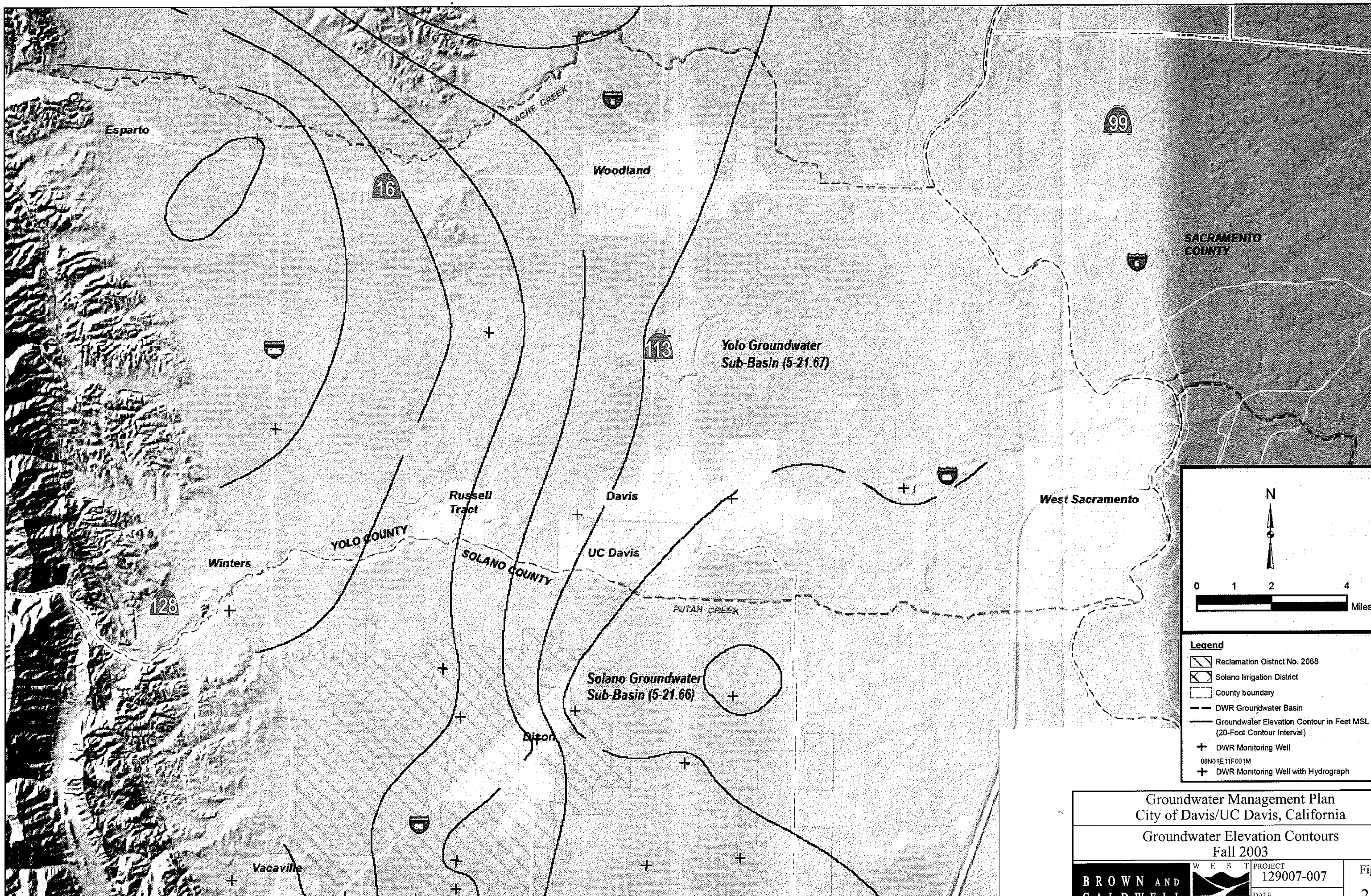


Groundwater Management Plan
City of Davis/UC Davis, California

Groundwater Elevation Contours
Fall 2003

BROWN AND CALDWELL | WEST YOST & ASSOCIATES | PROJECT 129007-007 | DATE 3-16-06 | Figure 2-15

P:\29000\129007 - Davis UC Davis GWMP\figs

2.5.9 Groundwater in Storage

In the vicinity of Davis and UC Davis, the base of fresh groundwater occurs at a depth of approximately 2,800 feet below mean sea level, implying that the fresh water aquifer is about 2,800 feet thick (DWR, 1978). However, it has only been practical thus far to construct wells less than 2,000 feet deep. The total amount of water contained to a depth of 2,000 feet in the 11,600 acre plan area (excluding Russell Tract) is over 2 million acre-feet. The useful amount of water in storage is probably somewhat less than the amount contained within the top 100 feet of the aquifer system, which is estimated to be approximately 120,000 acre-feet assuming a specific yield of 10%.

2.5.10 Groundwater Quality

Major groundwater production zones in the Davis area have traditionally been divided into the "Intermediate Aquifer" and "Deep Aquifer" based on general water chemistry, even though both are geologically part of the larger Tehama Formation. The "Intermediate Aquifer" begins at about 200 feet below ground surface, transitioning to the "Deep Aquifer" at about 700 feet below ground surface. A substantial sequence of fine-grained material (roughly 100 to 150 feet thick) separates the "Intermediate Aquifer" from the underlying "Deep Aquifer" water-producing zones. Groundwater mineral quality is characterized as calcium-magnesium bicarbonate in the "Intermediate Aquifer" and sodium bicarbonate in the "Deep Aquifer". Groundwater from the "Deep Aquifer" is more desirable for household use, having low concentrations of nitrate and selenium, and moderate hardness. Groundwater from the "Intermediate Aquifer" is more desirable for irrigation, having lower relative concentrations of sodium, but high hardness. Elevated concentrations of selenium and total dissolved solids in water from the "Intermediate Aquifer" also make compliance with increasingly stringent wastewater discharge requirements more difficult. Boron is found throughout all zones at concentrations that can have some adverse effects when used for irrigation of sensitive plants. Arsenic concentrations are relatively higher in some of the "Deep Aquifer" zones than in other zones, though still generally below drinking water limits. A comparison of water quality trends versus depth and direction is shown in Table 2-2.

Because of the better acceptability for household use, new drinking water supply wells for Davis and UC Davis are completed into the "Deep Aquifer". Water quality will be monitored in the future to determine if and when recharge from shallower sources is reaching deep wells. More information about water quality monitoring is in Section 3.4. A desire for improved water quality has been one of the driving forces behind the pursuit of higher quality supplemental surface water supplies.

Table 2-2. Summary of Relative Water Quality Results and Implications

Parameter	Intermediate Aquifer (< 700' bgs)	Portion of Deep Aquifer: Shallow (700'-900' bgs)[a]	Portion of Deep Aquifer: Middle (900'-1300' bgs)[a]	Portion of Deep Aquifer: Deep (> 1300' bgs)[a]	Intermediate Aquifer: Directional Trend	Intermediate Aquifer: Time Trend	Deep Aquifer: Directional Trend	Deep Aquifer: Time Trend
Arsenic	Low	Low	High	Moderate	None	None	Mildly towards E	None
Boron	High	Moderate	Moderate	Moderate	Higher towards NE	None	Higher N-NE	None
Chromium	Mod. to high	Moderate	Low	Low	None	None	None	None
Manganese	Low	Moderate	Moderate	Low	None	None	None	None
Nitrate-N	Mod. to high	Low	Low	Low	Higher towards W	Increasing	None	Possible gradual increase
Selenium	High	Moderate	Low	Low	None	None	None	Possible gradual increase
Sodium	Moderate	High	High	High	None	None	None	None
Total Salinity	High	Low	Low	Mod. low	None	None	Higher towards N	None
Hardness	High	Moderate	Moderate	Moderate	None	None	None	None
^{14}C Age	Moderate	Old	Oldest	Old	Older towards NE	Decreasing	Older towards NE	None

a) Depth zones are approximate and change from west to east.
Source: Phase II Deep Aquifer Study (Brown and Caldwell and West Yost Associates, 2005).

2.5.11 Land Subsidence

Land subsidence due to groundwater withdrawal is triggered by decreases in pore pressure in a confined aquifer system containing compressible clay layers. If this effective stress exceeds the maximum stress to which the aquifer skeleton has been subjected in the past, the clay layers will undergo permanent compaction.

The risk of significant impacts from differential land subsidence depends on a complex array of variables including: the degree of new groundwater development, land use, the mineral composition of the clays, and consolidation history of the aquifer skeleton.

Significant land subsidence has been documented in Solano and Yolo Counties over the years, especially in areas that rely solely on groundwater supplies. Land subsidence of up to 5.4 feet is documented over the past few decades in a north-south trending zone that extends from Zamora to Dixon (Ikehara, 1994). Down-well television surveys have been used to document well casings damaged by land subsidence over this same zone. A comparison of damaged and undamaged wells in the main area of subsidence showed similar amounts of compressible sediments and that the damaged wells were those in which the greatest declines in head had occurred after well installation (Borchers, et. al., 1998). Recent studies have verified that subsidence is continuing to occur in the Yolo County portion of this zone (Frame, 2005).

Figure 2-16 shows the preliminary results of repeat surveys of the Yolo County Subsidence Monitoring Network conducted in 1999 and 2005. Based on these preliminary results using Global Positioning System (GPS) survey measurements, 3.1 inches of subsidence have occurred at the UC Davis Continuously Operating Reference Station (CORS) and 0.8 inches at Conaway Ranch 10 miles northeast of Davis (Figure 2-16). This equates to an average rate of subsidence of about 0.5 inches per year at the UC Davis CORS. These rates measured by the subsidence surveys are significantly higher than the 0.03 inches per year average rate recorded at the Conaway Ranch extensometer, which is a high accuracy mechanical device that measures subsidence down to its completion depth at about 600 feet. The higher rates calculated from the repeat elevation surveys suggests that some of the land subsidence may be occurring due to compaction of geologic materials at depths greater than the completion depth of the extensometer, and some of the observed subsidence could be caused by factors other than groundwater withdrawal. Possible factors are withdrawal of gas and saline water from deep gas production zones, natural tectonic subsidence, and GPS raw data interpretation issues. Additional information is contained in the final recommendations report from the 2005 survey, which is contained in Appendix B.

During the 1976-1977 drought, more groundwater than surface water was used for agricultural irrigation in the Sacramento Valley. Drilling and pump contractors reported that in the summer of 1977 many wells were discovered to have broken casings, and the demand for new and replacement wells could barely be met, most likely as a result of subsidence (Borchers, et. al., 1998).

2.6 Groundwater Well Infrastructure

Groundwater has been the only source of drinking water supplies and the principal source of irrigation water supply in the GWMP area. The sizes and depths of wells range from small, shallow wells for individual residences to large wells completed into the "Deep Aquifer" for municipal domestic supplies. The locations of major groundwater production wells in the plan area are shown in Figure 2-17.

2.6.1 City of Davis Water Supply Facilities

The City has a single, potable water system which supplies domestic and irrigation water for residents and businesses. The City relies solely on groundwater to meet all its water demands. Its water supply system consists of 21 wells, distribution pipelines and storage tanks, whose characteristics are summarized in the following sections.

Wells

The locations of the City's 21 wells are shown in Figure 2-17. Of the 21 wells, 17 are screened in the intermediate aquifer at depths between approximately 200 and 600 feet. Newer wells 28, 29, 30, and 31 are completed in the deep aquifer at total depths ranging from 1,500 to 1,800 feet. Deep aquifer well 29 was given a low operating priority beginning in 2002 because of water quality issues. An investigation into the source of the problem is ongoing. Due to increasingly stringent water quality regulations and other water quality concerns, the City has begun shifting groundwater pumping from the intermediate to the deep aquifer. Two additional deep wells are presently being planned to replace capacity lost to intermediate-aquifer wells being removed from service (Brown & Caldwell, 2006).

Figure 2-18 is a schematic diagram showing the active City wells, and includes well depths, screened intervals, pump setting depths, and suction pipe depths, where applicable. A summary of active City wells is shown in Table 2-3.

Figure 2-16 shows the preliminary results of repeat surveys of the Yolo County Subsidence Monitoring Network conducted in 1999 and 2005. Based on these preliminary results using Global Positioning System (GPS) survey measurements, 3.1 inches of subsidence have occurred at the UC Davis Continuously Operating Reference Station (CORS) and 0.8 inches at Conaway Ranch 10 miles northeast of Davis (Figure 2-16). This equates to an average rate of subsidence of about 0.5 inches per year at the UC Davis CORS. These rates measured by the subsidence surveys are significantly higher than the 0.03 inches per year average rate recorded at the Conaway Ranch extensometer, which is a high accuracy mechanical device that measures subsidence down to its completion depth at about 600 feet. The higher rates calculated from the repeat elevation surveys suggests that some of the land subsidence may be occurring due to compaction of geologic materials at depths greater than the completion depth of the extensometer, and some of the observed subsidence could be caused by factors other than groundwater withdrawal. Possible factors are withdrawal of gas and saline water from deep gas production zones, natural tectonic subsidence, and GPS raw data interpretation issues. Additional information is contained in the final recommendations report from the 2005 survey, which is contained in Appendix B.

During the 1976-1977 drought, more groundwater than surface water was used for agricultural irrigation in the Sacramento Valley. Drilling and pump contractors reported that in the summer of 1977 many wells were discovered to have broken casings, and the demand for new and replacement wells could barely be met, most likely as a result of subsidence (Borchers, et. al., 1998).

2.6 Groundwater Well Infrastructure

Groundwater has been the only source of drinking water supplies and the principal source of irrigation water supply in the GWMP area. The sizes and depths of wells range from small, shallow wells for individual residences to large wells completed into the "Deep Aquifer" for municipal domestic supplies. The locations of major groundwater production wells in the plan area are shown in Figure 2-17.

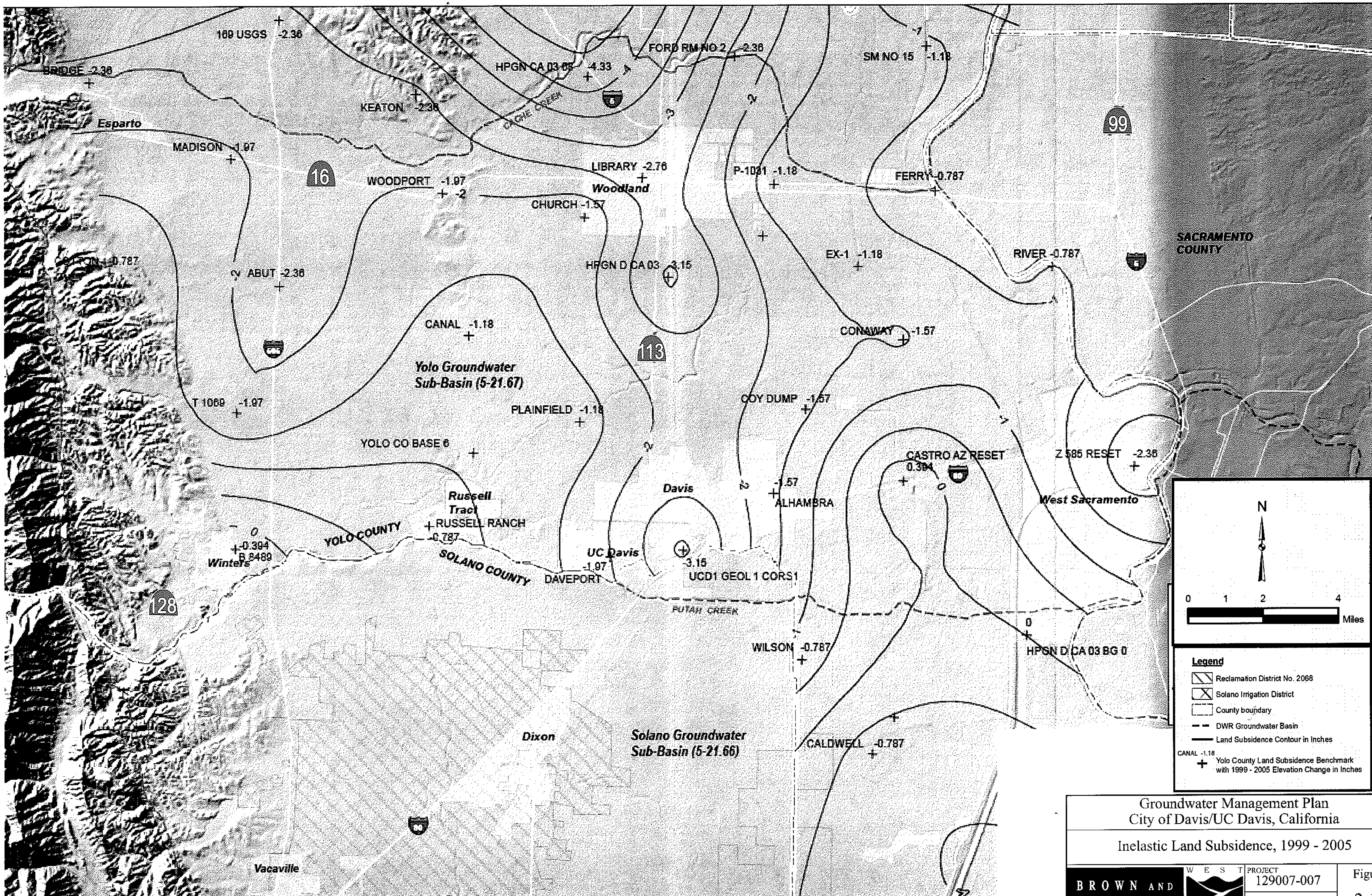
2.6.1 City of Davis Water Supply Facilities

The City has a single, potable water system which supplies domestic and irrigation water for residents and businesses. The City relies solely on groundwater to meet all its water demands. Its water supply system consists of 21 wells, distribution pipelines and storage tanks, whose characteristics are summarized in the following sections.

Wells

The locations of the City's 21 wells are shown in Figure 2-17. Of the 21 wells, 17 are screened in the intermediate aquifer at depths between approximately 200 and 600 feet. Newer wells 28, 29, 30, and 31 are completed in the deep aquifer at total depths ranging from 1,500 to 1,800 feet. Deep aquifer well 29 was given a low operating priority beginning in 2002 because of water quality issues. An investigation into the source of the problem is ongoing. Due to increasingly stringent water quality regulations and other water quality concerns, the City has begun shifting groundwater pumping from the intermediate to the deep aquifer. Two additional deep wells are presently being planned to replace capacity lost to intermediate-aquifer wells being removed from service (Brown & Caldwell, 2006).

Figure 2-18 is a schematic diagram showing the active City wells, and includes well depths, screened intervals, pump setting depths, and suction pipe depths, where applicable. A summary of active City wells is shown in Table 2-3.



Groundwater Management Plan
City of Davis/UC Davis, California

Inelastic Land Subsidence, 1999 - 2005

BROWN AND CALDWELL | WEST YOST & ASSOCIATES

PROJECT 129007-007

DATE 3-16-06

Figure 2-16

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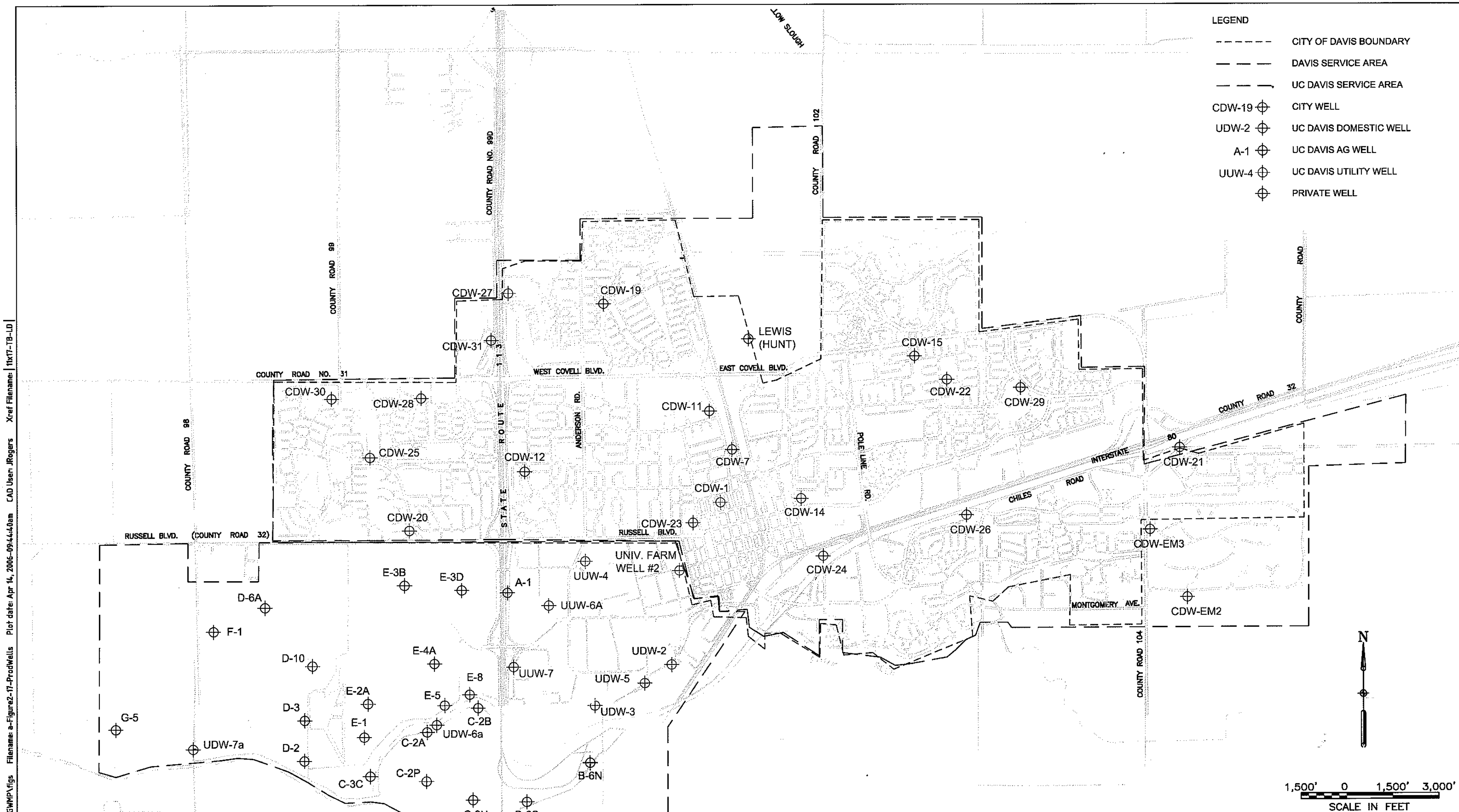


Groundwater Management Plan
City of Davis/UC Davis

Production Well Locations

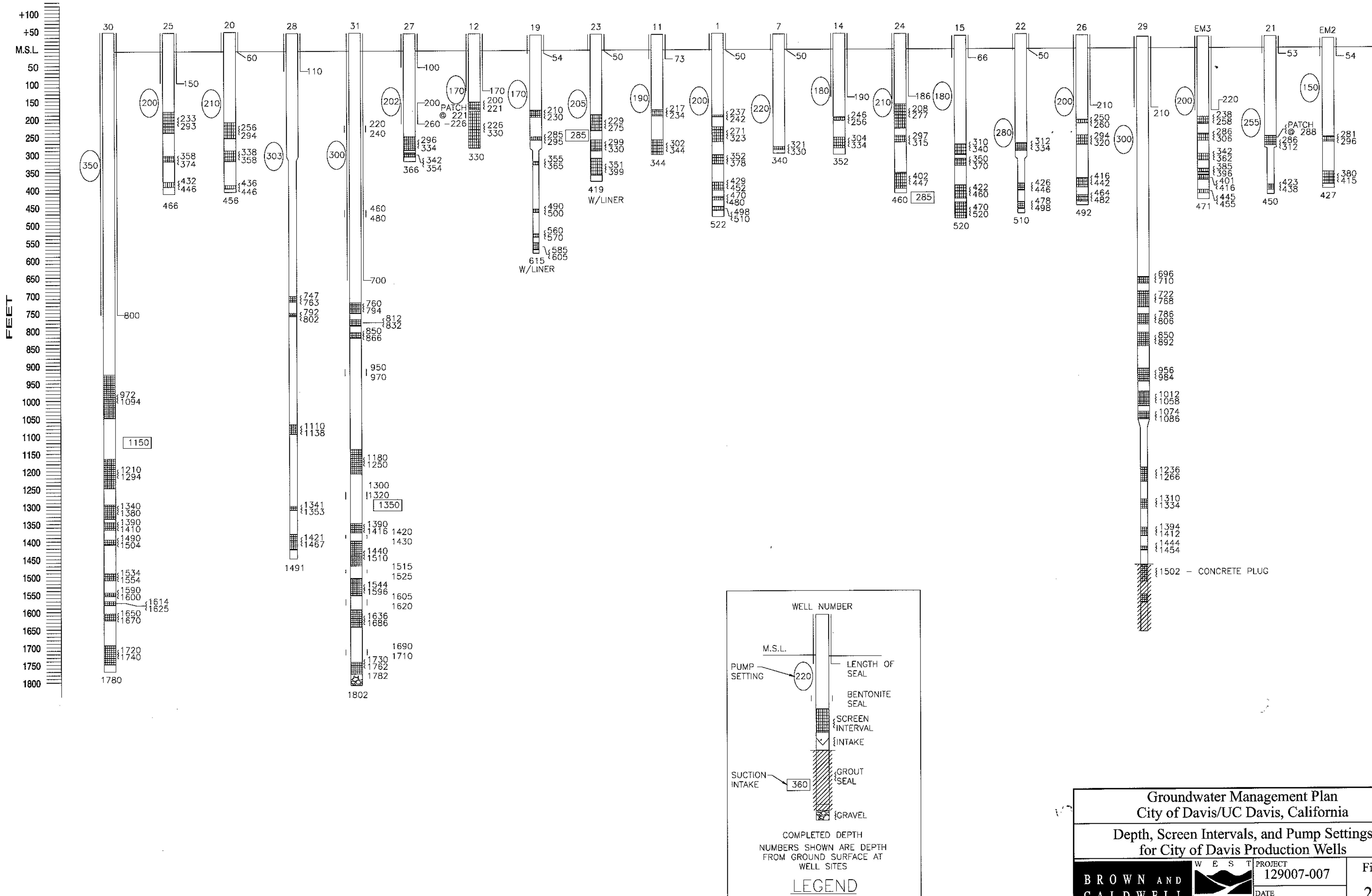
BROWN AND CALDWELL | WEST YOST & ASSOCIATES

PROJECT 129007-007

DATE 4-14-06

FIGURE 2-17

Path: P:\29000\129007 - Davis UC Davis GWMP\figs Filename: a-Figure2-17-ProdWells Plot date: Apr 14, 2006-09:44:40am CAD User: JRogers Xref Filename: 11x17-TB-LD



Source: Brown and Caldwell, Phase II Deep Aquifer Study, 2005

Groundwater Management Plan
City of Davis/UC Davis, California

Depth, Screen Intervals, and Pump Settings for City of Davis Production Wells

BROWN AND CALDWELL

WEST YOST & ASSOCIATES

PROJECT	Figure
129007-007	2-18
DATE 3-7-06	

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Table 2-3. City of Davis Well Information

Well	Date Drilled[c]	Depth, feet	Pump Setting, feet	Suction Intake Depth, feet	Well Pumping Capacity, gpm[a]	Pump, HP[b]
CDW-1	1982	522	200	-	1,000	75
CDW-7	1952	390	220	-	1,200	100
CDW-11	1961	344	190	-	1,225	100
CDW-12	1961	330	170	-	920	125
CDW-14	1970	352	180	-	1,100	Gas
CDW-15	1965	520	180	-	1,250	100
CDW-19	1973	615	170	285	1,300	100
CDW-20	1976	456	210	-	1,150	125
CDW-21	1977	450	255	-	1,300	100
CDW-22	1977	510	280	-	1,750	125
CDW-23	1980	419	205	-	1,900	150
CDW-24	1982	460	210	285	2,200	150
CDW-25	1987	466	200	-	1,250	100
CDW-26	1987	492	200	-	1,600	125
CDW-27	1989	366	202	-	1,250	125
CDW-28	1991	1,491	303	-	850	75
CDW-29	1997	1,502	300		1400	150
CDW-30	2001	1,780	350	1,150	2,500	300
CDW-31	2001	1,802	300	1,350	2,500	300
CDW-EM2	1969	427	150		1500	100
CDW-EM3	1991	471	200	-	1,280	125
Total					30,425	

(a) Gallons per minute
(b)Horsepower
(c) Typical well life is 30-50 years

The City's active wells range in age from four to more than 50 years old. Since 1987, the City has removed six intermediate depth wells from service due to age, poor water quality, production, and/or operational and maintenance problems. The City is currently proposing the addition of two new deep wells to replace wells that have been taken out of service. All active wells (Table 2-3), are available to supply water to the system. The City's average annual well production since 2000 has been approximately 4,800 million gallons (MG). This value includes years in which wells that are currently offline were in use, and years in which several current wells were not yet in service.

Of the presently active wells, Well 14, powered by an internal combustion engine, is primarily designated for emergency use. Well 31 is not available to meet peak demands due to water distribution system limitations when other nearby wells are running, and is used to fill the West Area Storage Tank. Well CDW-EM2 is run infrequently. Wells Nos. 7 and EM2 are likely candidates for retirement due to their age and other problems associated with their use. Well CDW-12 may be retired because of high chromium concentrations.

Distribution and Storage

The distribution system consists of about 175 miles of water mains and serves over 15,300 customer connections. Ductile iron and cast iron are the most common piping materials. There is some asbestos-cement pipe, mostly located in the El Macero area. The majority of the system is in good condition and is less than 30 years old. There are approximately 10 miles of water mains in the older parts of the system in Central Davis that are more than 80 years old, which are being replaced over the next 10 years (West Yost & Associates, 2002).

The hydraulic grade line of the water system is primarily determined by the water level in the 200,000 gallon elevated storage tank near Elmwood Drive and Eighth Street. The water level typically varies between 95 and 115 feet above ground level, maintaining system pressures between 40 and 50 pounds per square inch (psi) under most demand conditions. A four million gallon ground-based storage reservoir on John Jones Road, adjacent to Sutter Davis Hospital, was completed in July 2002 (FS, 2002).

2.6.2 UC Davis Water Supply Facilities

UC Davis currently relies solely on groundwater for its entire potable and landscape irrigation water supplies. UC Davis water facilities include separate domestic, landscape irrigation, and agricultural irrigation water systems. Water for domestic and laboratory use and for heating, cooling, and other "industrial" uses on campus is supplied from the deep aquifer by the domestic water system. The landscape irrigation ("utility") system supplies groundwater from the intermediate aquifer for campus landscape and turf irrigation. The agricultural irrigation facilities supply groundwater for irrigation both in the research area west of the main campus and for the Russell Tract, located approximately 5 miles west of the campus.

Domestic Supply System

The UC Davis domestic water service area encompasses a total of approximately 3,700 acres (Figure 2-15) and provides water to more than 38,000 persons, including approximately 27,000 students and 11,000 faculty and staff. The water supply system consists of wells, distribution pipelines and storage tanks.

UC Davis operates six wells exclusively for domestic water supply. All of the wells are completed in the deep aquifer, between 800 and 1,500 feet below ground surface. The wells are located along the east and southeast sides of the UC Davis service area as shown on Figure 2-15. A summary of domestic well construction and capacity is presented in Table 2-4. Total pumping capacity of the domestic system is 5,290 gpm, based on pump tests conducted during the winter of 1999.

Table 2-4. UC Davis Domestic Water Wells

Well	Date Drilled	Depth, feet	Pump Setting, feet	Suction Intake Depth, feet	Yield[(a)], gpm	Pump Motor, HP[(b)]	Status
UDW-2	1952	1,368	190	210	370	30	Active
UDW-3	1952	1,450	240	255	890	50	Active
UDW-4	1971	1,430	(c)	(c)	820	200	Active
UDW-5	1969	1,470	300	317	1,280	100	Active
UDW-6A	1988	1,470	240	247	1,160	125[(d)]	Active/Seasonal
UDW-7A	1995	800	180	184	770	100[(d)]	Active

(a) Gallons per minute, based on most recent pump tests conducted in winter 1999.
(b) Horsepower
(c) No information available
(d) Submersible pump

The domestic water system pipelines (about 50,000 linear feet) range from 6 to 14 inches in diameter and are composed of a variety of materials including asbestos-cement, cast iron, ductile iron, concrete coated steel and polyvinyl chloride (PVC). The majority of the pipeline material in the domestic system is asbestos-cement. There are two standby interties between the domestic water system and the City water system.

Wells UDW-2, UDW-3, and UDW-5 deliver water directly to an underground storage reservoir. These three wells are controlled automatically by a level monitor in the reservoir. As the water level drops, the wells are brought in service successively to maintain capacity. Wells UDW-4, UDW-6A, and UDW-7A discharge directly into the distribution system.

The UC Davis domestic water system currently has three storage reservoirs. An elevated steel storage tank, with a capacity of 200,000 gallons, is located near the intersection of Old Davis Road and California Avenue, and is the primary control on pressure in the distribution system. A 1.5 MG underground reservoir and booster pump station which receives groundwater from is located adjacent to the elevated tank. The booster pump serves to maintain the level in the elevated tank. A 300,000-gallon storage reservoir and a 1,500 gpm booster pump station are located west of the UC Davis Airport and serve to provide fire protection for the west campus area.

<u>Utility Water System</u>

Six utility wells completed in the intermediate aquifer provide groundwater for campus landscape and turf irrigation. Well construction and capacity information is presented in Table 2-5. The utility water system has interties to the domestic water system at Wells UUW-5 and UUW-6A to provide backup for the domestic system. The domestic water system is protected with backflow prevention devices at both locations.

Table 2-5. UC Davis Utility Wells

Well	Date Drilled	Depth, ft	Pump Setting, feet	Suction Intake Depth, feet	Yield, gpm[a]	Pump HP
UUW2	1945	324	(c)	(c)	750	75
UUW3	1909	321	(c)	(c)	680	75
UUW4	1938	326	(c)	(c)	660	30
UUW5[b]	1968	470	160	175	1,100	100
UUW6A[b]	1994	290	(c)	(c)	1,030	100
UUW7A	1951	414	160	178	1,150	100
Total					5,370	

(a) Gallons per minute, based on 1999 pump tests.
(b) Intertie to Domestic system
(c) No information available

Agricultural Irrigation System

UC Davis maintains 20 irrigation wells in the UC Davis service area on and adjacent to the campus (Figure 2-17). An additional 13 wells are located on the so-called Russell Tract (Figure 1-1). All are completed at depths corresponding to the intermediate aquifer zone. The available information for these wells is summarized in Table 2-6.

Table 2-6. UC Davis Agricultural Irrigation Wells

Well	Location	Date Drilled	Depth
UCD G6	Davis	1931	400
UCD F1	Davis	1955	220
UCD E8	Davis	1972	517
UCD E5	Davis	1956	344
UCD E4A	Davis	1956	340
UCD E3D	Davis	1972	455
UCD E3B	Davis	1952	250
UCD E2A	Davis	1948	250
UCD E1	Davis	1993	270
UCD D6A	Davis	1936	416
UCD D3	Davis	1936	382
UCD D2	Davis	1946	532
UCD D10	Davis	1939	520
UCD C2H	Davis	1932	244
UCD C2F	Davis	1932	224
UCD C2B	Davis	1932	264
UCD C2A	Davis	1932	250
UCD B6S	Davis	1972	500
UCD B6N	Davis	1964	635
UCD A1	Davis	1952	300
RUS R2W	Russell Tract	1978	739

Table 2-6. UC Davis Agricultural Irrigation Wells (continued)

Well	Location	Date Drilled	Depth
RUS R2E	Russell Tract	1947	385
RUS R1E	Russell Tract	1947	391
RUS P3	Russell Tract	1959	672
RUS P2	Russell Tract	1954	450
RUS P1	Russell Tract	1959	512
RUS M5	Russell Tract	1947	495
RUS L2	Russell Tract	1948	425
RUS K3	Russell Tract	1980	760
RUS J3	Russell Tract	1992	399
RUS J2	Russell Tract	Unknown	Unknown
RUS H1	Russell Tract	Unknown	Unknown
RUS J1	Russell Tract	Unknown	Unknown

2.6.3 Private Wells

The Wildhorse Golf Club, located north of Covell Boulevard and east of County Road 102, maintains a landscape irrigation well. The well is completed at a depth of 940 feet, in the upper portion of the "Deep Aquifer."

A well (Lewis-4) located on the former Hunt-Wesson cannery property, now owned by Lewis Properties, is completed at a depth of 1,370 feet. Lewis-4 is currently being replaced by a new deep well under construction (Lewis-5).

Known intermediate/shallow depth private wells located within the City's service area include:

- El Macero Golf Course
- Davis Cemetery
- Stonegate
- Lake Alhambra
- Andco
- East Eighth St.
- Drummond Lane

2.7 Water Demand and Supply

Domestic water demands have been generally increasing in the GWMP area as population has increased, and groundwater supply capacity has been incrementally added to meet the demand.

2.7.1 City of Davis Historical and Projected Demands

The historical and projected water demands for the City of Davis are shown on Figure 2-19. The historical water demands in water year 2000 and 2004 were 12,174 and 15,098 acre feet (ac-ft), respectively. The annual rate of increase from past water years 2000 through 2004 was approximately 5.4 percent. New water demands have increased along with population growth; however, per capita water demands have leveled off at between 10-15 percent less than the historic average, most likely due to the conversion to metered rates and other conservation programs.

The City of Davis Public Works Department estimates that the City will grow at a 1.2 percent annual rate through 2030. This corresponds to a demand projection of 20,588 ac-ft for the year 2030.

2.7.2 UC Davis Demands

UC Davis groundwater demands fall in three categories: domestic water supply, utility water supply and agricultural water supply. Each of these categories is discussed in the following sections.

Domestic Groundwater Demands

Nearly every campus facility receives domestic water. The domestic water use falls in three general categories:

- Buildings;
- Cooling Towers and Boilers; and
- Irrigation Areas (not served by the utility water system).

The total number of existing buildings relying on the domestic water system is 911. Building water use is for human consumption, research and building mechanical systems. The domestic water system provides cooling and boiler water to the Central Heating and Cooling Plant (CHCP), the Thermal Energy Storage facility (TES), the California National Primate Research Center (Primate Center), and other local cooling towers located in individual buildings. The domestic water system also provides water for fire protection at all but two hydrants.

Domestic water is also used for landscape irrigation where utility water lines are not available. The landscape irrigation needs of West and South Campus are currently served by the domestic water system because the utility water system does not extend to these areas.

Water production records have been available since 1968. Figure 2-20 shows that there was a general trend of increasing water consumption from 1968 through 1976, and then consumption dropped off dramatically. The sharp decline in consumption was most likely attributed to a concerted water conservation effort that began as a result of the 1976 - 1977 drought.

Information on future development projects that will increase demands on the UC Davis domestic water system was obtained from the following sources:

- Ten-year Capital Improvement Plan 2004/5 to 2013/14 by the UC Davis Office of Management and Planning, January 2005;
- Master Project List for Utility Forecasting, May 2005 Update, UC Davis; and
- Discussions with UC Davis Staff.

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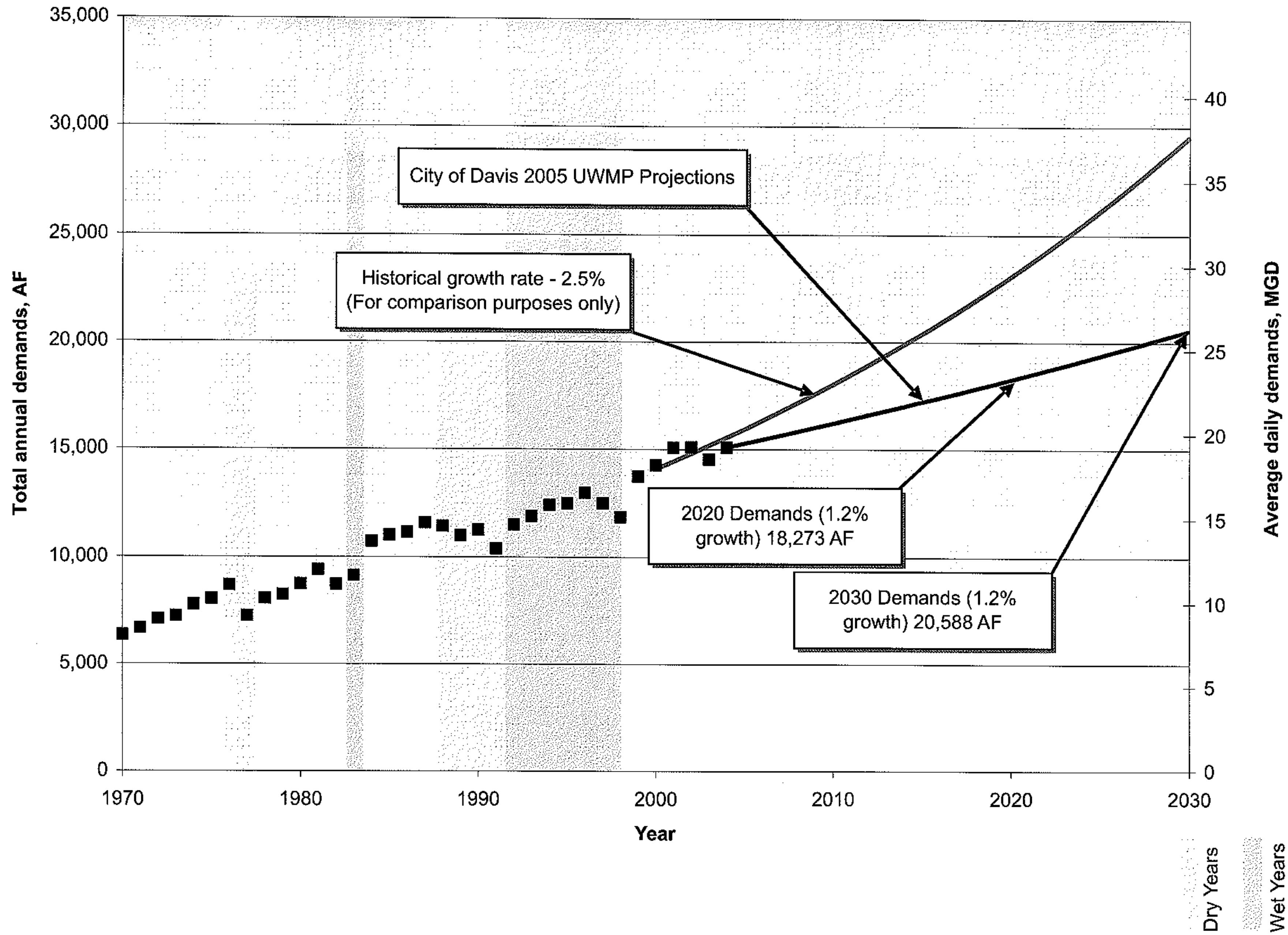
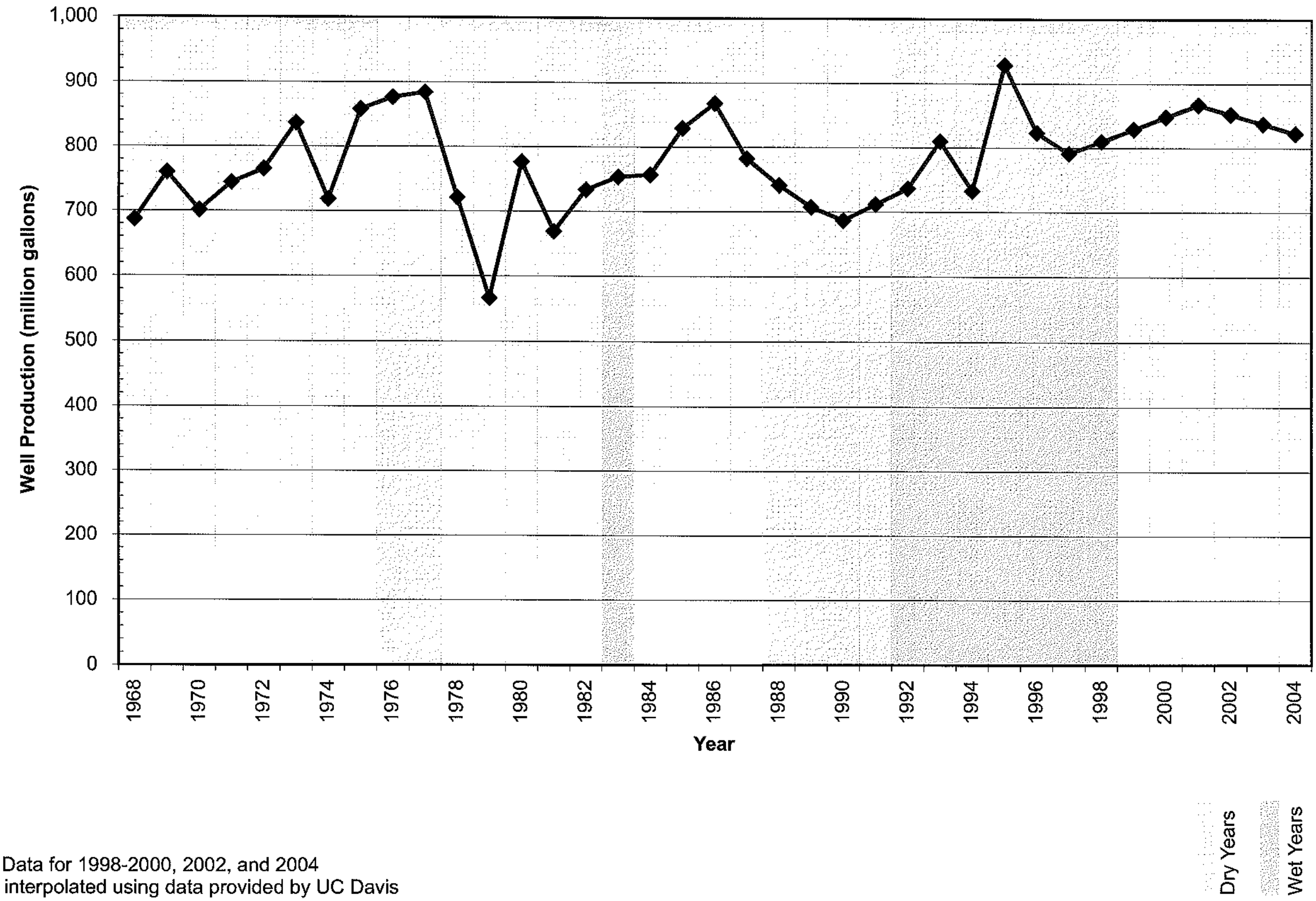


BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure
	DATE 2-17-06	Historical and Projected Annual Water Demands	2-19



Note: Data for 1998-2000, 2002, and 2004
interpolated using data provided by UC Davis

BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure
	DATE 3-7-06	UC Davis Domestic Well Production	2-20

Figure 2-21 summarizes the historical and projected annual water demands for the UC Davis domestic water system.

Utility Groundwater Demands

Utility water is designated primarily for the nonagricultural irrigation of approximately 300 acres of landscaped areas, and some greenhouses. Most irrigated areas in Central Campus are served by the utility water system. Landscape irrigation demands in South and West campus are served by the domestic water system because the utility water distribution system does not extend beyond Central Campus.

Annual utility water production records have been available since 1968 and indicate substantial fluctuations from year to year as shown on Figure 2-22. There has been a general increase in water demand from 1968 to 1989. Since then water demand has declined approximately 39 percent from peak levels in 1989 to 1990 primarily because of changes in landscape planting and watering practices.

Information on future development projects that will increase demands on the UC Davis utility water system was obtained from the following sources:

- Ten-year Capital Improvement Plan 2004/5 to 2013/14 by the UC Davis Office of Management and Planning, January 2005;
- Master Project List for Utility Forecasting, May 2005 Update, UC Davis; and
- Discussions with UC Davis Staff.

Future development projects in Central Campus will result in approximately 12 additional acres to be irrigated from the utility water system. The projected demands utility water demands are shown on Figure 2-23.

Agricultural Groundwater Demands

Groundwater is used for agricultural supply in the western part of the UC Davis service area and in the Russell Tract (Figure 1-1). The total metered pumping between January 1994 and November 2005 was 21,191 acre-feet. This is equivalent to an average pumping of approximately 1,800 acre-feet per year.

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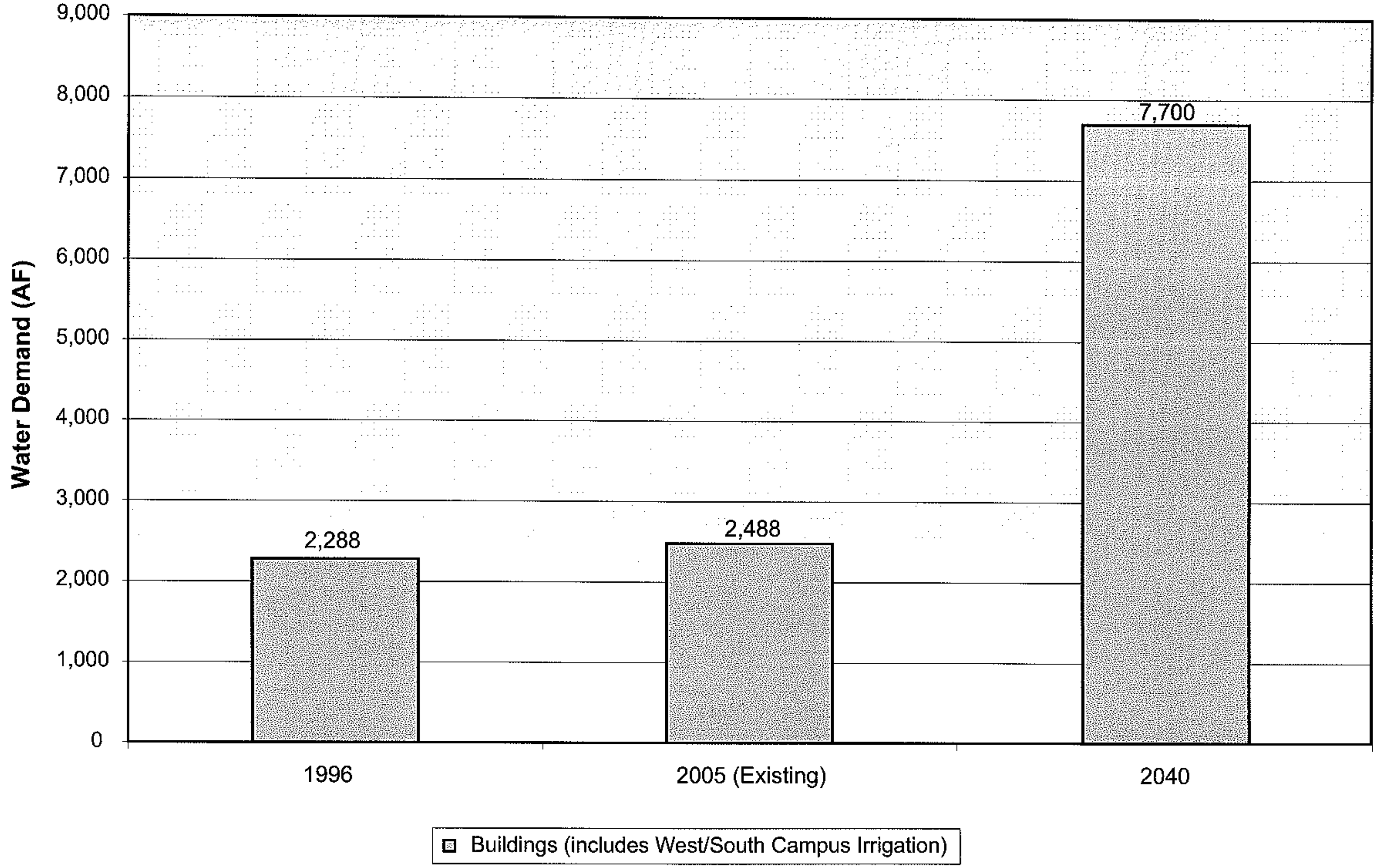

BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure 2-21
	DATE 3-7-06	UC Davis Historical and Projected Annual Domestic Water Demands	

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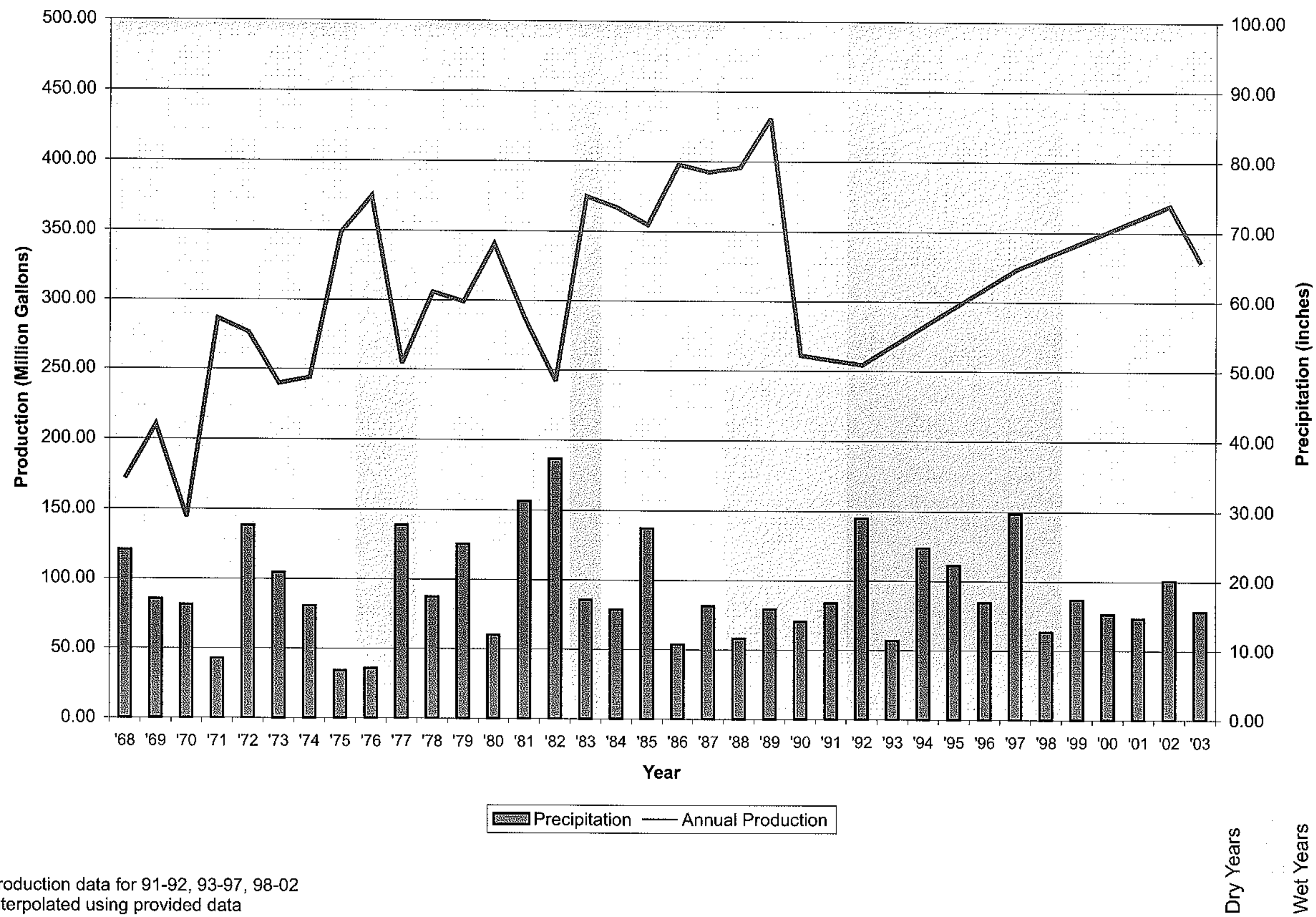
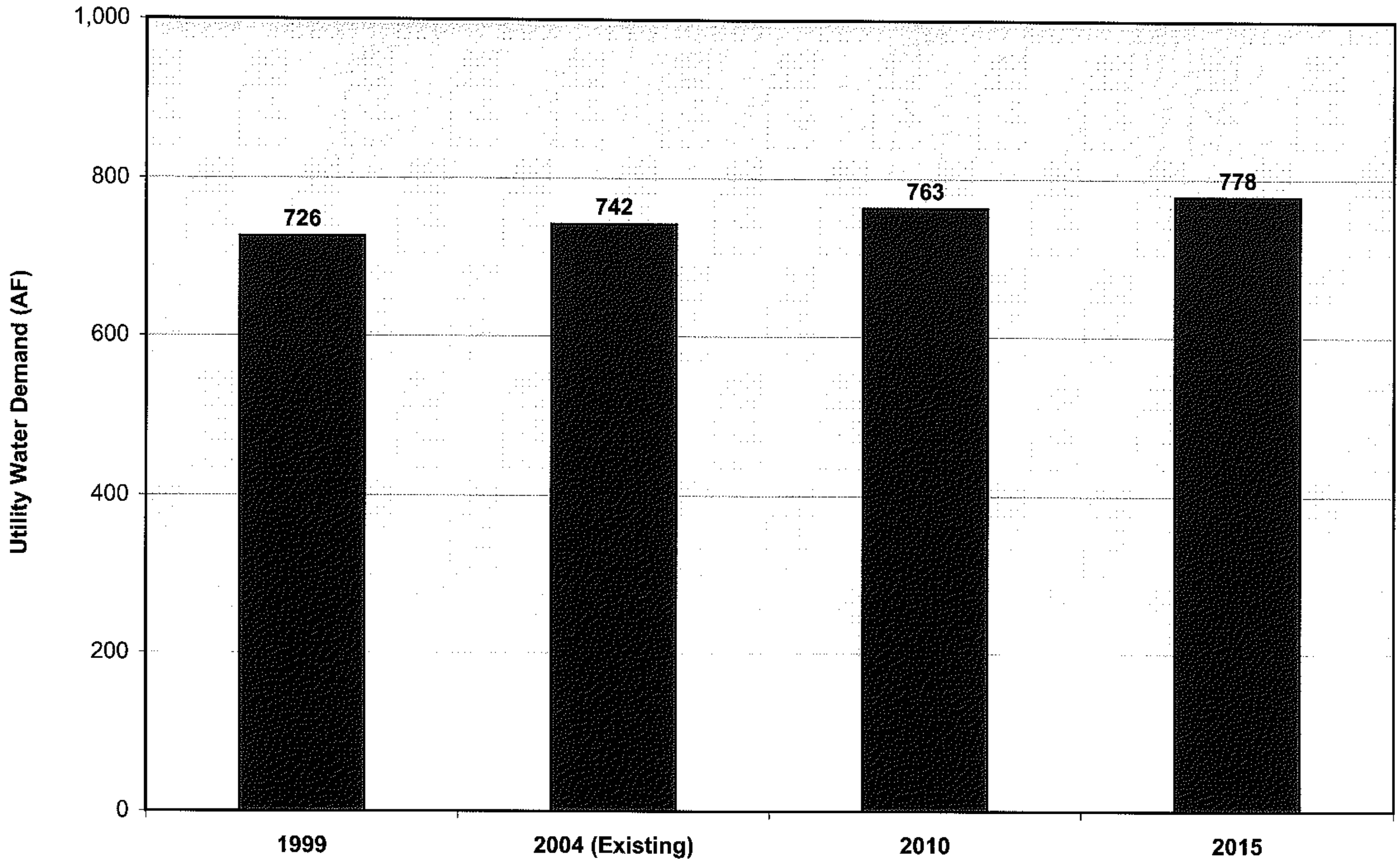


Note: Production data for 91-92, 93-97, 98-02 interpolated using provided data

BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure
	DATE 2-17-06	UC Davis Utility Water System Annual Production 1968-2004	2-22



BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California
	DATE 2-17-06	UC Davis Historical and Projected Annual Utility Water Demands

Figure 2-23

SECTION 3
PLAN IMPLEMENTATION

The City and UC Davis are already performing many of the groundwater management activities associated with a Groundwater Management Plan. Through plan development and implementation, the City and UC Davis are formalizing their common groundwater management goal, objectives, and plan components that elaborate on both current actions and planned future actions under the GWMP. As other neighboring entities are also engaged in groundwater management within the basin, the GWMP documents local conditions and management objectives that assist in facilitating the understanding and collaborative management among all groundwater users.

3.1 Groundwater Management Goal

The GWMP goal is to maintain or enhance local groundwater quantity and quality, resulting in a reliable groundwater supply for beneficial uses and avoidance of adverse subsidence. The goal will be met through the pursuit, accomplishment, and maintenance of the GWMP objectives which have been developed as a framework to coordinate and integrate basin management activities by the City, UC Davis, and adjacent groundwater management entities based on the provision of CWC §10750 *et seq*. It should be noted that even if a reliable groundwater supply is maintained as envisioned, the amount of available groundwater with desirable quality may not be adequate to meet future needs.

3.2 Groundwater Management Objectives

During GWMP development, the City and UC Davis considered and agreed upon qualitative and quantitative groundwater management objectives that complement and reinforce the GWMP goal. The qualitative objectives detail the common vision for groundwater management shared by both implementing entities.

The quantitative objectives are measurable objectives, commonly referred to as basin management objectives (BMOs), which establish numeric objectives for groundwater level, groundwater quality, and inelastic land subsidence. The quantitative objectives, or BMOs, are the desired physical conditions that are needed to satisfy the qualitative management objectives and the overarching plan goal.

The following sections 3.2.1 and 3.2.2 describe both the qualitative and quantitative groundwater management objectives, respectively.

3.2.1 <u>Qualitative Objectives</u>

To meet the GWMP goal, the City and UC Davis have adopted seven specific groundwater management objectives. The objectives include the following:

- Minimize the long-term drawdown of groundwater levels;
- Protect groundwater quality such that it remains viable for public water supply;
- Prevent adverse inelastic land surface subsidence from occurring as a result of groundwater pumping;

- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality;
- Minimize the effect of groundwater pumping on surface water flows and quality in sensitive areas of Putah Creek;
- Develop, plan, and implement groundwater replenishment and cooperative management projects; and
- Work collaboratively with and understand the goals and objectives of entities engaged in groundwater management in surrounding areas.

3.2.2 Quantitative Objectives

The quantitative groundwater management objectives, or BMOs, were developed to meet local needs as reflected in the GWMP goal and qualitative objectives. The BMOs, detailed in Section 3.5.1, reflect local groundwater conditions necessary for reliable groundwater supply for beneficial uses and avoidance of adverse subsidence. A key to successful groundwater management using BMOs is the participation in BMO development by local entities with the authority, responsibility, and knowledge needed to reflect local groundwater management needs. BMOs are not intended to serve as a method of protection against the groundwater management activities by entities beyond the GWMP area.

The BMO process can be subdivided into four distinct phases, which are discussed in detail in the following paragraphs and include:

- Planning;
- Implementation;
- Management; and
- Resolution

BMO Planning Phase: This phase of BMO development was incorporated into the GWMP development process and includes the establishment of a GWMP Working Group and public input process. The GWMP Working Group consists of representatives from the City and UC Davis. As the annual volume of groundwater produced within the Plan area is primarily associated with the City and UC Davis pumping, there is minor potential for conflict within the Plan area with groundwater extraction by other public or private entities utilizing groundwater.

BMO Implementation Phase: This phase of BMO development was also incorporated into the GWMP development process and includes the establishment of an advisory committee, monitoring elements, the monitoring program, and the quantitative management objectives. The GWMP Working Group served as the advisory committee during the BMO implementation phase. The Working Group developed the monitoring elements, monitoring program, and associated BMOs. The results of the BMO implementation phase are detailed in Section 3.5.1.

BMO Management Phase: The management BMO phase is the enduring aspect of the BMO program. It is an integral part of the GWMP implementation and includes data collection, data evaluation, reevaluation of the monitoring program, reevaluation of the quantitative management objectives, and determination of the need for resolution activities if BMOs are exceeded. GWMP components, discussed in Sections 3.3 and 3.4, have been developed for data collection and evaluation. Periodic re-evaluation of the monitoring program and quantitative BMOs, as well as assessment the need for resolution activities, is included in the GWMP implementation activities.

BMO Resolution Phase: This BMO phase centers on the responsibility and process for resolution in response to an observed exceedance of an established BMO. This phase could include a technical investigation and recommendation, pursuit of a mutually agreeable solution, and recommendation of action to appropriate decision-making bodies when an agreeable solution cannot be reached. The specifics of this BMO phase are not addressed in the GWMP; however, they will be considered during GWMP implementation.

3.3 GWMP Components

As introduced in Section 1.6 and summarized in Table 1-2, a number of mandatory, recommended, and voluntary components constitute the GWMP content. These components have been grouped into five general categories, as shown in Figure 3-1. The components are discussed, with proposed GWMP implementation actions under the following five headings:

- Groundwater Monitoring;
- Groundwater Resource Protection;
- Groundwater Sustainability;
- Stakeholder Involvement; and
- Interagency Water Resource Planning.

Activities identified for plan implementation are designed to help the City and UC Davis achieve and continually meet the GWMP qualitative objectives and allow for assessment of performance against quantitative BMOs.

3.4 Groundwater Monitoring

The City and UC Davis have coordinated their monitoring efforts to provide more extensive and consistent data. These data, in turn, enable better analysis of groundwater conditions and trends, supporting development and implementation of BMOs associated with:

- Groundwater elevations;
- Water quality; and
- Inelastic land subsidence monitoring.

Monitoring issues and methodology are presented in this section. Evaluation of monitoring data for achievement of BMOs is discussed later in Section 3.5.

The YCFCWCD is currently implementing a groundwater monitoring program throughout Yolo County. A major goal of that program is to establish a groundwater quality monitoring network utilizing the wells monitored by the District for groundwater levels. The coordinated monitoring program implemented by the City and UC Davis as part of this GWMP will provide a complementary groundwater monitoring program to the YCFCWCD effort.

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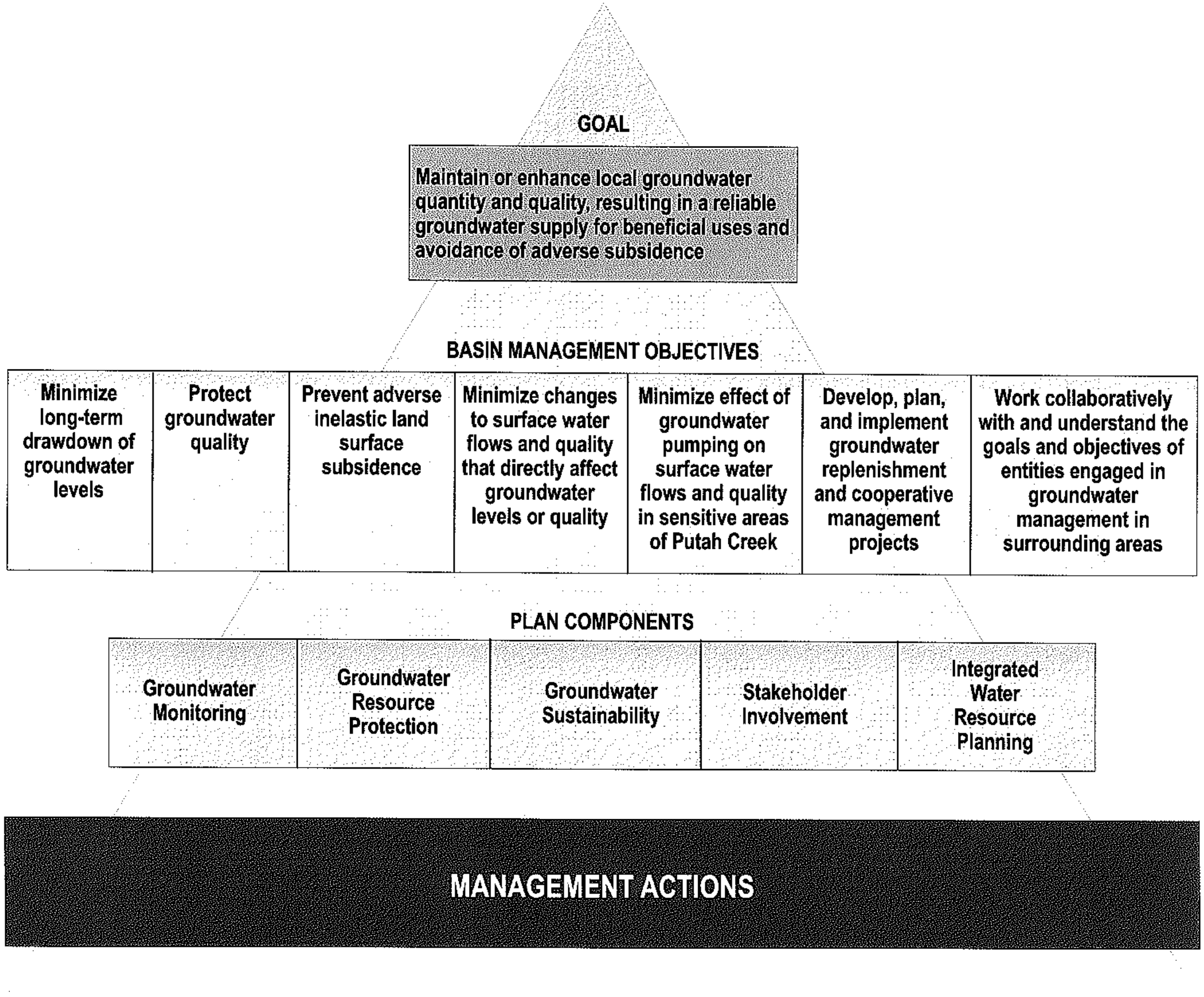


BROWN AND CALDWELL / WEST YOST & ASSOCIATES	PROJECT 129007-007	Groundwater Management Plan, City of Davis/UC Davis, California	Figure
	DATE 3-9-06	Groundwater Management Components	3-1

3.4.1 Groundwater Elevation Monitoring

Monthly water level monitoring is currently practiced by the City. Static water level stabilization periods (measurement time after pump shut-off) have been a minimum of one hour since 1992 and were a minimum of 15 minutes prior to 1992. The City's newer wells have automated water level monitoring transducers connected to the City SCADA system and can provide water level monitoring at whatever frequency is desired. The City will continue monthly water level monitoring for all of its wells.

UC Davis currently monitors groundwater levels on a semi-annual basis, using static water stabilization period of approximately 24 hours. While semi-annual monitoring can provide data for the evaluation of long term trends, it is inadequate for evaluating seasonal trends and for comparing water levels to production. UC Davis is instituting quarterly monitoring of groundwater levels for its domestic and utility wells in 2006. UC Davis will be adding automatic water level monitoring to wells UDW-4, UDW-6A, and UUW-6A by 2008.

The City and UC Davis have developed a coordinated monitoring program for well pumping, mineral quality parameters, and water levels for the City's domestic productions wells and UC Davis' domestic and utility wells. This program includes a minimum two hour stabilization period for static water level measurements. UC Davis also plans to begin obtaining monitoring data for at least one key agricultural well (D-6A). Data are entered into a combined relational database. This monitoring program is compatible with YCFCWCD formats and procedures.

A discussion of quality assurance for measurement and sampling is provided in Appendix C. Detailed purging and sampling procedures are contained in Appendix D. Well construction records are included in Appendix E. Screened zones and other relevant water production information are also included in Appendix E.

3.4.2 Groundwater Quality Monitoring

The main use of water quality data will be to determine compliance with applicable drinking water standards under Title 22 of the California Water Code (CWC). Additional sampling and analyses will be performed to indicate whether quantitative BMOs are being achieved.

The evaluation of water quality results needs to take into account both well construction and local hydrogeology. The City analyzes groundwater samples for nitrate and selenium every four months for most wells, more often for select wells. Sampling for most other parameters is approximately once every 16 months. UC Davis samples groundwater from deep wells for mineral and other select constituents on a 12 to 18 month frequency.

Title 22 of the CWC requires sampling of water supply wells for certain parameters related to drinking water suitability on a three year frequency. Title 22 also specifies the detection limits for those parameters. In addition to meeting the Title 22 requirements, groundwater samples taken from deep wells will be sampled and analyzed at least semi-annually for nitrate, selenium and chromium at the detection reporting limits shown below in Table 3-1.

Table 3-1. Special Parameter Detection Limits

Constituent	Detection Limit
Selenium	1.0 ug/L
Nitrate-Nitrogen	0.2 mg/L (as N)
Total Chromium	10 ug/L

Deep wells will also be sampled and analyzed for oxygen-18 and deuterium isotopes every three years. These additional mineral and isotopic monitoring results will be used for comparison with "trigger levels" in quantitative BMOs, as discussed in Section 3.5.1.

Detailed Standard Operating Procedures (SOPs) will be followed for purging and sample collection in order to obtain representative data that can be compared. General procedures are contained in Appendices B and C. The sample handling SOP from the analytical lab will also be followed. Additional samples will be collected for the specific purpose of documenting the Quality Assurance/Quality Control (QA/QC) of the field sampling procedures. Field QA/QC samples provide technically and legally defensible data regarding the reproducibility and overall quality of the groundwater sample. Further discussion of QA/QC samples is contained in Appendix C.

3.4.3 Groundwater Supply Volume and Flow

Both the City and UC Davis monitor their wells for flow and total volume of water extracted. The City's wells have automated water flow monitoring transducers connected to the City SCADA system and can provide water flow monitoring at whatever frequency is desired. UC Davis currently monitors well production on a monthly basis. UC Davis plans to add automatic flow monitoring to all utility and domestic production wells by Year 2008. Both the City and UC Davis report groundwater production on a monthly basis.

3.4.4 Groundwater Data Management

A relational database was initially developed for deep wells as part of the Phase II Deep Aquifer Study for storage of well construction, water level, and water quality data (Brown and Caldwell and West Yost Associates, 2005). This database was expanded to include intermediate depth wells operated by the City and UC Davis during GWMP development. Internet-based data interface features were also upgraded as part of the groundwater management project. The database was designed for a high degree of compatibility with the countywide database recently developed for the YCFCWCD through a grant from DWR. This will enable easy sharing of data to the YCFCWCD database.

The database will be maintained by the City and used jointly by both Davis and UC Davis for data storage, retrieval, and analysis. Database specifications and details are provided in Appendix F.

3.4.5 Surface Water/Groundwater Interaction

The City and UC Davis are members of the Lower Putah Creek Coordinating Committee, which is a multiple stakeholder organization overseeing implementation of the 2000 Settlement Agreement governing instream flows in Lower Putah Creek (Section 2.3). SCWA is the lead agency responsible for estimating the riparian flow that would exist in the absence of the Solano Project and the necessary releases from the Putah Diversion Dam. Following the PRWP, net gains and losses to five defined reaches of Lower Putah Creek are estimated as the sum of groundwater seepage and evapotranspiration. The net gains and losses are used to estimate the riparian flow and the necessary instream releases from the Putah Diversion Dam. Current and historical groundwater elevation measurements are used to estimate the groundwater seepage. These procedures are defined in Exhibit E-3 and Attachment 1 of Exhibit E-3 of the Settlement Agreement at http://www.putahcreek.org/.

The City and UC Davis will continue to participate in the Lower Putah Creek Coordinating Committee to ensure that surface water/groundwater interactions in Lower Putah Creek continue to be adequately monitored under the Settlement Agreement and the PRWP.

3.4.6 Inelastic Land Subsidence Monitoring

The City and UC Davis are active participants in the Yolo County Subsidence Network. The Yolo County Subsidence Network was conceived in late 1998 through the cooperative efforts of:

- City of Davis;
- City of Woodland;
- California Department of Water Resources;
- California Department of Transportation;
- University of California, Davis;
- U.S. Army Corps of Engineers, Topographic Engineering Center;
- U.S. Bureau of Reclamation;
- Yolo County Planning and Public Works Department; and
- Yolo County Flood Control and Water Conservation District.

In 1999, an initial survey of a network of 50 benchmarks, including benchmarks at DWR's Zamora and Conaway Ranch extensometers, was surveyed using GPS. In a report on the initial survey, the group recommended densification of the land subsidence monitoring network in certain areas of Yolo County, including Davis. The network was resurveyed and expanded to the previously unsurveyed southeastern portion of the county in 2002.

The City and UC Davis have sponsored expansion of the network. Three subsidence monuments in the Davis and UC Davis area were installed using the specifications, plans and procedures employed in developing the Yolo County Subsidence Network. One monument each was placed at UC Davis and in west Davis in locations expected to be most susceptible to drawdown from multiple wells. A second monument was placed in west Davis approximately 2000 feet west from the first monument in west Davis. Installation included the initial Global Positioning Survey to the North American Datum of 1983 and the North American Vertical Datum of 1988, consistent with the Yolo County Subsidence Network.

A repeat survey of the expanded network was conducted in 2005. This survey showed that previously recognized land subsidence is ongoing (Section 2.6, Figure 2-16, and Appendix B). However, comparison of the rates determined from the repeat surveys and area extensometers indicates that some compaction is occurring at depths greater than the completion depths of the extensometers and some of the measured subsidence may be due to factors other than groundwater withdrawal. At present, the factors controlling the total rate of inelastic land subsidence and the consequences of this subsidence are not fully defined. Additional subsidence monitoring recommendations are contained in Appendix B.

The City and UC Davis plan to continue to actively participate in the Yolo County Subsidence Network. Repeat surveys of the network will be used to monitor for changes in the rate of subsidence and for signs that differential subsidence is occurring. The subsidence rate will be compared to groundwater production information to determine whether there is an observable correlation between the two. The City and UC Davis will also advocate for funding to allow the Yolo County Subsidence Network to compare production records from the California Division of Oil and Gas to subsidence rates for evidence of a correlation. Furthermore, the City and UC Davis will advocate for a new extensometer in the vicinity of the GWMP area. The primary goal of these efforts will be to predict future subsidence rates and the ultimate amount of subsidence due to groundwater withdrawal under anticipated future land and water use scenarios.

3.4.7 Groundwater Monitoring Actions

Davis and UC Davis will take the following actions:

- Update monitoring procedures as necessary to be compatible with this monitoring program;
- UC Davis to add automatic flow monitoring to all utility and domestic wells;
- Maintain a coordinated database of monitoring data;
- Export requested data annually from the database to YCFCWCD for inclusion in the Water Resources Information Database;
- Evaluate the data annually and compare with quantitative BMO trigger levels;
- Monitor surface water / groundwater interaction on Lower Putah Creek through participation on Lower Putah Creek Coordinating Committee; and
- Continue to support triennial land subsidence surveys through the Yolo County Subsidence Network.

3.5 Groundwater Resource Protection

This section describes policies and measures planned to help protect groundwater resources within the City and UC Davis service areas.

3.5.1 Drought Water Conservation

The local groundwater aquifer is understood to be effected by various factors. Coast Range and Valley precipitation and YCFCWCD surface water delivery are two factors that appear to directly influence groundwater levels. Years of below average precipitation and/or reduced surface water delivery from Clear Lake or Indian Valley Reservoir to YCFCWCD customers correlate to years with decreased water levels in the County and Plan area. The majority of precipitation and reservoir inflow has occurred by approximately April 15 of each year. As such, the City and UC Davis will assess annual precipitation and reservoir storage on or about April 15 of each year as an indication of expected groundwater elevation trends for the upcoming peak groundwater demand period within the Plan area. The necessity for drought water conservation programs within the City and UC Davis will be determined during years where the April 15 water-year-to-date precipitation total or YCFCWCD surface water in storage values are less than the 20th percentile of the historic values. These drought conservation trigger values are shown in Table 3-2.

Table 3-2. Drought Conservation Action Trigger Levels

Item	Value
Cumulative Water Year Precipitation	12.5[(a)] inches
YCFCWCD Water in Storage	325,000 acre-feet

(a)20th percentile total water year precipitation is 12.85 inches, estimated 12.5 inches through April 15.

3.5.2 Implementation of Quantitative Basin Management Objectives

An important element of groundwater resource protection is the monitoring and evaluation of the local groundwater aquifer physical characteristics. Current monitoring has generally focused on confirmation that source water quality is better than CWC Title 22 drinking water requirements and that water levels are adequate to avoid damage to pumps and associated infrastructure.

Proper groundwater aquifer management is critical because groundwater serves as the sole source of water supply for the City and UC Davis. To that end, the City and UC Davis have considered appropriate quantitative BMOs within the GWMP area associated with water level, water quality, and inelastic land subsidence. Establishment of BMOs and the associated monitoring and evaluation focus on maintaining or enhancing local groundwater quantity and quality, resulting in a reliable groundwater supply for beneficial uses and avoidance of adverse subsidence. Additional background on development of quantitative BMOs is provided on Section 3.2.2.

The development of quantitative BMOs began by considering the groundwater management goal and qualitative objectives in relation to the data and associated understanding necessary to develop appropriate quantitative BMOs. The Working Group concluded that both an adequate data set and understanding exist to support quantitative BMOs for water level and water quality. Neither an adequate historic database nor an understanding of the threshold where detrimental impacts occur associated with inelastic land subsidence or depletion currently exist. Because of this, additional data collection and evaluation is needed before a quantifiable BMO can be established for inelastic land subsidence.

BMOs have been developed by considering monitoring locations and parameters that best represent the overall conditions of the groundwater aquifer. Key well locations have been identified that best represent the groundwater aquifer relative to water level and water quality. The following subsections provide detail on the BMOs for water level, water quality, and inelastic land subsidence.

Water Level BMOs

Quantitative water level BMOs have been developed to measure groundwater management performance against the qualitative objectives, specifically,

- Minimizing the long-term drawdown of groundwater levels, and
- Maintaining groundwater levels to protect existing infrastructure.

Water level BMO development began by considering which combination of well locations provides information needed to represent groundwater levels, both in the aerial context and in definable vertical intervals. Section 3.4.1 provides an overview of current groundwater elevation monitoring and Section 2.6 and 2.7 describe the differentiation between the intermediate and deep production intervals within the overall Tehama formation groundwater aquifer. Potential wells for use in monitoring of the water levels is complicated by the fact that most wells currently used for monitoring water level also serve as production wells. As mentioned previously, water levels in production wells are allowed to stabilize with the well off for a period of time prior to water level measurements. In the absence of additional dedicated monitoring wells, wells have been identified as key wells for monitoring of water level elevation based on location, screen interval, accessibility, and operational patterns.

Following identification of key wells, the time of year that monitoring should be completed to best represent the aquifer status was considered. Based on discussion within the Working Group, it was agreed that both spring and summer/fall water level target elevations are needed to best manage aquifer conditions. Spring represents the time of year when groundwater elevations are at the annual maximum, based on aquifer recharge and minimal landscape irrigation water demand during the wet winter months. Summer and fall represent the time of year when groundwater levels are at the annual minimum, based on maximum groundwater extraction to satisfy water demand.

After identifying the time of year that BMO compliance monitoring will be completed, appropriate trigger levels were considered and agreed upon. Trigger levels, identifying the minimum desired groundwater elevation, were derived for both spring and summer/fall. Trigger elevations at key monitoring locations for spring BMO compliance are generally consistent with the lowest historic seasonal peak spring water elevation at key wells, or slightly lower for wells with a brief monitoring history. These seasonal peak spring water elevations represent the recovery of aquifer intervals from the previous years' pumping. If recovery water levels are below these trigger levels prior to the summer demand period, the City and UC Davis want an early season warning so resolution actions can be considered.

Trigger elevations at key monitoring locations for the summer/fall BMO compliance are representative of the static water level necessary to protect well infrastructure. The summer/fall BMO water level elevations are derived considering pump intake elevation, average operational drawdown, and the desired distance between the pump intake and the operational water level in the well.

Table 3-3 includes details the selected key wells and its trigger level. Groundwater level BMO locations are shown on Figure 3-2.

Resolution actions that will be initiated if water levels fall below a trigger level may include any or a combination of the following:

- Continued monitoring;
- Additional conservation measures and reduced groundwater pumping;
- System reoperation to redirect pumping either to another area or depth interval;
- Development of new wells to allow reduced pumping from existing wells; and
- Acceleration of surface water supply source development.

Table 3-3. Water Level BMO Well Location and Trigger Level

Aquifer Interval	Well ID	Owner	Spring Recovery Levels (ft msl) Historical Minimum	Spring Recovery Levels (ft msl) Trigger	Summer/Fall Minimum Levels (ft msl) Historical Minimum	Summer/Fall Minimum Levels (ft msl) Trigger
Intermediate	UCD D-6A (ag)	UC Davis		tbd[a]		tbd[a]
	F Street – S	City	14	5	-51	-70
	UUW-6A	UC Davis	8	5	-7	-60
	CDW-7	City	-15.6	-20	-90	-100
	CDW-21	City	-8.1	-10	-69	-100
Deep	F Street - M	City	-4.8	-10	-35	-60
	F Street - D	City	-3.9	-10	-42	-60
	CDW-30	City	0.8	0	-104	-140
	UDW-4	UC Davis	-15.4	-20	-50	-80
	UDW-6A	UC Davis	17	15	2	-60

(a) To be determined in the GWMP 5 year update after developing a monitoring record

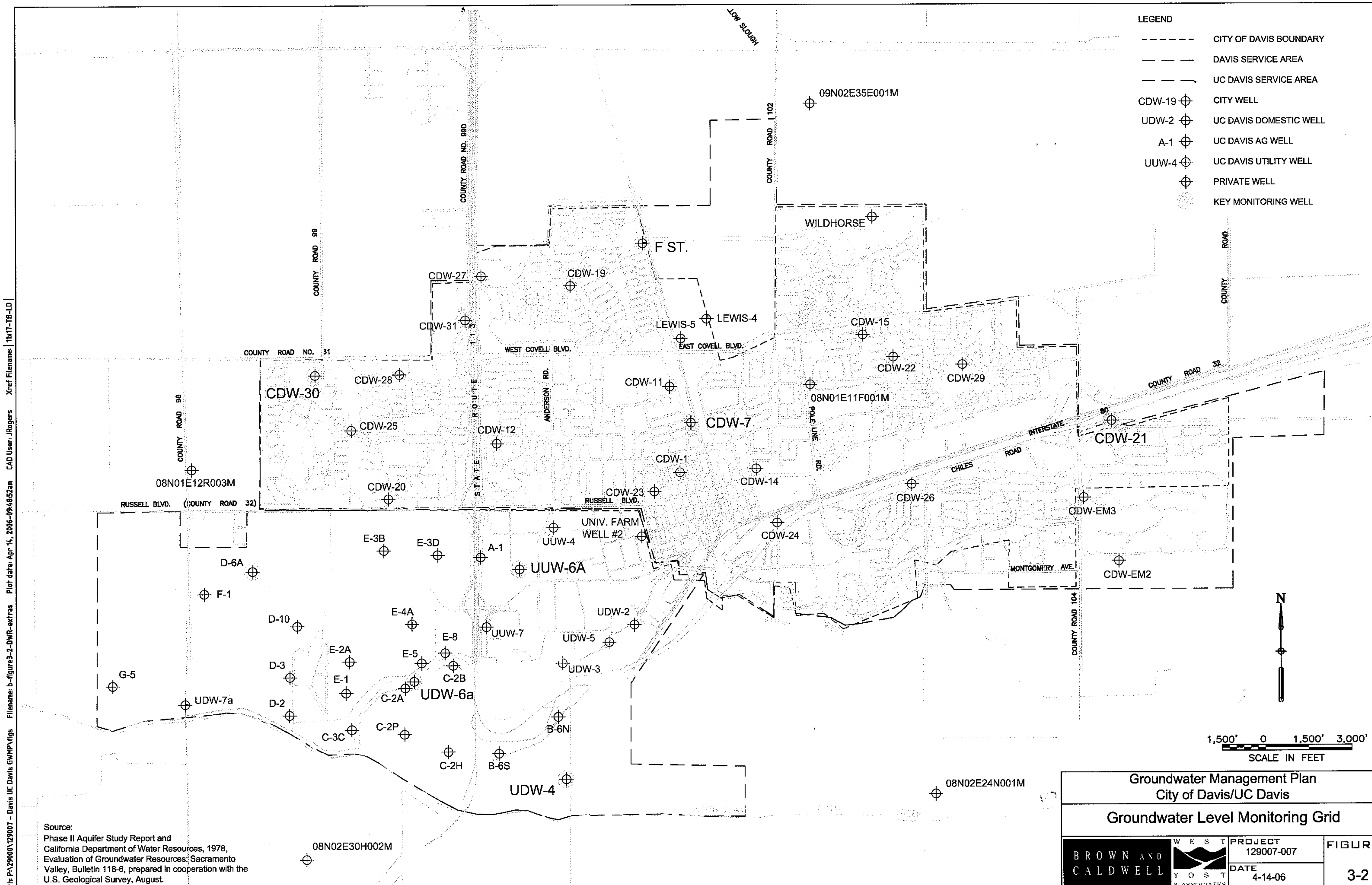
Water Quality BMO

Quantitative water quality objectives have been developed to measure groundwater management performance against the qualitative objective of protection of groundwater quality. As discussed in Section 2.6.4, the quality of the groundwater generally meets drinking water standards throughout the aquifer. However, the deeper portion of the aquifer generally has more desirable quality water when compared to the intermediate portion of the groundwater aquifer. Both the City and UC Davis will manage the aquifer in a manner that it remains a viable source of drinking water into the future. In addition, the deep aquifer will be also be managed, to the extent feasible, to preserve the higher quality water.

Based on this management philosophy, the Working Group has developed qualitative BMOs for water quality across the Plan area. As any localized change in water quality is important, the water quality monitoring network will consist of all drinking water production wells in the City and UC Davis service areas.

As discussed in Section 3.4.2, production wells are regularly monitored consistent with CWC Title 22. This monitoring is performed to demonstrate that water quality continues to meet all requirements for drinking water sources. The selection of BMO water quality parameters and trigger levels is based on criteria separate and independent from Title 22 requirements.

Parameters and trigger levels selected to function as water quality BMOs are based on their ability to represent groundwater movement within the aquifer system. The nature and distribution of the selected parameters are well defined across the service areas and vary both spatially and with depth. Because of their spatial and vertical variability, they are good indicators of groundwater movement both laterally and vertically within the aquifer system. Parameters selected for use in water quality BMOs are included in Table 3-4.



Source:
Phase II Aquifer Study Report and
California Department of Water Resources, 1978,
Evaluation of Groundwater Resources: Sacramento
Valley, Bulletin 118-6, prepared in cooperation with the
U.S. Geological Survey, August.

Groundwater Management Plan
City of Davis/UC Davis

Groundwater Level Monitoring Grid

BROWN AND CALDWELL | WEST YOST & ASSOCIATES

PROJECT 129007-007
DATE 4-14-06
FIGURE 3-2

Table 3-4. Water Quality BMO Parameters and Trigger Levels

Water Quality Parameter	Intermediate Aquifer Trigger Level	Deep Aquifer Trigger Level
Electrical Conductivity	None	>650 μmhos/cm
Selenium	>5 μg/L	>2 μg/L
Nitrate as N	>5 mg/L	>2 mg/L
Total Chromium	> 25 μg/L	>15 μg/L
^{18}O Isotope	None	-7.5 $\delta^{18}O$

The trigger levels associated with the individual parameters have been set at levels that will indicate a change of the current concentrations typically observed. The difference in trigger level concentrations between the intermediate and deep intervals of the overall groundwater aquifer system have been established to alert the City and UC Davis of increased interaction between the two aquifers, based on the desire to maintain the higher quality in the deep portion of the aquifer. Water quality BMO monitoring locations are shown on Figure 3-3, and essentially include all active City and UC Davis domestic and utility wells. Table 3-4 includes the water quality trigger levels for both the intermediate and deep portion of the groundwater aquifer.

Resolution actions that will be initiated if observed quality exceeds the trigger level may include any or a combination of the following:

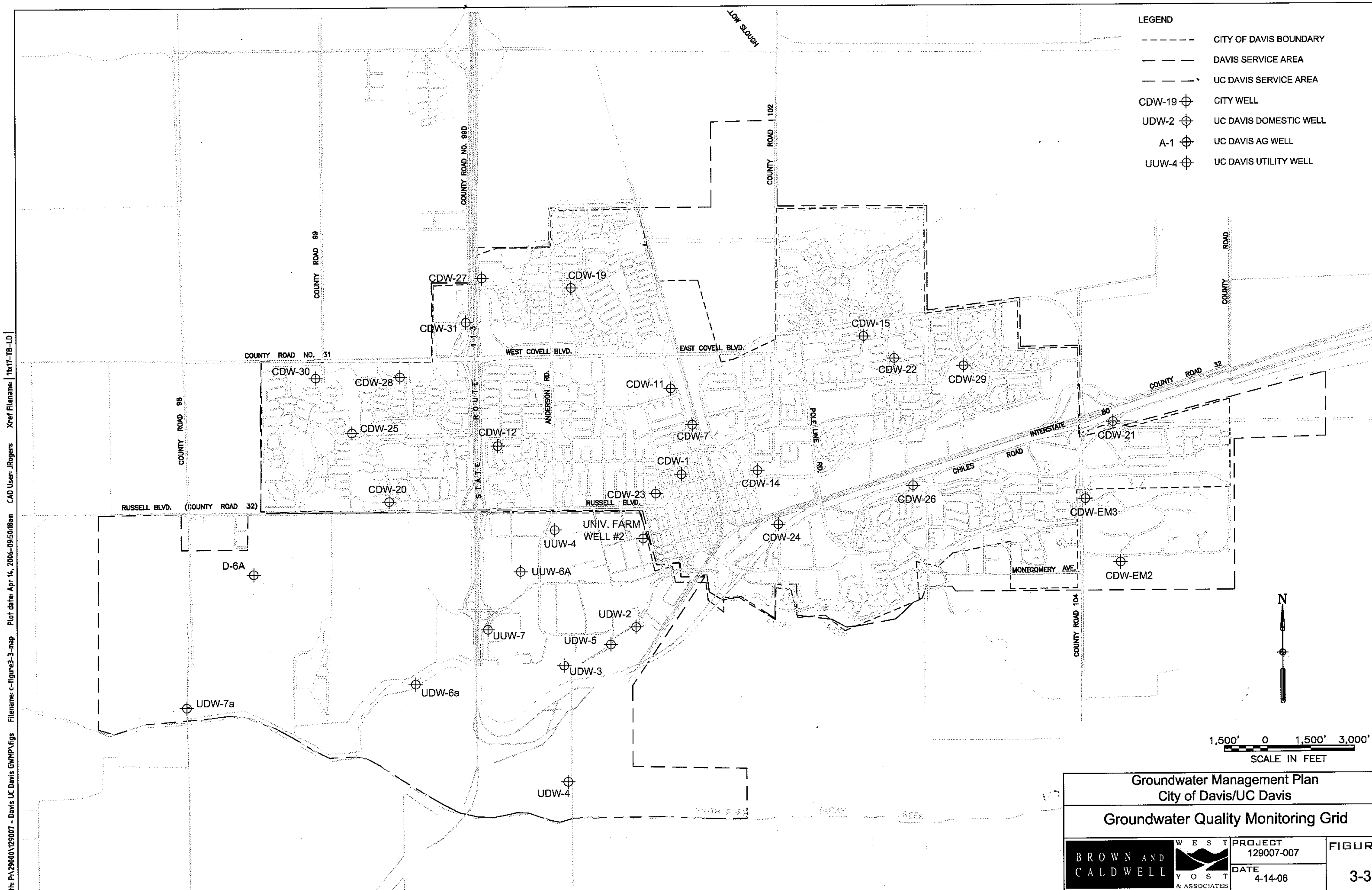
- Continued monitoring;
- System reoperation to redirect pumping either to another area or depth interval;
- Development of new wells;
- Acceleration of surface water supply source development; and
- Wellhead treatment where feasible.

<u>Inelastic Land Subsidence BMO</u>

As discussed in Section 2.6.5, inelastic land subsidence often results from consolidation of clay intervals following a reduction of aquifer pore pressure. To better understand the location, rate, and cause of land subsidence, regional land subsidence monitoring has been completed that includes the City and UD Davis GWMP area. Initial results indicate that inelastic land subsidence is occurring in the GWMP area, however there is not currently an adequate historic database nor an understanding of the threshold where significant detrimental impacts occur.

Because of this, additional data collection and evaluation is needed before a quantifiable BMO can be established for inelastic land subsidence. Monitoring of land subsidence will continue to result in an improved understanding of the subsidence rates and causes. The addition of a land subsidence BMO will be considered during the five year update based on a better understanding the rate and impacts of land subsidence.

Path: P:\29000\129007 - Davis UC Davis GWMP\figs Filename: c-figure3-3-map Plot date: Apr 14, 2006-09:50:18am CAD User: JRogers Xref Filename: 11x17-TB-LD



Groundwater Management Plan
City of Davis/UC Davis

Groundwater Quality Monitoring Grid

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PROJECT 129007-007

DATE 4-14-06

FIGURE 3-3

3.5.3 Groundwater Well Ordinances

CWC Sections 13700 through 13806 require proper construction of wells, and minimum standards for the construction of wells are specified in DWR Bulletins 74-81 and 74-90. These standards apply to all water wells, cathodic protection wells, and monitoring wells. In addition the City has adopted Ordinance 39.05.0 governing "all new and existing water wells, cathodic protection wells, heat-pump wells, test or exploratory borings, or any other nonmonitoring type of well within the jurisdictional boundaries of the City. Monitoring wells remain under full jurisdiction of the 'Water Quality Law of the County of Yolo' (chapter 8, section 6-8 of County Code). (Ord. No. 1812, § 1 (part).)".

The need for special well construction and destruction policies has not been identified within the UC Davis service area. Therefore, the construction and destruction standards put forth in CWC Section 13700 through 13806 and detailed in DWR Bulletins 74-81 and 74-90 have been adopted as the applicable standards. These standards are enforced through the well construction and destruction permitting process administrated by the Yolo County Department of Environmental Health.

3.5.4 Groundwater Management Program

With the development of this groundwater management plan the City and UC Davis have taken the first steps towards a formal groundwater management plan.

Currently, both agencies, along with all other Yolo Subbasin stakeholders, are members of the Water Resource Association of Yolo County. The WRA provides a forum for coordination of groundwater management program activities. The Solano Water Authority (SWA) serves a similar role in the Solano Subbasin.

3.5.5 Wellhead and Recharge Area Protection Measures

To date, there are no formally adopted wellhead or recharge area protection policies applicable to the City and UC Davis service areas, except for the well construction and destruction standards described in the preceding section. The City and UC Davis understand that point and non-point sources of contamination could jeopardize wells and recharge areas within their service areas.

The City and UC Davis will continue to coordinate with the Yolo County Planning Departments during evaluation of new projects in the vicinity of their service areas; the Yolo County Department of Environmental Health for permitting of any wells they construct; and the Central Valley Regional Water Quality Control Board and the California Department of Toxic Substances Control for updates on known and suspected point and non-point sources of groundwater contamination.Control of Saline Water Intrusion

Saline water intrusion into water supply aquifers has not been identified in the vicinity of the City and UC Davis service areas, and is not expected to be an issue in the future. However, the City and UC Davis have retained this element of groundwater resource protection in their GWMP in the unlikely event that groundwater quality data show increasing salinity in the future due to upwelling of deep saline water from below the Tehama formation.

3.5.6 Groundwater Resource Protection Actions

Davis and UC Davis will take the following actions:

- Ensure that well construction/destruction projects meet the applicable standards (City Ordinance, County Ordinance or CWC);
- Continue to cooperate with other local agencies in their groundwater management efforts;
- Endeavor to evaluate the potential for proposed projects to impact existing private wells and future wells that may be constructed by either entity;
- Consider the location of existing potential point and non-point sources of contamination when selecting well sites;
- Design wells to minimize the risk of wellhead contamination and spread of contaminants caused by pumping; and
- Continue to evaluate groundwater quality data for evidence of increasing salinity.

3.6 Groundwater Sustainability

The City and UC Davis are currently engaged in various activities that promote groundwater sustainability. Specific actions currently being pursued include:

- Incremental hydrogeologic investigation;
- Initial groundwater modeling;
- Support of efforts by YCFCWCD to develop additional water supply for areas north and west of this GWMP area;
- Environmental documentation for importation of surface water from the Sacramento River; and
- Construction and operation of groundwater and subsidence monitoring facilities.

3.6.1 Incremental Hydrogeologic Investigation

The City and UC Davis will perform detailed water quality zone sampling for any new wells constructed. They will also perform brief aquifer testing with each new well to determine how pumping impacts propagate through the aquifer system. Other testing, such as provenance (geologic source) analysis for sands and gravels, and a continuous deep core investigation are currently under consideration. These incremental hydrogeologic investigation steps will further the understanding of the aquifer system.

3.6.2 Groundwater Modeling

Groundwater models are a tool that can be effectively used to assess how proposed groundwater management actions or changes affect hydrologic conditions. In both the Phase I and Phase II Deep Aquifer Studies, numerical aquifer characteristics were calculated based on the results of pumping tests (West Yost & Associates, 1999; Brown and Caldwell and West Yost Associates, 2005). This also included characteristics for intermediate depth zones in the Phase I Study. These numerical characteristics were used for 2 dimensional modeling to obtain initial estimates of interference from the construction of additional deep wells.

The Integrated Ground and Surface water Model (IGSM) is currently being developed for YCFCWCD through a grant from DWR. The IGSM has been extended through the area of this GWMP to just south of Putah Creek. The IGSM is a quasi-three-dimensional water resources model that should be effective for modeling large scale groundwater conditions, especially for the shallower aquifer zones.

The City and UC Davis are exploring the possibility of developing a detailed groundwater model for the GWMP area. The previous studies and the IGSM would provide the initial basis for the model. A groundwater model could be used to:

- Evaluate interference between wells;
- Evaluate impacts of additional wells;
- Study drought impacts to City and UC Davis wells; and
- Support updates of water inventory and analysis and groundwater status reports.

Future updates could also be used to model groundwater quality and inelastic land subsidence.

3.6.3 Support of YCFCWCD Efforts

The YCFCWCD has proposed several projects to capture and store excess winter stream flows in Yolo County. These projects include one that would divert excess winter flows from lower Cache Creek and another that would divert and store excess winter and spring flows from the Colusa Basin Drain. These projects could provide direct and in-lieu groundwater recharge in areas north of the Davis/UC Davis groundwater management plan area. The City and UC Davis support these efforts directly through their memberships in the Yolo County WRA and the WRA Technical Advisory Committee.

3.6.4 Importation of Surface Water from the Sacramento River

The City of Davis, UC Davis, and the City of Woodland are jointly pursuing the diversion of water from the Sacramento River to supplement groundwater as a municipal water supply. This project has the potential to supply most of the water needed for Year 2040 target municipal water demands, with only peaking capacity provided by groundwater wells. The agencies are currently completing environmental documentation for the diversion and pipeline facilities. The agencies intend to continue this long-term effort. The Sacramento River diversion project may also be supported through the Yolo County Integrated Regional Water Management Plan (IRWMP) currently under way.

3.6.5 Construction and Operation of Groundwater Management Facilities

Ensuring the long-term sustainable use of the groundwater resources within the Plan area may require the planning and construction of projects that:

- Evaluate the need and potential for in-lieu groundwater recharge;
- Facilitate conjunctive use projects through improvements to recharge, extraction, and distribution infrastructure; and

- Protect groundwater quality, or remediate contaminated sites.

The Yolo County WRA is developing the IRWMP, and is considering policies, programs, and projects associated with the construction and operation of groundwater management facilities.

3.6.6 Groundwater Sustainability Actions

The City and UC Davis will take the following actions:

- Complete environmental documentation for Sacramento River diversion to eventually offset a portion of the need for groundwater pumping;
- Continue other planning actions for Sacramento River diversion;
- Support the development of a local groundwater model;
- Perform detailed zone sampling and aquifer tests at any new wells constructed by the City and UC Davis;
- Support YCFCWCD efforts to develop additional water supplies for areas north of this GWMP area; and
- Pursue funding from state agencies, federal agencies, and partnerships for groundwater sustainability activities.

3.7 Stakeholder Involvement

Public outreach and education are core activities of both the City and UC Davis.

The primary stakeholder outreach was through a GWMP Advisory Committee, which was formed to solicit input and guidance from major agency stakeholders. Public outreach and stakeholder input have also been encouraged through the City's Natural Resources Commission, whose mission includes providing two-way dialogue with the public and dissemination of information on water resources. The City and UC Davis have provided public outreach for the many previous projects leading up to this GWMP, including the Future Water Supply Study, Joint Water Supply Feasibility Study, and the Phase I and Phase II Deep Aquifer Studies (West Yost & Associates 1999 and 2002; Brown and Caldwell and West Yost & Associates, 2005).

Information on this project and other water resource projects is provided on the City's web site at http://www.ci.davis.ca.us/pw/water/. The City and UC Davis regularly engage in cooperative efforts with state and other local agencies. The following sections provide details on the involvement by the City and UC Davis with the water resource stakeholders.

3.7.1 Interagency and District Cooperation

Effective groundwater management requires coordination and cooperation between state, local, and federal agencies. The City and UC Davis will continue to work proactively with key agencies, local districts, and County departments, such as:

- State Water Resources Control Board (SWRCB): The SWRCB is responsible for establishing water rights and maintaining water quality standards. The SWRCB provides the framework and direction for groundwater protection efforts. The City and UC Davis have established a working relationship with the SWRCB to develop an appropriative surface water rights application that, if permitted, will allow diversion from the Sacramento River.

- California Department of Water Resources (DWR): DWR plays an important role in the management of both surface water and groundwater resources. Davis and UC Davis have worked closely with DWR Central District on a number of important studies and programs, including previous groundwater studies and land surface subsidence studies. DWR continues to support groundwater management and land surface monitoring in the Davis/UC Davis service areas. Current projects with substantial funding managed by DWR include IGSM development, the Yolo County IRWMP, and this GWMP development.

- Water Resources Association of Yolo County (WRA): The WRA is a consortium of entities authorized to provide a regional forum to coordinate and facilitate solutions to water issues in Yolo County. Davis and UC Davis are active members of the WRA along with YCFCWCD, Yolo County, and other cities and water districts.

- Yolo County Flood Control and Water Conservation District (YCFCWCD): YCFCWCD provides surface water throughout much of western and central Yolo County from water rights on Cache Creek and storage in Clear Lake and Indian Valley Reservoir. YCFCWCD has statutory authority for groundwater management throughout its original service area, which included some of the area currently served by The City and UC Davis. The City and UC Davis work collaboratively with YCFCWCD in water resource planning.

- Solano County Water Agency (SCWA) and Solano Irrigation District (SID): SCWA provides untreated water to cities and agricultural districts in Solano County from the Federal Solano Project and the North Bay Aqueduct of the State Water Project. SID is the retail water district that serves the northern portion of Solano County using surface water from SCWA and groundwater wells. Actions by the Solano water agencies could have some effects on groundwater within the Davis and UC Davis service areas and vice-versa. A representative from SID has been included on the Advisory Committee for the Davis/UC Davis GWMP to insure coordination in GWMP development.

- Reclamation District 2035 (RD 2035): RD 2035 serves surface and groundwater to the Conaway Ranch area several miles north of Davis. RD 2035 is one of the main surface water suppliers to eastern Yolo County. RD 2035 could be a potential partner in a Sacramento River water diversion project for the City and UC Davis. The City and UC Davis coordinate water resource planning with RD 2035 through joint participation in the WRA.

- City of Woodland: Although Woodland is distant enough from Davis and UC Davis that groundwater pumping interference is not anticipated, Woodland is interested in further exploration of the hydrogeology in and around its service area. Woodland participated with Davis and UC Davis in the recent Phase II Deep Aquifer Study. Woodland is also an active member in the WRA and could be a participant in a Sacramento River diversion project.

- City of West Sacramento: West Sacramento currently supplies its municipal water needs with water diverted from the Sacramento River. West Sacramento is a potential partner in a Sacramento River diversion project for Davis and UC Davis.

3.7.2 Advisory Committees and Stakeholders

The following local agencies were considered to be stakeholders in the management of groundwater in and around the Davis/UC Davis service areas:

- YCFCWCD
- RD 2035
- Yolo County
- WRA
- SID
- SCWA

These local agencies were discussed above in 3.7.1. In addition to these local agencies, the following advisory committees were specifically involved in the development of the GWMP and stakeholder outreach:

- Davis NRC
- WRA TAC

The City and UC Davis staff are active members of the WRA Technical Advisory Committee (TAC). The Advisory Committee for this GWMP was comprised of the WRA TAC and a member from SID. Advisory, stakeholder, and public meetings held during the GWMP development process were listed previously in Table 1-1.

3.7.3 Ongoing Stakeholder Involvement Actions

The City and UC Davis will take the following actions:

- Continue to work cooperatively with DWR Central District and the Division of Local Planning and Assistance (DLPA) on groundwater investigation and management activities;
- Continue to work cooperatively with YCFCWCD on groundwater management and other water resource activities;
- Be active in the WRA and responsive to the needs and requests of the WRA TAC;
- Continue to disseminate groundwater management planning information to other nearby local water districts and agencies; and
- Continue to support locally-driven stakeholder groups.

3.8 Integrated Water Resource Planning

The WRA expectes to complete its IRWMP in September 2006. The IRWMP will be closely coordinated with the Yolo County General Plan process that has a planning horizon of 2025. The goal of the IRWMP is to improve water resource management in five areas:

1. Water supply and drought preparedness;
2. Water quality;
3. Flood control and storm drainage;
4. Recreation; and

5. Riparian and aquatic ecosystem enhancement.

A series of community workshops are being scheduled and conducted to inform interested parties of the IRWMP, answer questions and solicit input on the IRWMP.

Drawing from data and information presented in the IRWMP document, water resource plans, technical studies, and expressed public concern, the WRA TAC has identified particular findings and issues, and in some cases needs, related to the respective water resource management categories. The groundwater related issues and guidelines for water supply are as follows:

Issues

1. Need to improve existing water supply quality and pursue higher quality water sources to meet current and future demands;
2. Availability of adequate water supplies during severe drought conditions;
3. Subsidence as a result of groundwater extraction; and
4. Ability of deep aquifer to sustain current and future demands.

Guidelines

Water Supply Reliability

1. Wellhead protection plans will be developed to maintain groundwater quality.
2. Drought protection and contingency plans will be developed to improve water supply reliability during extended droughts.
3. Data and information related to water resources and land use will be compiled, evaluated, and reported on a regular basis.

Groundwater

1. Groundwater resources will be managed on a sustainable basis to ensure sufficient amounts of high quality water for existing and future uses, and protection and enhancement of natural ecosystems.
2. Conjunctive use of surface water and groundwater will be maximized.
3. Monitoring and assessment/modeling of groundwater and surface water resources will be enhanced in concert with water supply and wastewater recycling projects.

3.8.1 Integrated Water Resource Planning Actions

The City and UC Davis will take the following actions:

1. Through participation in the WRA and WRA TAC, assist in the development of the IRWMP;
2. Implement plan policies, programs, and projects approved by the WRA for which funding is available; and
3. Pursue funding sources for implementation of plan policies, programs, and projects.

3.9 GWMP Reporting and Updating

The City and UC Davis consider the GWMP to be a living document that guides groundwater management. Plan implementation centers on the implementation actions under each of the five groundwater management components.

Section 3.3 identifies the five GWMP components. Individual plan components are described in Sections 3.4 through 3.8. Plan implementation actions are identified at the conclusion of each section. Additionally, this section concludes with Table 3-5 which summarizes implementation actions and the associated schedule. The City and UC Davis Working Group will meet periodically to assess progress toward completion of the identified implementation actions. The following sections provide additional discussion on plan implementation, reporting, and updates.

3.9.1 GWMP Implementation Report

The City and UC Davis will collaborate annually to develop a brief status report to document progress on GWMP implementation during the previous year and to review and confirm implementation actions for the next year. The report will discuss the status of groundwater levels, groundwater quality, and inelastic land subsidence in relation to established BMOs. Data necessary for completion of the annual report will continue to be input and managed within the combined relational database shared by the City and UC Davis.

3.9.2 GWMP Update

The continually evolving knowledge of subsurface conditions coupled with improved groundwater management strategies will result in the need for periodic Plan updates. The City and UC Davis will at least annually consider improvements to the groundwater management techniques, and will incorporate these improvements as they develop. BMOs may be modified in future years based on monitoring results, new information, or evolving objectives. If changes need to be made, the City and UC Davis will formalize changes to this GWMP at least once every five years.

3.9.3 GWMP Reporting and Updating Actions

The City and UC Davis will take the following actions:

- Work cooperatively with local stakeholders, county government, and local advisory committees to assess needed GWMP updates;
- Document BMO performance status, actions ongoing or completed, and prioritized actions for the next year; and
- Assess and modify, if necessary, BMOs based on monitoring results and management strategies.

Table 3-5. Summary of GWMP Actions

	Description of Action	Implementation Schedule
I.	**Groundwater Monitoring**	
1	Update monitoring procedures as necessary to be compatible with monitoring program.	As needed
2	UC Davis to add automatic flow monitoring to all active domestic and utility wells, automatic water level monitoring to select wells.	By 2008
3	Maintain a coordinated database of monitoring data.	Ongoing
4	Export requested data annually from the database to YCFCWCD for inclusion in the Water Resources Information Database.	Annual
5	Evaluate the data annually and compare with quantitative BMO trigger levels.	Annual
6	Monitor groundwater / surface water interaction on Lower Putah Creek through participation on Lower Putah Creek Coordinating Committee.	Ongoing
7	Continue to support triennial land subsidence surveys through the Yolo County Subsidence Network.	Ongoing
II.	**Groundwater Resource Protection**	
1	Ensure that any well construction or destruction projects meet the applicable standards (City Ordinance, County Ordinance or CWC).	As needed
2	Continue to cooperate with other local agencies in groundwater management efforts.	As needed
3	Endeavor to evaluate the potential for proposed projects to impact existing private wells and future wells that may be constructed by either entity.	Ongoing
4	Consider the location of existing potential point and non-point sources of contamination when selecting well sites.	As needed
5	Design wells to minimize the risk of wellhead contamination and spread of contaminants caused by pumping.	Ongoing
6	Continue to evaluate groundwater quality data for evidence of increasing salinity	Annual
III.	**Groundwater Sustainability**	
1	Complete environmental documentation for Sacramento River diversion to eventually partially offset the need for groundwater pumping.	Pending
2	Continue other planning actions for Sacramento River diversion.	Annual
3	Support the development of a local groundwater model.	Ongoing
4	Perform detailed zone sampling and aquifer tests at any new wells constructed by the City and UC Davis.	As new wells are constructed
5	Support YCFCWCD efforts to develop additional water supply for areas north of this GWMP area.	Annual
7	Pursue funding from state agencies, federal agencies, and partnerships for groundwater sustainability activities.	Annual
IV.	**Stakeholder Involvement**	
1	Continue to work cooperatively with DWR Central District and Division of Local Planning and Assistance on groundwater investigation and management activities.	Annual
2	Continue to work cooperatively with YCFCWCD on groundwater management and other water resource activities.	Annual
3	Be active in the WRA and responsive to the needs and requests of the WRA TAC.	Ongoing
4	Continue to disseminate groundwater management planning information to other nearby local water districts and agencies.	Ongoing
5	Continue to support locally-driven stakeholder groups.	Ongoing

Table 3-5. Summary of GWMP Actions (continued)

	Description of Action	Implementation Schedule
V.	**Integrated Water Resources Planning**	
1	Through participation in the WRA and WRA TAC, assist in the development of the IRWMP.	Fall 2006
2	Implement plan policies, programs, and projects approved by the WRA for which funding is available	2007, 2008
3	Pursue funding sources for implementation of plan policies, programs, and projects.	Annual
VI.	**GWMP Implementation, Reporting and Updating**	
1	Work cooperatively with local stakeholders, county government, and local advisory committees to assess needed GWMP updates.	Ongoing
2	Document BMO performance status, actions ongoing or completed, and prioritized actions for the next year.	Annual
3	Assess and modify, if necessary, BMOs based on monitoring results and management strategies.	Annual

SECTION 4
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APPENDIX A

Groundwater Management Plan Resolutions

RESOLUTION NO. 05-278, SERIES 2005

RESOLUTION NOTICING THE INTENT OF THE CITY OF DAVIS AS THE LEAD AGENCY ON BEHALF OF UC DAVIS TO PREPARE A GROUNDWATER MANAGEMENT PLAN (GWMP) UNDER WATER CODE SECTION 10750 et seq. (AB 3030, STATS 1992) FOR THE DAVIS AREA NOT COVERED BY ANOTHER GROUNDWATER MANAGEMENT PLAN UNDER THIS AUTHORITY OR ANY OTHER AUTHORITY

WHEREAS, it is the intent of the Legislature through the passage of AB 3030 (Stats 1992) codified as Water Code Section 10750 et seq. to encourage local agencies to work cooperatively to manage groundwater resources within their jurisdictions to ensure both its safe production and quality; and

WHEREAS, the Legislature also finds and declares that the additional study of groundwater resources is necessary to better understand how to manage groundwater effectively to ensure the safe production, quality, and proper storage of groundwater in the state; and

WHEREAS, the adoption of a GWMP is encouraged, but not required by law; and

WHEREAS, any local agency, whose service area includes a groundwater basin, or a portion of a groundwater basin, that is not subject to groundwater management pursuant to other provisions of law or a court order, judgment, or decree, may, by ordinance, or by resolution if the local agency is not authorized to act by ordinance, adopt and implement a GWMP pursuant to this part within all or a portion of its service area not served by a local agency or served by a local agency whose governing body, by a majority vote, declines to exercise the authority to implement a GWMP and enters into an agreement with the local public agency pursuant to Water Code Sections 10750.7 and 10750.8; and

WHEREAS, the City of Davis is interested in the development of a GWMP, working collaboratively with UC Davis, as defined under Water Code Section 10750, et seq. for the Davis Area not covered by another GWMP; and

WHEREAS, prior to adopting a resolution of intention to draft a GWMP, Water Code Section 10753.2 requires a local agency to hold a hearing, after publication of notice pursuant to Government Code Section 6066, on whether or not to adopt a resolution of intention to draft a GWMP pursuant to this part for the purposes of implementing the plan and establishing a GWMP; and

WHEREAS, such hearing was noticed pursuant to Government Code Section 6066 and held on October 4, 2005 at 6:30 p.m. in the City of Davis Community Chambers, 23 Russell Boulevard in Davis, California; and

WHEREAS, at the conclusion of the hearing, the local agency may draft a resolution of intention to adopt a GWMP pursuant to this part for the purposes of implementing the plan and establishing a GWMP.

NOW, THEREFORE, BE IT RESOLVED that the City Council of the City of Davis does hereby agree to:

1. Adopt a Resolution of Intention to Draft a GWMP pursuant to Water Code Section 10750 et seq. for the purposes of implementing the plan and establishing a GWMP for the Davis Area.

2. Direct the City Clerk to publish the Resolution of Intention under Government Code Section 6066 pursuant to Water Code Section 10753.3(a).

3. Direct the City Manager to prepare the GWMP for the Davis Area by May 2006 in accordance with AB303 project funding contract requirements.

PASSED AND ADOPTED by the City Council of the City of Davis this 4th day of October, 2005 by the following vote:

AYES: GREENWALD, PUNTILLO, SAYLOR, SOUZA, ASMUNDSON.

NOES: NONE.

RUTH UY ASMUNDSON
Mayor

ATTEST:

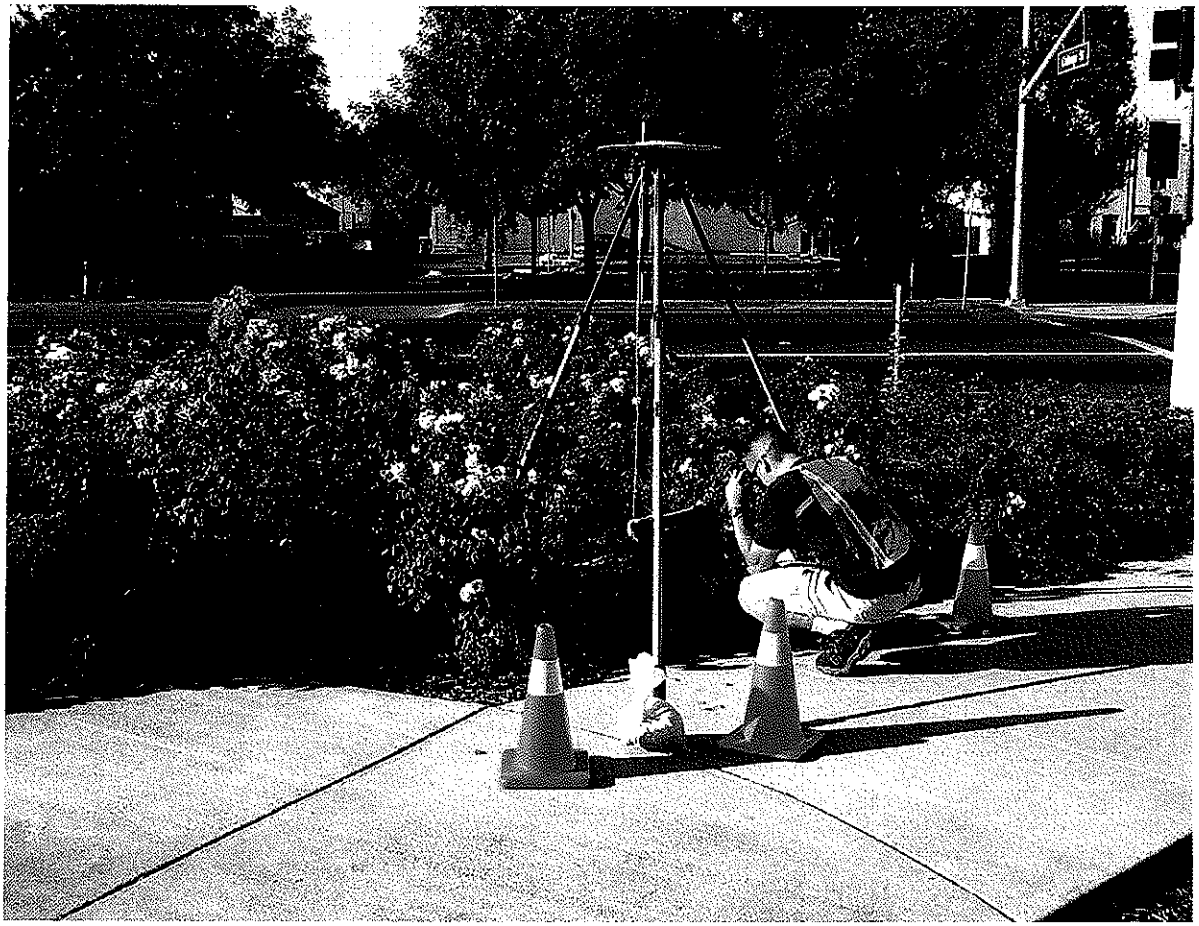
BETTE E. RACKI
City Clerk

APPENDIX B

2005 Subsidence Survey Recommendations Report

The Yolo County GPS Subsidence Network

Recommendations and Continued Monitoring



(Photo: Station LIBRARY, in Woodland)

Submitted by:

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March, 2006

Executive Summary

From July through September, 2005 the third set of observations of the Yolo County GPS Subsidence Network were obtained. This marks the third time the Yolo network has been observed. The original observations were obtained in 1999. The second observation of the network was obtained in 2002. In 2002 the network was expanded to include stations south of the Highway 80 corridor. Also, the City of Sacramento added several stations to the network for the 2002 observations. In the 2005 project a few new stations were added to the network.

The results of the 2005 observations validate the findings of the 2002 results. The results show continuing subsidence in the Davis to Zamora corridor. The 2005 observations also provide an opportunity to take a more in-depth look at the underlying assumptions of subsidence based on the issue of what is believed to be stability. The project incorporates a few continuously operating GPS sites. These sites provide a continuous record of ground movements, both horizontal and vertical. It is in light of these data that we may now be able to refine some of our assumptions about stability against which subsidence is measured.

The 2005 project included the addition of one station (RWF1) that is part of the Davis Deep Aquifer study, and one station (RD2068) that was established for Reclamation District 2068 in Solano County. Both were established in 2004. Including RD2068 entailed adding two additional stations (SURVEYOR and MILLAR) in order to meet the network geometry specification. These two stations were part of earlier subsidence network observations in the Sacramento/San Joaquin River Delta.

Station ellipsoid heights for the 1999, 2002 and 2005 projects, as developed by CSRC, are included in **Appendix A**.

The provisional results of the elevations (orthometric heights) for the 2005 project are included in **Appendix B.** Also included in this appendix are the values obtained from the earlier 1999 and 2002 projects along with the inter-survey subsidence values.

A map of the project showing the local network stations, cumulative subsidence contours and water source information, may be found in **Appendix C**.

The hypothetical results of continued subsidence at rates seen to date is shown for selected stations in **Appendix F**.

The report of the 1999 survey (The Yolo County Subsidence Network: Recommendations for Future Recommendations, Frame and D'Onofrio, 1999) included a series of ten recommendations. The 2002 report (The Yolo County GPS Subsidence Network: Recommendations and Continued Monitoring, Frame and D'Onofrio, 2003) added an additional two recommendations. All of these recommendations are further discussed in Section IV of this report.

I. INTRODUCTION

This report outlines the results of the 2005 Yolo County GPS Subsidence Project. It also includes comparisons with the earlier 1999 and 2002 projects. Each of the recommendations in the 1999 and 2002 reports are addressed with updated comments. This report also includes a discussion of the subsidence findings with respect to a more thorough review of the relationship of subsidence areas to neighboring stable areas and/or subsiding areas with continuous records of earth movement.

As with the earlier 1999 and 2002 projects, the 2005 project was accomplished with cooperation from several agencies. Observation personnel were provided by the California Department of Water Resources, the cities of Woodland and Davis, the US Bureau of Reclamation, the Yolo County Planning, Resources & Public Works Department, and Frame Surveying & Mapping. GPS equipment was supplied by the University of California Davis, the US Bureau of Reclamation, and Frame Surveying & Mapping.

II. BACKGROUND

The 2005 GPS subsidence survey is the third in the series of observations. These observations have been conducted at three year intervals, the previous observations being in 1999 and 2002. The greatest portion of the GPS network has been the same. Several new stations were added in 2002 and four additional stations were added in the 2005 survey.

The results of the 2005 survey indicate that subsidence trends throughout much of the county are continuing. The largest amount of subsidence occurs in the Zamora area, especially near the Zamora extensometer (station ZAMX) which has subsided a total of about 12 to 15 centimeters (roughly 6 inches) over the six years of the project. A map of the subsidence contours based upon the CSRC ellipsoid height analysis is provided in **Appendix C.**

It should be noted that only a very few stations in the network showed no subsidence. It should also be noted that the accuracy of the subsidence values is +/- 2 centimeters.

III. PROJECT ISSUES

All stations observed in the 2002 project were recovered in good condition. There were four additional stations added to the network. One of the stations is part of the Davis Deep Aquifer Study (station RWF1), and one was established in 2004 for Reclamation District 2068 (station RD2068). Station RD2068 is in Solano County. Two additional stations in Solano County (SURVEYOR and MILLAR) were added to allow for a more complete relationship with RD2068. The two additional Solano County stations were part of earlier GPS subsidence projects. Station RWF1 is inside Yolo County and required no additional station observations.

The City of Sacramento stations included in the 2002 survey were not observed in 2005.

There were a greater percentage of re-observations required for this project than for previous projects. All baselines (those inter-station lines indicated on the project map – see **Appendix D**) are observed at least twice. Baseline comparisons must agree within 2 centimeters. In the 2005 project over 15 percent of the baselines did not meet this criterion. All were re-observed and all ultimately met the 2 centimeter criterion.

All other activities associated with the 2005 project were routine.

Provisional coordinates (latitude, longitude and elevations) are included in **Appendix E.**

IV. RECOMMENDATIONS AND COMMENTS

After the 1999 project was completed a series of ten recommendations was made. After the 2002 project an additional two recommendations were made. We will include two additional recommendations in **Section V. NEW RECOMMENDATIONS.**

A summary of the recommendations is immediately below, followed by more detailed information.

Summary of Recommendations

Recommendation	Year	Status
1. Inform the public & make data easily available	1999 2002 2005	Implemented for 1999 & 2002; in process for 2005.
2. Annual field review of network station condition	1999 2002 2005	Not formally implemented.
3. Pre-emptive replacement of endangered station marks	1999 2002 2005	Untested.
4. Re-observe network every 3 years	1999 2002 2005	Implemented.
5. Consider more frequent observations	1999 2002	Discontinued due to lack of demand.
6. Network densification	1999 2002 2005	Limited implementation near Davis.
7. Non-financial support for continued operation of UCD1	1999 2002 2005	Not formally implemented.
8. Establish a new CORS in the north county	1999 2002	Obsolete.
9. Encourage FEMA to adopt network results	1999 2002 2005	Not formally implemented. Early attempt to involve FEMA met no response.
10. Investigate supplemental detection technologies	1999 2002 2005	Not implemented due to lack of demand.
11. Incorporate extensometer data	2002 2005	Implemented.
12. Extend network into Solano County near Davis	2002 2005	Limited implementation in 2005.
13. Review technical approach to data analysis	2005	In process.
14. Document subsidence effects	2005	New.

Recommendation 1. Inform public and private agencies involved in construction, utilities management, public works and related activities in the county about the network and the location of all stations. Information about the project's web site should be included in this information. (Note: As of the date of this report, the website – http://www.yarn.org/subsidence/about.html – not has not been updated. The update is pending final publication of station positions by NGS.)

As noted in the report after the 2002 observations there continues to be anecdotal information about the utility of the network, especially among the surveying community. Survey painting and flagging indicate that the network stations are being used. The County Surveyor reports that many of the stations are used and reported in Records of Survey submitted to him.

Recommendation 2. Task a single entity with visiting each monument in the network annually to assess the integrity of the individual monuments. Any discrepancies in the monument description and condition should be brought to the attention of the interested parties and to the National Geodetic Survey (NGS). Follow proper steps for reporting such discrepancies.

It continues to appear that no agency has accepted this responsibility. It might appear that this is unnecessary since all stations used in the 2005 survey were recovered in good condition. As the network ages experience indicates that some stations may be destroyed due to construction or other activities. It becomes more imperative that this recommendation be followed. In the absence of an agency accepting this responsibility a private entity should be considered to undertake this responsibility on a contractual basis.

Recommendation 3. Identify stations in imminent danger of destruction and replace them in advance, following National Geodetic Survey guidelines. (A copy of these guidelines may be obtained from the NGS California State Geodetic Advisor, Marti Ikehara – Marti.Ikehara@noaa.gov). A station destroyed before replacement represents a permanent break in the subsidence history for that station.

As indicated in Recommendation 2, above, the absence of occasional visits to each of the stations increases the possibility of stations being lost. While there is no difference in the cost of replacing a monument either before or after it is destroyed, replacing it after it has been destroyed breaks the subsidence history of the mark.

Recommendation 4. Re-observe the entire network in three years. Depending on the results of the re-observation, the county can better determine the time period for subsequent re-observations.

It appears that the decision to re-observe the network on a three-year cycle is acceptable to project participants. A review of the latest three-year cycle (2005 – 2002) indicates a slightly larger amount of subsidence at several of the stations than that observed in the first three year cycle (2002 – 1999). The next three year cycle should provide a more definitive overview of subsidence effects. The fact that subsidence rates over one cycle differ from those of another cycle provide additional information about the nature of subsidence. Because subsidence is a result of several factors (e.g., aquifer re-charge, amount of pumping, etc.) it tends to be a non-linear phenomenon.

Recommendation 5. Investigate the benefits of more frequent re-observation of particular areas of the county.

Based on the results of the 2005 survey and its comparison with the 1999 and 2002 surveys it does not appear that more frequent observations of the network will add significantly more reliable information than is provided under the current 3-year observation cycle.

Recommendation 6. Investigate densification of the network in areas of particular interest.

The approach made for this recommendation after the 2002 survey still seems valid. If an area of the county is deemed to need a more densified approach this can be accomplished by either GPS or a combination of GPS and terrestrial observations. In the areas of greatest subsidence this might be worthwhile. This assumes that there is a need for such densified observations. Planned construction in these areas might necessitate that this option be considered.

Recommendation 7. Provide continuing non-financial support for the Continuously Operating Reference Station (CORS) at the University of California, Davis. This site can be of significant value in ongoing subsidence measurement operations.

The CORS site at UC3D provides the only continuous record of land movement in the area. The following figure shows the downward (subsiding) trend of the site as well as the seasonal trends of the site. This seasonal trend seems to be symbolic of sites in subsiding areas. Efforts should be made to ensure continuous operation of the site. As long as it continues in operation it will continue to provide a piece of the framework for continued, accurate monitoring of subsidence in the county.

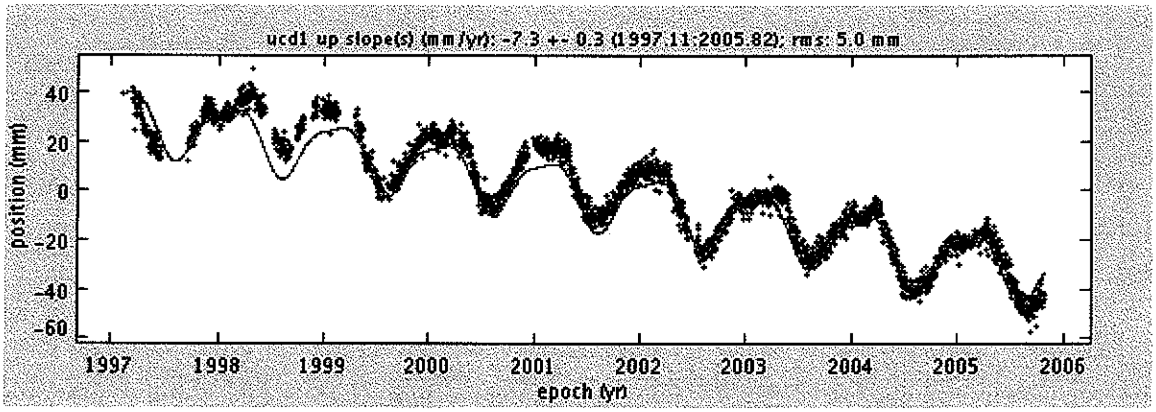


Fig. 1. UCD CORS site vertical record, 1997 through 2005.

Recommendation 8. Investigate the establishment of a CORS site in the north county area.

This recommendation was made prior to the establishment of the Plate Boundary Observatory (PBO) program. The PBO program includes the establishment of over 400 continuous GPS sites in California. Four of these have been established in the vicinity of Yolo County: three in the county (near Woodland, Dixon and Winters), and one to the north in Colusa County (near the city of Colusa). These should help with long term measurements of earth movement and obviate the need for a station in northern Yolo County. This recommendation will be removed from future reports unless there is a need to re-consider the need for a station in that vicinity.

There is an additional continuous tracking GPS site in the Sutter Buttes. This station has been part of the three Yolo County surveys.

Recommendation 9. Consider the merits of encouraging the Federal Emergency Management Agency (FEMA) to adopt the results of the project in its flood plain mapping efforts.

The county should consider following up on this recommendation with FEMA. Since accepting the results of the 1999 survey it appears that FEMA would be receptive to such a request. The 2002 City of Woodland Flood Insurance Rate Maps (FIRMs) were developed using vertical control from the 1999 Yolo project. These FIRMS indicate flood contours in both the NGVD29 and NAVD88 datums.

Recommendation 10. Investigate other supporting technologies as an adjunct to the GPS Subsidence Network within Yolo County.

The 2002 report suggested considering the use of either LIDAR or Synthetic Aperture Radar (SAR) technology which could provide more densified coverage of the project area. Because the accuracy of LIDAR technology is currently less than what is required for Yolo County subsidence monitoring, its application is not recommended at this time.

In the absence of any apparent interest in more densified measure of subsidence, the use of SAR is similarly not recommended at this time. SAR technology offers a potentially better alternative to LIDAR. However, the use of SAR continues to be somewhat more problematic in agricultural areas.

Recommendation 11. Incorporate measurements to relate the two DWR extensometers (at Zamora and Conaway ranch) to the Yolo County Subsidence network.

In July of 2005 DWR personnel took measurements relating both the Conaway and Zamora extensometers to their respective adjacent network station marks (CONAWAY and ZAMX). Continued annual measurements of this nature will simplify tracking the relationship between movement indicated by the extensometers and that indicated by the GPS measurements.

In the 2002 survey, a discrepancy was noted between the amount of subsidence indicated by the GPS results and that indicated by the Stevens chart recorders mounted on the extensometers. This trend – which is attributed to the fact that the extensometers only reflect subsidence in the upper region of the ground (716 feet at Conaway, 1003 feet at Zamora) – continues. See **Appendix H** for details.

Recommendation 12. Seek cooperation with the County of Solano to determine the magnitude and extent of the subsidence in the vicinity of Davis.

The addition of station RD2068 of the Davis Deep Aquifer project and two of its neighboring stations (SURVEYOR and MILLAR) in Solano will help resolve this issue. The inclusion of up to three additional stations in Solano County that were part of the San Joaquin/Sacramento Delta project would provide the necessary observations to complete this recommendation. In the absence of working with Solano County these stations could be added into the base Yolo project. The candidate stations are CURREY (PID AE9856), STORE (PID AE9852) and X 128 RESET (PID JS1613).

V. ADDITIONAL RECOMMENDATIONS

There are now five continuous GPS sites in or near the county. Two of these stations, at UC Davis and Sutter Buttes, have been in continuous operation since 1997. They provide the potential to form a better basis for measuring and monitoring subsidence in the county. These stations are on a more or less north-south axis so might not account for an east-west bias, if any, in the GPS observations. The three additional PBO sites, especially the two in Woodland and Winters, should help resolve this issue. These stations (and the Dixon station) have not been operational long enough to provide any useful data for the current survey but should prove more beneficial in future surveys.

Recommendation 13. Given the longer continuous time series now available at the Sutter Buttes and UC Davis sites, and the apparent subsidence at sites previously believed to be stable, we recommend that the 2005 data be reviewed more thoroughly.

When the Yolo project was initiated in 1999, the survey results were constrained to ellipsoid height values based upon the best information available from NGS. At the time, relatively little work had been done to comprehensively analyze the data being accumulated at northern California continuous GPS monitoring sites.

For the 2005 project, CSRC reanalyzed the data from the 1999, 2002 and 2005 surveys with regard to ellipsoid heights. This analysis was informed by the analysis of data gathered continuously over the 1999-2005 period at the Sutter Buttes and UC Davis permanent GPS stations. Although some discrepancies between the CSRC and NGS values remain, the relative ellipsoid heights derived from the CSRC analysis are considered to be the most reliable indicator of cumulative subsidence at this time. The subsidence contour map (Appendix B) reflects this analysis.

The most significant discrepancies between the NGS and CSRC analyses are found toward the periphery of the county. The magnitude of the discrepancies range from 2cm to 9cm. It is important to note that both analyses show the same areas of concentrated subsidence, in particular the area centered on station ZAMX.

Once the NGS and CSRC height values are reconciled, updated values for the project station positions will be incorporated into the NGS database.

Recommendation 14. Establish a coordinated interagency approach to the identification and documentation of subsidence effects. This would require agencies to gather supplemental data that demonstrates the impact of subsidence upon facilities and operations. Photographs and descriptions of observed impacts (e.g., raised well pads and crushed well casings) will assist in rounding out the understanding of subsidence impacts among the project partners, non-technical officials and the general public. (See **Appendix G** for example photographs.)

VI. CONCLUSION

With the completion of the 2005 project observations, a clearer picture of ongoing subsidence begins to emerge. The 2002 survey indicated subsidence, but the time frame between the 1999 and 2002 surveys was too short to allow definitive measures of subsidence given the myriad potential causes. The 2005 survey results, when compared with the earlier surveys, provide definitive proof of such subsidence. It begins to give a clearer picture of the amount and distribution of subsidence across the project area. As indicated in the 2002 report, the central corridor of the project is undergoing the greatest subsidence. The corridor runs north from Davis, through Woodland, north to Zamora and through to the northeast corner of the county. It is generally characterized as having little or no surface water availability and substantial groundwater pumping. The subsidence does not appear to be strictly uniform – a common characteristic of the phenomenon – but rather the result of several factors. For this reason it is recommended that continued re-observations of the network be planned on a 3-year cycle. It is recommended that other studies of ground water pumping, water usage and related issues be studied as well.

Please note that the horizontal coordinates (latitude and longitude) have changed again for all stations in the network. The county is in the area of the North American and Pacific tectonic plate boundary. This tectonic motion causes all stations in the project move northwesterly a few centimeters per year.

Respectfully submitted:

Jim Frame Frame Surveying & Mapping	Don D'Onofrio Geodetic Consultant

APPENDIX A.

CSRC NAD83 Ellipsoid Height Values
from 1999, 2002 and 2005 Surveys (with differences)

4-CH ID	1999	2002	Change 02-99	2005	Change 05-02	Change 05-99
0308	-6.842	-6.880	-0.038	-6.910	-0.030	-0.068
03BG		-21.122		-21.120		0.002
03DG	-6.730	-6.759	-0.029	-6.762	-0.003	-0.032
03EH	-19.335	-19.347	-0.012	-19.339	0.008	-0.004
1031	-20.402	-20.401	0.001	-20.418	-0.017	-0.016
1069	23.627	23.646	-0.019	23.630	-0.016	0.003
1075	-15.424	-15.424	0.000	-15.425	-0.001	-0.001
1200	47.507	47.483	-0.024	47.494	0.011	-0.013
1699	21.812	21.833	0.021	21.829	-0.004	0.017
2068				-19.213		
ABUT	22.034	22.033	-0.001	22.034	0.001	0.000
ALHA	-18.089	-18.106	-0.017	-18.127	-0.011	-0.038
ANDR		-27.837		-27.845	-0.008	
B849	8.482	8.459	-0.023	8.482	0.023	0.000
BIRD	63.747	63.773	0.026	63.780	0.007	0.033
BRID	33.505	33.527	0.022	33.510	-0.017	0.005
CALD		-25.915		-25.904	0.011	
CANA	-1.250	-1.235	0.015	-1.246	-0.011	0.004
CAST	-25.680	-25.690	-0.010	-25.680	0.010	0.000
CHUR	-6.689	-6.675	0.014	-6.694	-0.019	-0.005
CODY	-17.502	-17.551	-0.049	-17.586	-0.035	-0.084
CONA	-23.079	-23.091	-0.012	-23.088	0.003	-0.009
COTT	60.663	60.711	0.048	60.710	-0.001	0.047
COUR		-23.354		-23.358	-0.004	
COY1	-22.381	-22.383	-0.002	-22.400	-0.017	-0.019
CVAP	-22.180	-22.187	-0.007	-22.217	-0.030	-0.037
DAVE	-11.868	-11.872	-0.004	-11.876	-0.004	-0.008
DRAI	-17.049	-17.053	-0.004	-17.050	0.003	-0.001
DUFO	-10.193	-10.232	-0.039	-10.284	-0.052	-0.091
EX11	-22.835	-22.865	-0.030	-22.863	0.002	-0.028
F859	-16.022	-16.028	-0.006	-16.066	-0.038	-0.044
FERR	-18.509	-18.498	0.011	-18.510	-0.012	-0.001
FORD	-12.948	-12.953	-0.005	-12.989	-0.036	-0.041
FREM	-17.820	-17.782	0.038	-17.798	-0.016	0.022
GAFF		-30.304		-30.294	0.010	
GW17	54.278	54.292	0.014	54.302	0.010	0.024
GW32	82.143	82.169	0.026	82.140	-0.029	-0.003
HERS	-16.223	-16.210	0.013	-16.205	0.005	0.018
JIME	-17.587	-17.586	0.001	-17.586	0.000	0.001
KEAT	5.083	5.112	0.029	5.093	-0.019	0.010
LIBR	-10.801	-10.810	-0.009	-10.824	-0.014	-0.023
MADI	16.177	16.170	-0.007	16.196	0.026	0.019
MILL				-20.869		
PLAI	-11.133	-11.142	-0.009	-11.124	0.020	0.011

RIVE	-18.667	-18.673	-0.006	-18.678	-0.005	-0.011
RUSS	-1.918	-1.899	0.019	-1.916	-0.017	0.002
RWF1				-16.414		
SM15	-23.150	-23.128	0.022	-23.161	-0.033	-0.011
SURV				-18.080		
SUTB	617.087	617.078	-0.009	617.070	-0.008	-0.017
SYCA	-22.449	-22.426	0.023	-22.435	-0.009	0.014
T462		-21.893		-21.889	0.004	
T849	5.687	5.702	0.015	5.684	-0.018	-0.003
TYND	-20.949	-20.936	0.013	-20.965	-0.029	-0.016
UCD1	0.197	0.190	-0.007	0.171	-0.019	-0.026
VINC	17.812	17.828	0.016	17.800	-0.028	-0.012
WILS		-21.685		-21.700	-0.015	
WOOD	8.873	8.892	0.019	8.841	-0.051	-0.032
X200	-0.315	-0.309	0.006	-0.310	-0.001	0.005
YCAP		-1.558		-1.566	-0.008	
Z585	-24.492	-24.521	-0.029	-24.520	0.001	-0.028
ZAMX	-17.289	-17.357	-0.068	-17.411	-0.054	-0.122

Notes:

1. All height values are expressed in meters.

2. The 1999 height value shown for station VINCOR was calculated from the 1999 height value for station PHILLIPS (not shown). PHILLIPS was rendered unsuitable for GPS observations prior to the 2002 monitoring event. VINCOR was installed nearby, and a leveling tie made to transfer the 1999 elevation from PHILLIPS to VINCOR.

APPENDIX B.

FSM Provisional NAVD88 Orthometric Height Values from 1999, 2002 and 2005 Surveys (with differences)

4-CH ID	1999	2002	Change	2005	Change	Change
			02-99		05-02	05-99
0308	23.78	23.73	-0.05	23.67	-0.06	-0.11
03BG	9.91	9.91	0.00	9.91	0.00	0.00
03DG	24.13	24.09	-0.04	24.05	-0.04	-0.08
03EH	10.75	10.73	-0.02	10.74	0.01	-0.01
1031	10.26	10.26	0.00	10.23	-0.03	-0.03
1069	54.73	54.71	-0.02	54.68	-0.03	-0.05
1075	14.90	14.87	-0.03	14.85	-0.02	-0.05
1200	77.38	77.38	0.00	77.38	0.00	0.00
1699	52.52	52.50	-0.02	52.46	-0.04	-0.06
2068				12.42		
ABUT	53.03	53.01	-0.02	52.97	-0.04	-0.06
ALHA	12.99	12.97	-0.02	12.95	-0.02	-0.04
ANDR	3.68	3.68	0.00	3.70	0.02	-0.02
B849	39.68	39.68	0.00	39.69	0.01	-0.01
BIRD	94.13	94.11	-0.02	94.08	-0.03	-0.05
BRID	64.21	64.20	-0.01	64.15	-0.05	-0.06
CALD	5.42	5.42	0.00	5.43	0.01	0.01
CANA	29.80	29.79	-0.01	29.77	-0.02	-0.03
CAST	5.27	5.27	0.00	5.28	0.01	-0.01
CHUR	24.13	24.12	-0.01	24.09	-0.03	-0.04
CODY	12.80	12.75	-0.05	12.68	-0.07	-0.12
CONA	7.72	7.71	-0.01	7.68	-0.03	-0.04
COTT	91.51	91.52	0.01	91.49	-0.03	-0.02
COUR	8.06	8.06	0.00	8.06	0.00	0.00
COY1	8.56	8.55	-0.01	8.52	-0.03	-0.04
CVAP	8.05	8.01	-0.04	7.96	-0.05	-0.09
DAVE	19.44	19.39	-0.05	19.39	0.00	-0.05
DRAI	12.99	12.97	-0.02	12.93	-0.04	-0.06
DUFO	20.31	20.25	-0.06	20.18	-0.07	-0.13
EX11	7.88	7.86	-0.02	7.85	-0.01	-0.03
F859	14.23	14.21	-0.02	14.16	-0.05	-0.07
FERR	12.12	12.13	0.01	12.10	-0.03	-0.02
FORD	17.55	17.53	-0.02	17.49	-0.04	-0.06
FREM	12.54	12.56	0.02	12.54	-0.02	0.00
GAFF	0.99	1.00	0.01	1.02	0.02	0.03
GW17	84.85	84.79	-0.06	84.77	-0.02	-0.08
GW32	112.58	112.58	0.00	112.50	-0.08	-0.08
HERS	13.99	13.97	-0.02	13.94	-0.03	-0.05
JIME	12.30	12.30	0.00	12.25	-0.05	-0.05
KEAT	35.84	35.83	-0.01	35.78	-0.05	-0.06
LIBR	19.93	19.90	-0.03	19.86	-0.04	-0.07
MADI	47.03	47.00	-0.03	46.98	-0.02	-0.05
MILL				10.88		
PLAI	19.99	19.96	-0.03	19.96	0.00	-0.03

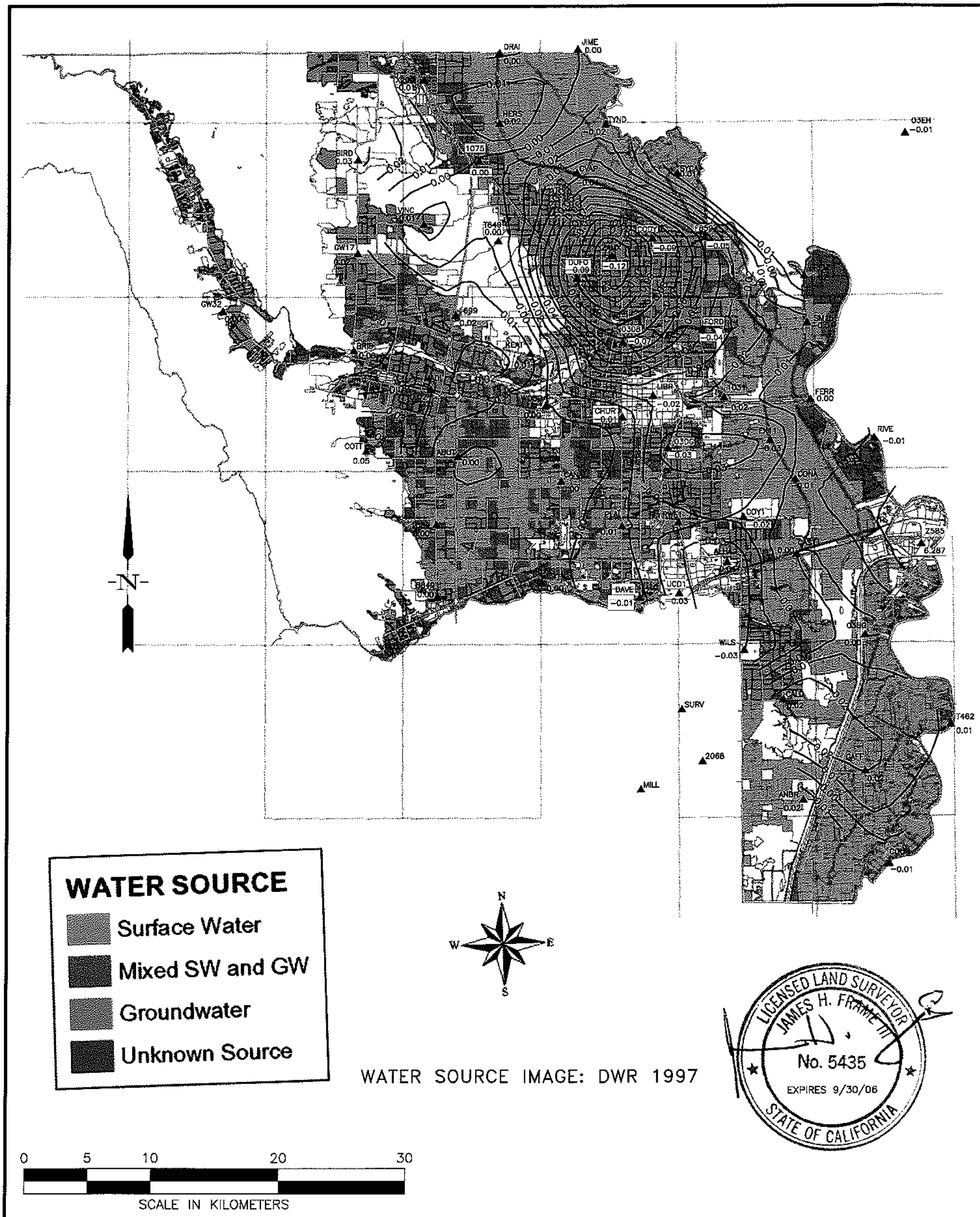
RIVE	12.03	12.02	-0.01	12.01	-0.01	-0.02
RUSS	29.38	29.37	-0.01	29.36	-0.01	-0.02
RWF1				14.60		
SM15	7.30	7.33	0.03	7.27	-0.06	-0.03
SURV				13.45		
SYCA	7.67	7.66	-0.01	7.65	-0.01	-0.02
T462	9.14	9.14	0.00	9.15	0.01	0.01
T849	36.20	36.17	-0.03	36.12	-0.05	-0.08
TYND	9.10	9.08	-0.02	9.04	-0.04	-0.06
UCD1	31.50	31.44	-0.06	31.42	-0.02	-0.08
VINC	48.32	48.28	-0.04	48.24	-0.04	-0.08
WILS	9.61	9.60	-0.01	9.59	-0.01	-0.02
WOOD	39.75	39.74	-0.01	39.70	-0.04	-0.05
X200	29.91	29.88	-0.03	29.85	-0.03	-0.06
YCAP		29.61		29.61	0.00	
Z585	6.35	6.30	-0.05	6.29	-0.01	-0.06
ZAMX	13.10	13.03	-0.07	12.95	-0.08	-0.15

Notes:

1. All height values are expressed in meters.

2. The 1999 height value shown for station VINCOR was calculated from the 1999 height value for station PHILLIPS (not shown). PHILLIPS was rendered unsuitable for GPS observations prior to the 2002 monitoring event. VINCOR was installed nearby, and a leveling tie made to transfer the 1999 elevation from PHILLIPS to VINCOR.

3. The orthometric values shown for 2005 may change following reconciliation between NGS and CSRC methodology.



FRAME SURVEYING & MAPPING
609 A Street
Davis, CA 95616
(530) 756-8584 (TEL)
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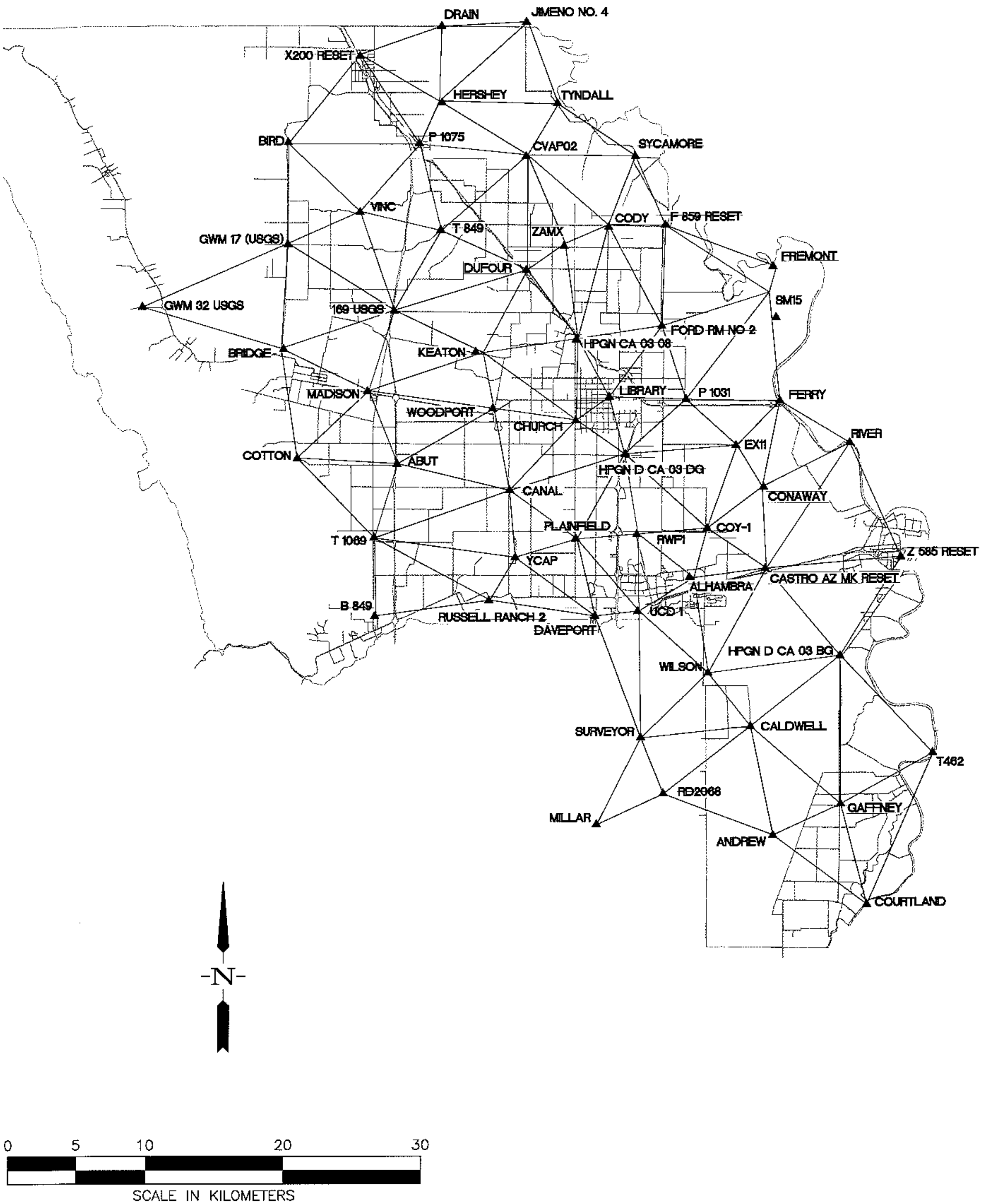
1280-039D

APPENDIX C

CUMULATIVE SUBSIDENCE, 1999 - 2005
SOURCE: CSRC ELLIPSOID HEIGHT DATA
FEBRUARY, 2006 SCALE: 1"= 10KM



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APPENDIX D

YOLO SUBSIDENCE NETWORK
LOCAL NETWORK DIAGRAM

FEBRUARY, 2006 SCALE: 1"= 10KM

APPENDIX E.

NAD83/NAVD88 Station Coordinates

From the provisional NAD83/NAVD88 orthometric height adjustment performed by Frame Surveying & Mapping, epoch 2005.53.

Name	Latitude	Longitude	Elevation
0308	38°43'01.99912"N	121°48'07.54199"W	23.67m
1031	38°40'38.14545"N	121°42'34.07851"W	10.23m
1069	38°35'09.99988"N	121°58'17.45682"W	54.68m
1075	38°50'51.29614"N	121°56'00.25863"W	14.85m
1200	38°47'09.87441"N	121°14'32.09663"W	77.38m
1699	38°44'12.69655"N	121°57'15.85761"W	52.46m
2068	38°24'54.17942"N	121°43'48.53696"W	12.43m
03BG	38°30'20.00966"N	121°34'55.09259"W	9.91m
03DG	38°38'27.43783"N	121°45'39.59676"W	24.05m
03EH	38°51'59.61326"N	121°32'32.95872"W	10.74m
ABUT	38°38'05.70691"N	121°57'06.70369"W	52.97m
ALHA	38°33'31.09844"N	121°42'26.68932"W	12.95m
ANDR	38°23'12.17822"N	121°38'18.72121"W	3.70m
B849	38°32'01.29164"N	121°58'15.18465"W	39.69m
BIRD	38°50'54.73577"N	122°02'37.47813"W	94.08m
BRID	38°42'41.39602"N	122°02'50.18451"W	64.15m
CALD	38°27'33.51381"N	121°39'24.21525"W	5.44m
CANA	38°37'02.05496"N	121°51'30.11681"W	29.77m
CAST	38°33'50.77672"N	121°38'37.80451"W	5.28m
CHUR	38°39'48.00606"N	121°48'09.05896"W	24.09m
CNDR	37°53'47.04470"N	121°16'42.53232"W	11.68m
CODY	38°47'30.59822"N	121°46'29.02105"W	12.68m
CONA	38°37'05.49521"N	121°38'40.42972"W	7.68m
COTT	38°38'20.24510"N	122°02'08.12319"W	91.49m
COUR	38°20'24.76030"N	121°33'40.05187"W	8.06m
COY1	38°35'28.05177"N	121°41'31.83561"W	8.52m
CVAP	38°50'19.76454"N	121°50'39.17729"W	7.96m
DAVE	38°31'59.46481"N	121°47'14.17767"W	19.39m
DRAI	38°55'31.04609"N	121°54'52.46304"W	12.93m
DUFO	38°45'48.09680"N	121°50'39.06873"W	20.18m
EX11	38°38'46.40956"N	121°40'03.02645"W	7.85m
F859	38°47'34.20154"N	121°43'36.01819"W	14.16m
FERR	38°40'32.00765"N	121°37'49.18140"W	12.10m
FORD	38°43'33.23620"N	121°43'47.39279"W	17.49m
FREM	38°45'52.89431"N	121°38'08.00645"W	12.54m
GAFF	38°24'25.68547"N	121°34'56.13691"W	1.02m
GW17	38°46'52.25893"N	122°02'38.10825"W	84.78m
GW32	38°44'21.97173"N	122°09'59.02874"W	112.50m
HERS	38°52'28.84831"N	121°54'51.96597"W	13.94m
JIME	38°55'39.86256"N	121°50'35.87572"W	12.25m
KEAT	38°42'33.52335"N	121°53'11.08379"W	35.78m
LIBR	38°40'44.18520"N	121°46'28.10144"W	19.86m
MADI	38°41'00.22860"N	121°58'36.36143"W	46.98m
MILL	38°23'41.28013"N	121°47'10.32967"W	10.88m
P268	38°28'24.67974"N	121°38'47.02602"W	7.94m

P271	38°39'26.44695"N	121°42'52.32465"W	13.10m
PLAI	38°35'05.49797"N	121°48'11.62253"W	19.96m
RIVE	38°38'50.46155"N	121°34'20.06352"W	12.01m
RUSS	38°32'38.06565"N	121°52'33.83899"W	29.37m
RWF1	38°35'09.99921"N	121°45'05.10194"W	14.60m
SM15	38°43'51.60440"N	121°37'59.39294"W	7.27m
SURV	38°27'08.54500"N	121°44'56.17353"W	13.45m
SUTB	39°12'20.99549"N	121°49'14.10261"W	646.08m
SYCA	38°50'19.12405"N	121°45'06.39012"W	7.65m
T462	38°26'25.99278"N	121°30'17.76296"W	9.15m
T849	38°47'24.93361"N	121°54'56.34535"W	36.12m
TYND	38°52'26.17801"N	121°49'03.81267"W	9.04m
UCD1	38°32'10.44819"N	121°45'04.37875"W	31.42m
VINC	38°48'08.11990"N	121°59'00.32287"W	48.24m
WILS	38°29'41.85159"N	121°41'31.51549"W	9.59m
WOOD	38°40'17.76208"N	121°52'20.38185"W	39.70m
X200	38°54'20.73206"N	121°58'59.79260"W	29.85m
YCAP	38°34'20.34492"N	121°51'18.37410"W	29.61m
Z585	38°34'15.79736"N	121°31'49.55629"W	6.29m
ZAMX	38°46'45.78557"N	121°48'44.63079"W	12.95m

APPENDIX F.

Subsidence Projections

Quantitative monitoring of subsidence in Yolo County has been conducted over a relatively short time span, and presently comprises only 3 monitoring events (1999, 2002 and 2005). The monitoring measurement technology and its associated analytical tools continue to evolve, which may necessitate a comprehensive review of prior analyses. Nevertheless, it may be useful to consider the potential long-term effects of land subsidence by projecting the rates of subsidence observed to date.

In the examples below, a range of cumulative subsidence has been projected to the year 2030 at selected stations in Davis (ALHAMBRA), Woodland (LIBRARY) and the area of most rapid subsidence (ZAMX). The ranges are bounded by the more conservative ellipsoid height results returned by CSRC following a readjustment of the 1999 through 2005 data sets, and on the higher end by values derived from the published 1999 and 2002 NGS orthometric heights and the provisional 2005 orthometric heights produced by Frame Surveying & Mapping.

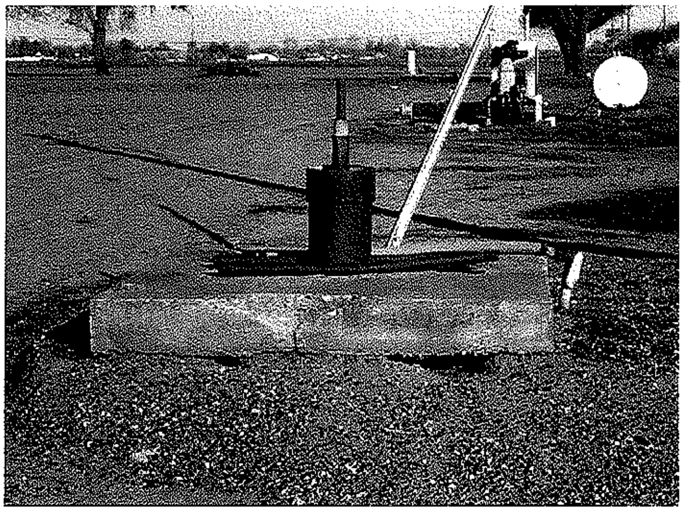
As more data are gathered in future years and the analytical tools refined, these rates will likely change. Caution is advised in applying these projected results to subsidence mitigation planning efforts.

Site	Cumulative Subsidence 1999 to 2030 Low Projection	Cumulative Subsidence 1999 to 2030 High Projection
ALHAMBRA	-0.20	-0.21
LIBRARY	-0.12	-0.36
ZAMX	-0.63	-0.78

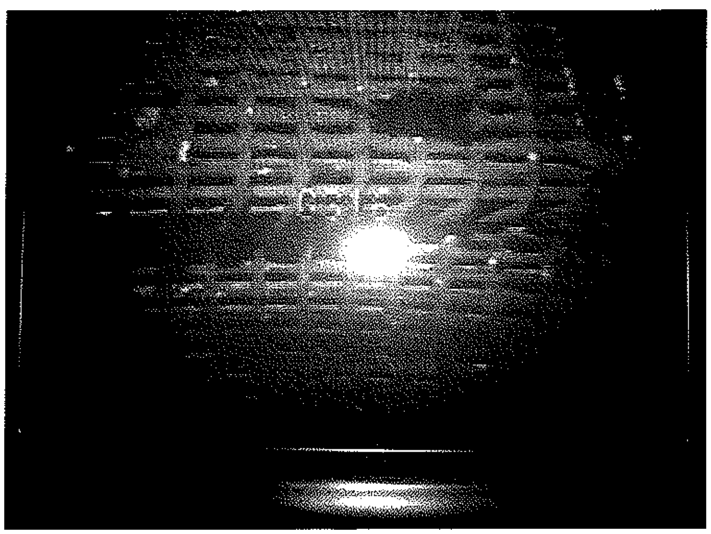
Subsidence values are in meters.

APPENDIX G.

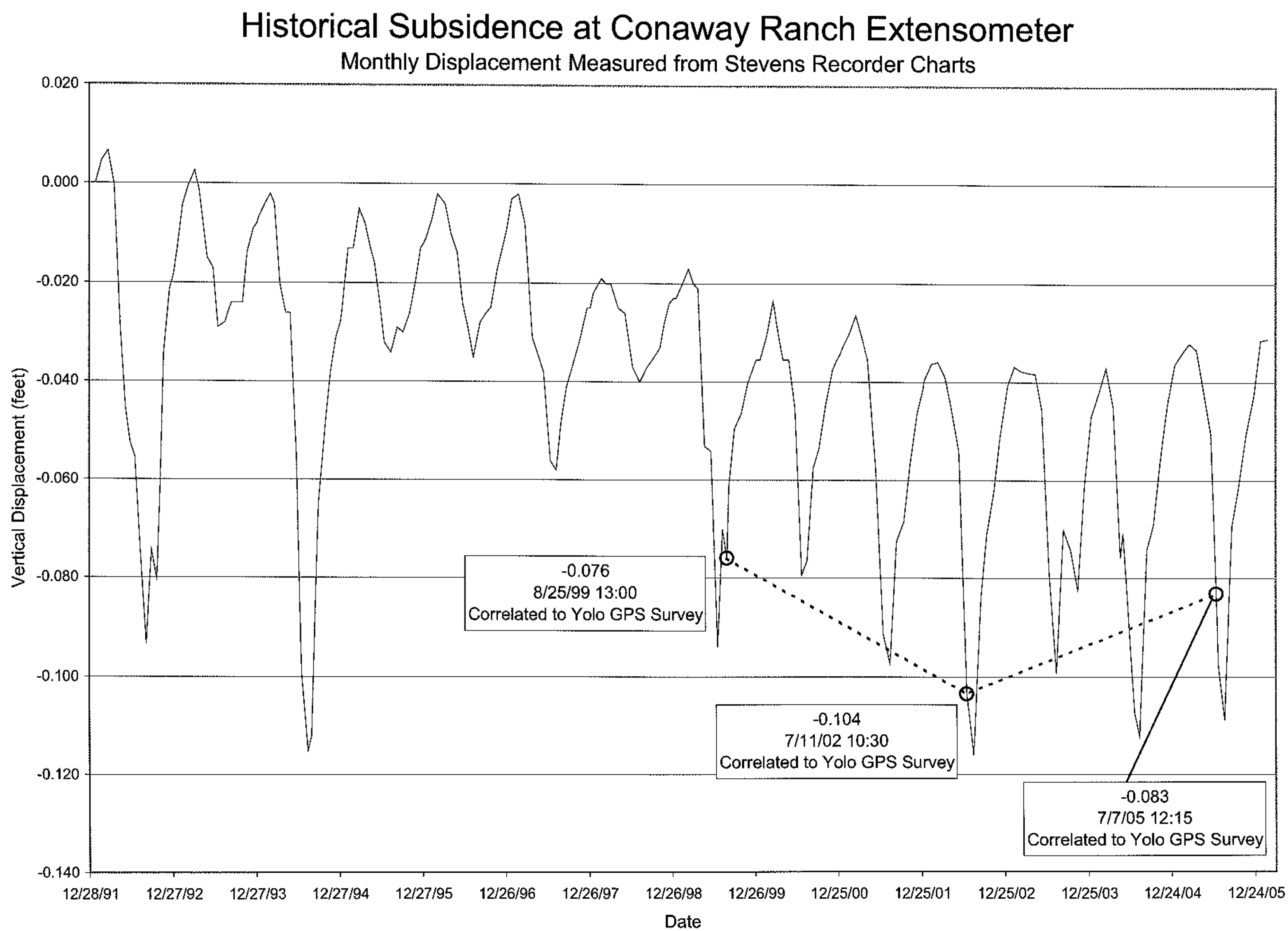
Subsidence Impact Evidence



Well pad near Zamora. The pad appears to be fixed to the well casing, while the adjacent ground surface appears to have subsided.

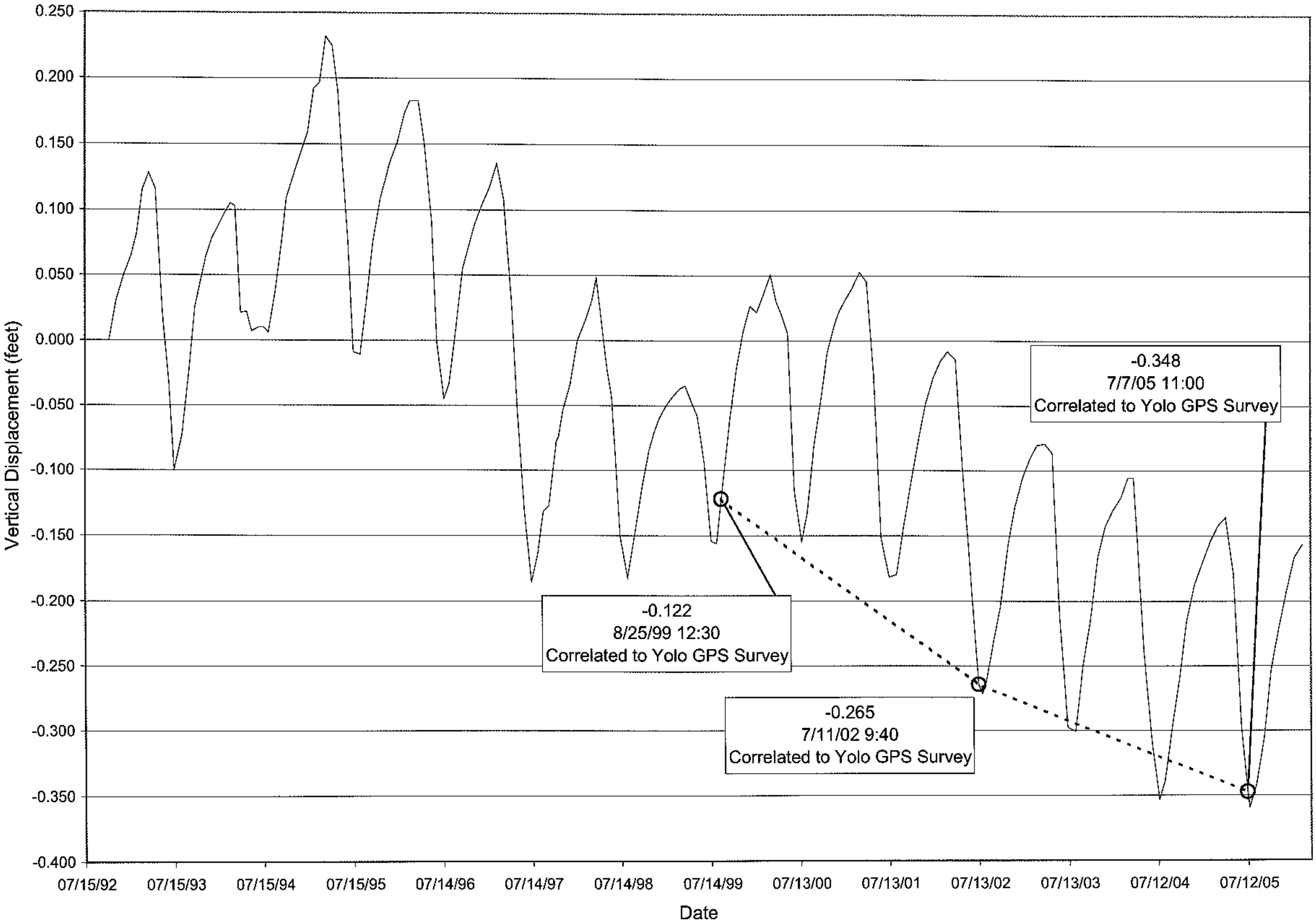


Crushed well screen, Well 22, City of Davis. This is a photo of a monitor displaying a well inspection video. The well screen at 316 feet below the surface appears to have deflected inward in response to downward pressure on the casing above. This might occur when the friction of a subsiding land mass upon a well casing exceeds the compressive strength of the well screen.


Historical Subsidence at Conaway Ranch Extensometer
Monthly Displacement Measured from Stevens Recorder Charts
Vertical Displacement (feet)
0.020
0.000
-0.020
-0.040
-0.060
-0.080
-0.100
-0.120
-0.140
-0.076
8/25/99 13:00
Correlated to Yolo GPS Survey
-0.104
7/11/02 10:30
Correlated to Yolo GPS Survey
-0.083
7/7/05 12:15
Correlated to Yolo GPS Survey
12/28/91
12/27/92
12/27/93
12/27/94
12/27/95
12/26/96
12/26/97
12/26/98
12/26/99
12/25/00
12/25/01
12/25/02
12/25/03
12/24/04
12/24/05
Date

Historical Subsidence at Zamora Extensometer

Monthly Displacement Measured from Stevens Recorder Charts



Yolo Subsidence Network **GPS/Extensometer Comparisons** **March, 2005**

SITE	SOURCE	YEAR 1999	YEAR 2002	YEAR 2005	NET CHANGE (2005 - 1999)	GPS - EXTENSOMETER (DISCREPANCY)
CONAWAY	GPS	-22.835	-22.865	-22.863	-0.028	
	EXTENSOMETER	-0.023	-0.032	-0.025	-0.002	-0.026
ZAMORA	GPS	-17.289	-17.357	-17.411	-0.122	
	EXTENSOMETER	-0.037	-0.081	-0.106	-0.069	-0.053

GPS SOURCE: 2005 CSRC ELLIPSOID HEIGHTS
EXTENSOMETER SOURCE: DWR
VALUES SHOWN ARE IN METERS

APPENDIX C

Quality Assurance for Groundwater Measurements and Sampling

Appendix C
Quality Assurance for Groundwater Measurements and Sampling

Standard Operating Procedures

The City of Davis (City) and UC Davis are each developing their own detailed Standard Operating Procedures (SOPs) for monitoring. The SOPs are being developed according to these common guidelines so that each agency has a consistent approach.

Staff Qualifications

Staff selected for groundwater level monitoring and sampling should be trained in the procedures given in this appendix and in any detailed SOPs that are to be followed.

Groundwater Level Measurements

Groundwater level measurements should be taken as close to the beginning of each month as possible to allow comparison between City and UC Davis measurements. Pumping water levels should be measured for wells that have been pumping for at least 24 hours. Static water level measurements should be measured after wells have been shut off for at least 2 hours. For static water level measurements, the date and time of both well shutoff and water level measurement should be recorded for each well.

Water level measurement results that are questionable because of field conditions, equipment behavior, inadequate non-pumping duration, or other issues observed by the measurement personnel should be marked as such for entry into the joint groundwater management database. Water level measurement results should also be compared with previous trends to note results that appear out of reasonable bounds. Apparent out of bounds results should trigger recalibration of the measurement equipment and additional measurements.

Groundwater Quality Sampling

Applying a common, consistent purging procedure is especially important for obtaining representative data that can be compared. Short purging durations will result in samples that are more affected by seepage down the well gravel pack, which often are not representative of water quality conditions in the general aquifer.

For the monitoring purposes envisioned, the pumps in the wells are adequate for purging the well and pumping the water for sampling. Purging should include pumping 5 well volumes and then checking for stabilization of indicator parameters (EC, pH, temperature, ORP) measured with a field meter as discussed in Appendix C.

Sampling equipment and field meters should be standardized to get comparable data. Field meters should also be routinely calibrated according to manufacturer's specifications.

Depth to water should be measured prior to initiation of all purging and sampling activities.

Field QA/QC Samples

Additional samples should be collected for the specific purpose of documenting the Quality Assurance/Quality Control (QA/QC) of the field sampling procedures. Field QA/QC samples provide technically and legally defensible data regarding the reproducibility and overall quality of the groundwater sample. These additional QA/QC samples will normally be specified by the analytical lab. Further discussion of QA/QC samples is contained in Appendix C.

Sample Containers and Shipping

The appropriate sample containers and associated preservatives must be obtained from the lab or be lab-approved. Containers and tubing that won't react with the constituents of interest must be used. Delivery of samples should utilize chain of custody forms and should follow all QA/QC recommendations from the analytical laboratory.

Field Records

Accurate field records must be maintained to document groundwater sampling activities. These records include technical field data, sample identification labels, and chain-of-custody information for each sample. These records are described in detail in Appendix C. Field data sheets should be initiated prior to the start of sampling. An example purging and sampling form is also contained in Appendix C.

Sample Analysis Procedures

Sample Analysis procedures should be in accordance with Title 22 requirements and methods. Identical methods should be used for analyzing groundwater samples from both Davis and UC Davis. Joint procurement of analytical services from a common lab for both agencies would be ideal from a data consistency viewpoint.

Quality Assurance/Quality Control

Quality assurance and quality control protocols should be coordinated with the analytical lab. The steps in developing QA/QC protocols are as follows:

- Define quality control parameters;
- Target analyte list;
- List maximum reporting limits and proper limits;
- Determine spike recovery limits (based on laboratories' abilities and project data quality objectives);
- Determine duplicate frequency and maximum relative percent difference; and
- Specify adequate numbers of blanks.

After receipt of analytical results from the lab, the following items should be checked to insure that the data quality is reasonable:

- Check for completeness and accuracy of data transfer;

- Review laboratory case narrative and data qualifiers;
- Check holding times;
- Check reporting limits;
- Check blanks for contamination;
- Check spike recoveries; and
- Check precision of duplicate samples.

After checking the quality of the data, the data usability should be summarized, including the following measures:

- Percent complete;
- Rejected data;
- Qualified data; and
- Statement of data usability.

Data that have been qualified as estimated or rejected during the data review process should be marked as such prior to storage and use as part of the database.

Data Compilation and Storage

Data should be compiled and stored in the joint groundwater management database. New data should be exported annually to YCFCWCD for incorporation into the countywide database.

APPENDIX D

Recommended Purging and Sampling Procedures

Appendix D

Recommended Purging and Sampling Procedures

The primary objective of a standard operating procedure (SOP) is to establish a uniform method for the collection of representative groundwater samples from monitoring wells, and to reduce the potential variability associated with purging and sampling.

Equipment that will be in contact with the sample must be decontaminated prior to each use. This is necessary to minimize inadvertent contamination of the sample. Specific methods for equipment cleaning are dependent upon a number of factors including the sample media, analytical parameters, the purpose of the investigation, the equipment to be cleaned, and the specific regulatory guidelines that may apply.

Some of the factors that should be considered in the selection of purging and sampling devices include:

- Well yield;
- Depth to water;
- Well diameter and depth;
- Required material of construction;
- Analytical parameters;
- Regulatory requirements; and
- Cost.

Purging Strategies

The strategy that will be employed for well purging should be determined prior to sampling and presented in project-specific planning documents. Several different strategies are commonly used in order to assess the completeness of well purging. The most common purging strategies are listed below.

- Purging is continued until stabilization of certain indicator parameters is observed in successive measurements over a specified time or volume. The most commonly used indicator parameters include pH, specific conductivity, turbidity, temperature, oxidation/reduction potential (ORP), and dissolved oxygen (DO).
- Purging 3 to 5 well volumes of water from the well.

Sample Containers and Preservatives

The appropriate sample containers and associated preservatives must be obtained to prevent absorption or reactions with the constituents sampled. The containers and preservatives are normally, but not always, supplied by the laboratory that will be responsible for the analyses. Sample containers should be organized and inventoried several days prior to initiation of the sampling program in order to provide sufficient time to rectify any problems, should they occur. Whenever possible, pre-printed sample labels should be created prior to mobilization, if possible.

Initiation of Field Data Records

Field data sheets should be initiated prior to the start of sampling. Examples of initial data to be recorded include site and sampling location identification, well depth and construction, and purging and sampling collection methods. Field data sheets can be combined in a bound field notebook as well. Field data sheet forms are usually part of detailed agency or lab SOP's.

Water Level Measurements

The depth to water should be measured prior to initiation of all purging and sampling activities.

Calculation of Well Purge Volume

The volume of water standing in the well should be calculated through the application of the depth to water data, the known well depth, and the well diameter using the constants presented below. Well depth information obtained from the well completion records are generally sufficiently precise for the purpose of well volume calculations that would be used for subsequent purging determinations.

Alternatively, the well casing volume may be calculated using the formula:

$V = CF*d^2h$, where

V = volume of water (gallons)
d = diameter of well (inches)
h = height of water column (feet)
CF = conversion factor (0.0408) that includes conversion of cubic feet to gallons, inches to feet, and diameter to radius.

Add extra for the borehole volume calculated by the formula:

$V = 0.0408\ d^2h + 0.0408\ (D^2-d^2)\ h*\text{Theta}$ including borehole, where

D = diameter of borehole (inches)
Theta = porosity of gravel pack, usually approximately 0.4

An adequate purge is normally achieved when three to five times the volume of standing water in the well has been removed. After three well volumes have been removed, if the chemical parameters have not stabilized according to the criteria given below, additional well volumes may be removed. If the parameters have not stabilized within five volumes, it is at the discretion of the project manager whether or not to collect a sample or to continue purging.

Considering groundwater chemistry, an adequate purge is achieved when the pH, specific conductance, and temperature of the groundwater have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). Stabilization occurs when parameter measurements are within 10 percent between two readings spaced approximately one well volume apart.

Field QA/QC Samples

Additional samples should be collected for the specific purpose of documenting the Quality Assurance/Quality Control (QA/QC) of the field sampling procedures. Descriptions of the type and frequency of QA/QC sampling should be specified in the project-specific planning documents. Field QA/QC samples include field blanks, equipment blanks, trip blanks, and blind duplicates. These samples are collected in addition to the laboratory QA/QC samples which may include method blanks, matrix spikes and matrix spike duplicate samples.

Field Records

Accurate field records must be maintained to document groundwater sampling activities. These records include technical field data, sample identification labels, and chain-of-custody information for each sample.

Specifically for groundwater sampling, the field sampling records should include, at a minimum, the following information:

- Sampling location;
- Date and time;
- Condition of the well;
- Static water level (depth to water);
- Depth to the bottom of the well;
- Calculated well volume;
- Purging method;
- Actual purged volume;
- Sample collection method;
- Sample description;
- Field meter calibration data;
- Water quality measurements; and
- General comments (weather conditions, etc.).

All data entries should be made using black indelible ink and should be written legibly. Entry errors should be crossed out with a single line, dated, and initialed by the person making the correction.

Example Purging and Sampling Form

GROUNDWATER PURGE AND SAMPLING FIELD DATA SHEET

1. PROJECT INFORMATION

WELL ID: ______

Project Number:____________ Task Number:________ Date:__________________ Time:__________

Client:____________________________________ Personnel:____________________________________

Project Location:__________________________ Weather:______________________________________

2. WELL DATA

Casing Diameter:_________ inches | Type of Casing: ______________________

Screen Diameter:_________ inches (d) | Type of Screen:______________________ Screen Length : ____________

Total Depth of Well from TOC:____________ feet

Depth to Static Water from TOC:__________ feet

Depth to Product from TOC:______________ feet

Length of Water Column (h):____________ feet Calculated Casing Volume:__________ gal (3 to 5 times one well volume)

Purge Volume Calculation (one casing volume = $0.041d^2h$):

Note: 2-inch well = 0.167 gal/ft 4-inch well = 0.667 gal/ft

3. PURGE DATA

Purge Method: ______________________________

Materials: Pump/Bailer ______________________________

Materials: Rope/Tubing ______________________________

Equipment Model(s)

1. ____________________

2. ____________________

Was well purged dry? ☐ Yes ☐ No Pumping Rate: gal/min

Time	Cum. Gallons Removed	pH	Temp (Units)	Spec. Cond. (Units)	Eh (Units)	DO (Units)	Turbidity (NTU)	Other: ______	Comments

4. SAMPLING DATA

Analyses Requested:

Method(s): ______________________________

Materials: Pump/Bailer ______________________________

Materials: Tubing/Rope ______________________________

Depth to Water at Time of Sampling:__________ Field Filtered? ☐ Yes ☐ No

Sample ID:____________ Sample Time:___________ # of Containers:_______

Duplicate Sample Collected? ☐ Yes ☐ No ID:____________

5. COMMENTS

____

APPENDIX E

City of Davis and UC Davis Well Information

City of Davis Well Construction Information

Well No.	Location	Year Constructed	Ground Elevation (ft AMSL)	Depth (ft)	Seal Depth (ft)	Casing Diameter	Motor HP		Avg. Pumping Rates (Jul-Aug 2004) (gpm)	(mgd)
1	617 E Street	1982	46	510		16"	75	*	860	1.2
7	800 11th Street	1952	44	390		14"	100		989	1.4
11	1405 F Street	1961	44	344		14"	100		1319	1.9
12	921 Sycamore Lane	1961	48	330	170	14"	125		816	1.2
14	530 L Street	1970	45	352	190	16"	gas		1004	1.4
15	1812 Manzanita	1965	38	520		14",10"Lin	100	*	1119	1.6
19	2910 Catalina Drive	1973	44	615		16",12",8"	100	*	1343	1.9
20	2300 Evenstar Lane	1976	55	456		18",12"	125		1127	1.6
21	5050 Chiles Road	1977	33	448		16",12"	100		1165	1.7
22	1414 Tulip Lane	1977	42	510		16",12"	125	*	1017	1.5
23	527 B Street	1980	45	419		16"	150		1763	2.5
24	1600 Olive Drive	1982	44	480	186	18"	150		1808	2.6
25	1188 Arlington Blvd.	1987	53	466	150	18"	75		1145	1.6
26	2850 Cowell Blvd.	1987	38	492	210	18"	125	*	1432	2.1
27	3000 Sycamore Lane	1989	49	364	100	18"	125	*	990	1.4
28	2101 Glacier Drive	1991	51	1491	110	18"	75	*	760	1.1
29	3535 Alhambra Drive	1997	37	1502	210	18",14"	150		1231	1.8
30	1819 Lake Blvd.	2002	55	1780	800		300		2537	3.7
31	2074 John Jones Road	2003	50	1782	700		300		2540	3.7
LIC	Lewis Investing Corp.#4			1364					775	1.1
EM2	44285 S. El Macero Dr.	1969	27	427		14",12"	100		1007	1.5
EM3	800 Mace Boulevard	1991	33	471	220	18"	125	*	973	1.4
							Totals		**27,720**	**39.9**

* = submersible pump/motor

UC Davis Well Data

Well	Date Drilled	Method	Depth	Seal Depth	Perf Depth	Aquifer	UC Davis Classification
UDW-2	Apr - 1952	Cable Tool	1,368	none	1,180-1,258 1,274-1,350	Deep	Domestic
UDW-3	1952	Cable Tool	1,450	none	1,264-1,290 1,342-1,370 1,384-1,432	Deep	Domestic
UDW-4	1971	Rotary	1,430	80	1,120-1,400	Deep	Domestic
UDW-5	1969	Rotary	1,470	60	1,164-1,174 1,360-1,380 1,388-1,452	Deep	Domestic
UDW-6A	1987	Rotary	1,470	60	1,218-1,234 1,296-1,316 1,342-1,352 1,380-1,450	Deep	Domestic
UDW-7	Dec - 1978		600	50	262-273 348-354 425-432	Inter.	Domestic
UDW-7A	Sep - 1995	Rev. Rotary	857	595	740-780 822-842	Deep	Domestic
UUW-2	1945		352		247-290 306-338	Inter.	Utility
UUW-3	1929		321			Inter.	Utility
UUW-4	1938		326	none	99-123 152-162 183-191 228-323	Inter.	Utility
UUW-5	1968		470	50	180-450	Inter.	Utility
UUW-7	1951		414	none	134-174 234-274 344-354 374-414	Inter.	Utility
A1	1952		300		110-122 179-185 209-293	Inter.	Ag.
B6N	1964		635			Inter.	Ag.
B6S	1972		500			Inter.	Ag.
C2A	1932		248		202-248	Inter.	Ag.
C2B	1932		285		221-264	Inter.	Ag.
C2F	1932		250			Inter.	Ag.
C2H	1932		244			Inter.	Ag.
C3C	1932		270			Inter.	Ag.
D2	1946		538			Inter.	Ag.
D3	1936		382			Inter.	Ag.
D6A	1936		416			Inter.	Ag.
D10	1939		529			Inter.	Ag.

UC Davis Well Data

Well	Date Drilled	Method	Depth	Seal Depth	Perf Depth	Aquifer	UC Davis Classification
E2A	1948		250			Inter.	Ag.
E3B	1952		240		116-136 204-244	Inter.	Ag.
E3D	1972		455		185-225 250-270 366-371 418-443	Inter.	Ag.
E4A	1956		340		unk	Inter.	Ag.
E5	1956		344		unk	Inter.	Ag.
E8	1972		517			Inter.	Ag.
G6	1962		400			Inter.	Ag.

APPENDIX F

Regional Database Schema

Properties

DateCreated:	9/29/2005 3:32:13 PM	DefaultView:	Datasheet
GUID:	{guid {BC454BD7-EF9E-4F02-AF35-83A306485D0E}}	LastUpdated:	1/4/2006 5:00:55 PM
NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	15605
Updatable:	True		

Columns

Name	Type	Size
AEID	Long Integer	4
Field_Point_Name	Text	32
Depth_Zone	Text	4
Sample_ID	Text	24
Sample_Date	Date/Time	8
Sample_Delivery_Group	Text	10
Lab	Text	32
Sub_Lab	Text	32
Chain_Custody_ID	Text	16
Lab_Sample_ID	Text	24
Analytical_Method	Text	24
Prep_Method	Text	24
Prep_Batch	Text	12
Analysis_Date	Date/Time	8
Parameter	Text	16
Result	Double	8
Par_Value_Qualifier	Text	8
MDL	Double	8
PQL	Double	8
Units	Text	16
Dilution	Double	8
Surrogate	Yes/No	1
Preservation	Text	20
Lab_Qualifier_Note	Text	24
Source	Text	32
Remarks	Text	80
QA_Status	Yes/No	1

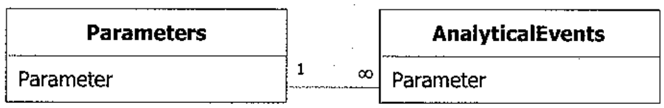
Relationships

LocationAnalyticalEvents

Location		AnalyticalEvents
Field_Point_Name	1 — ∞	Field_Point_Name

Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

ParametersAnalyticalEvents



Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

Properties

DateCreated:	1/10/2002 6:21:07 PM	DefaultView:	Datasheet
GUID:	{guid {846F1736-5FA4-4DEB-AC0D-8E2C81891F2E}}	LastUpdated:	11/4/2005 12:19:38 PM
NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	38
Updatable:	True		

Columns

Name	Type	Size
CONSID	Long Integer	4
Field_Point_Name	Text	32
Constr_Date	Date/Time	8
Driller	Text	32
Drilling_Method	Text	16
Log_Exists	Yes/No	1
Lognum	Text	32
Logimg	Text	50
Use	Text	32
Casing_Dia	Single	4
HP	Long Integer	4
Well_Depth	Long Integer	4
Hole_Depth	Long Integer	4
Seal_Depth	Double	8
Source	Text	50

Relationships

LocationConstruction

Location			Construction
Field_Point_Name	1	1	Field_Point_Name

Attributes:	Unique, Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-One

Properties

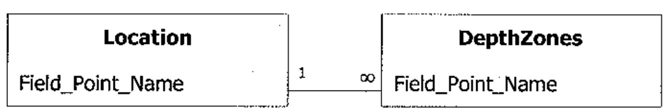
DateCreated:	11/4/2005 12:13:02 PM	GUID:	{guid {B32925FB-4395-4788-85C4-F7A88C7A4DEE}}
LastUpdated:	11/4/2005 12:24:19 PM	NameMap:	Long binary data
OrderByOn:	False	Orientation:	Left-to-Right
RecordCount:	140	Updatable:	True

Columns

Name	Type	Size
DZID	Long Integer	4
Field_Point_Name	Text	32
Depth_Zone	Text	4
Top_Of_Zone	Long Integer	4
Bottom_of_Zone	Long Integer	4
Screen_Type	Text	24
Screen_Dia	Double	8
Screen_Material	Text	24
Remarks	Text	80
Hydro_Zone	Text	32

Relationships

LocationDepthZones



Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

Properties

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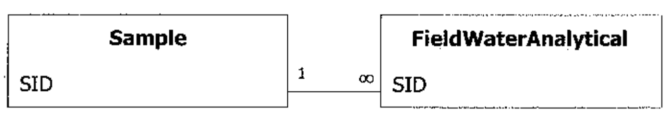
LastUpdated:	9/23/2005 2:27:01 PM	NameMap:	Long binary data
OrderByOn:	False	Orientation:	Left-to-Right
RecordCount:	0	Updatable:	True

Columns

Name	Type	Size
FWAID	Long Integer	4
SID	Long Integer	4
Sample_Date	Date/Time	8
Temperature	Single	4
pH	Single	4
DO	Text	50
ORP	Single	4
EC	Single	4
Personnel	Text	50
Source	Text	50

Relationships

SampleFieldWaterAnalytical



Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

Properties

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NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	38
Updatable:	True		

Columns

Name	Type	Size
LOCID	Long Integer	4
Field_Point_Name	Text	32
State_Well_Num	Text	24
YCFCWCD_Name	Text	50
Description	Text	80
Owner	Text	50
Lat	Double	8
Lon	Double	8
Coord_Datum	Text	12
X	Double	8
Y	Double	8
Tship_Range	Text	16
Location_Source	Text	24
GS_Elev	Double	8
Ref_Elev	Double	8

Relationships

LocationAnalyticalEvents

Location			**AnalyticalEvents**
Field_Point_Name	1	∞	Field_Point_Name

Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

LocationConstruction

Location			**Construction**
Field_Point_Name	1	1	Field_Point_Name

Attributes:	Unique, Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-One

LocationDepthZones

Location		DepthZones
Field_Point_Name	1 — ∞	Field_Point_Name

Attributes: Enforced, Cascade Updates, Cascade Deletes
RelationshipType: One-To-Many

LocationMonthlyProduction

Location		MonthlyProduction
Field_Point_Name	1 — ∞	Field_Point_Name

Attributes: Enforced, Cascade Updates, Cascade Deletes
RelationshipType: One-To-Many

LocationSample

Location		Sample
Field_Point_Name	1 — ∞	Field_Point_Name

Attributes: Enforced, Cascade Updates, Cascade Deletes
RelationshipType: One-To-Many

LocationWaterLevel

Location		WaterLevel
Field_Point_Name	1 — ∞	Field_Point_Name

Attributes: Enforced, Cascade Updates, Cascade Deletes
RelationshipType: One-To-Many

Properties

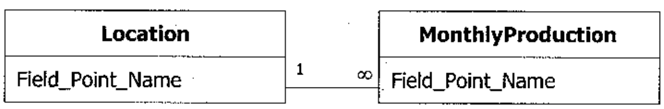
DateCreated:	11/21/2005 9:52:56 AM	LastUpdated:	12/2/2005 3:13:43 PM
NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	3960
Updatable:	True		

Columns

Name	Type	Size
PRODID	Long Integer	4
Field_Point_Name	Text	32
Month	Date/Time	8
Production	Double	8
Source	Text	50
Remarks	Text	80
QA_Status	Yes/No	1

Relationships

LocationMonthlyProduction



Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

Properties

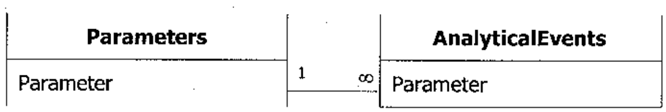
DateCreated:	11/4/2005 4:48:41 PM	DefaultView:	Datasheet
GUID:	{guid {D5850412-1FB2-4CAA-B811-2CA5B3EAC5F7}}	LastUpdated:	1/4/2006 4:16:59 PM
NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	64
Updatable:	True		

Columns

Name	Type	Size
ParID	Long Integer	4
Parameter	Text	50
Display_Name	Text	50
Next_Selected	Text	50
Units	Text	32
Analyte_Class	Text	50
Default_Method	Text	50
Default_DL	Double	8
MCL	Single	4
Description	Text	160

Relationships

ParametersAnalyticalEvents



Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

Properties

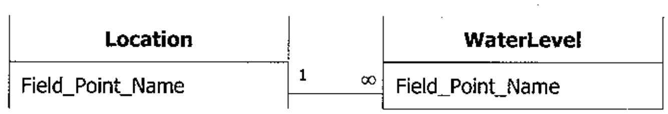
DateCreated:	2/28/2002 10:36:57 PM	DefaultView:	Datasheet
GUID:	{guid {1909671C-D960-422B-94AC-80E9EBA6CEB5}}	LastUpdated:	12/2/2005 3:59:00 PM
NameMap:	Long binary data	OrderByOn:	False
Orientation:	Left-to-Right	RecordCount:	4168
Updatable:	True		

Columns

Name	Type	Size
WLEVID	Long Integer	4
Field_Point_Name	Text	32
Sample_Date	Date/Time	8
Ref_Elev	Double	8
Depth_To_Water	Double	8
Q_CODE	Text	16
NO_CODE	Text	16
Source	Text	50
Remarks	Text	80
QA_Status	Yes/No	1

Relationships

LocationWaterLevel



Attributes:	Enforced, Cascade Updates, Cascade Deletes
RelationshipType:	One-To-Many

Major Data Table Relationships