10540 White Rock Road, Suite 180
Sacramento, California 95670

Tel: (916) 444-0123
Fax: (916) 635-8805

www.brownandcaldwell.com

July 13, 2006

BROWN AND CALDWELL

Mr. Dave Todd
Department of Water Resources
Office of Water Use Efficiency
Post Office Box 942836
Sacramento, CA 94236-0001

017-128906-001/3

Subject: Submittal of City of Merced Final 2005 Urban Water Management Plan

Dear Mr. Todd:

I am pleased to submit to you the final 2005 Urban Water Management Plan (Plan), completed December 15, 2005, on behalf of the City of Merced. This final Plan is written according to the requirements of the Urban Water Management Plan Act (Act) and the guidelines as provided by the California Department of Water Resources (DWR).

One copy is submitted to DWR as required in Section 10644 (a) of the Act:

> *"An urban water supplier shall submit to the department [DWR], the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan...."*

If you have any questions, please contact Mr. Wellington Yee at (530) 747-0650 extension 109 or Ms. Jennifer Chen at (530) 747-0650 extension 105.

Sincerely,

BROWN AND CALDWELL

Melanie Holton, P.E.
Engineer

Enclosures
JC:ds

cc: John Ainsworth, City of Merced
Jennifer Chen, Brown and Caldwell
Paul Selsky, Brown and Caldwell
Maria Suico, City of Merced
David Tucker, City of Merced
Wellington Yee, Brown and Caldwell

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10540 White Rock Road, Suite 180
Sacramento, California 95670

Tel: (916) 444-0123
Fax: (916) 635-8805

www.brownandcaldwell.com

December 15, 2005

BROWN AND CALDWELL

Mr. David L. Tucker
City of Merced
678 West 18th Street
Merced, California 95340

017-128906-001/3

Subject: Submittal of Final 2005 Urban Water Management Plan

Dear Mr. Tucker:

I am pleased to submit to you the final 2005 Urban Water Management Plan (Plan). This final Plan is written according to the requirements of the Urban Water Management Plan Act (Act) and the guidelines as provided by the California Department of Water Resources (DWR).

Enclosed are nineteen (19) sets of inserts to finalize the copies of the draft final Plan previously submitted to the City of Merced (City). Per your request, the revised portions of the Plan (report cover, page 2-7, and Appendix B) are provided as inserts to replace the corresponding sections in your copies of the draft final Plan. After replacement, the draft final Plan constitutes the final Plan.

Also included are two (2) complete hardcopies of the final Plan for submittal by the City to DWR and the California State Library, as required in Section 10644 (a) of the Act:

> *"An urban water supplier shall submit to the department [DWR], the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption...."*

The addresses for these two agencies are listed below.

Attn: Dave Todd
Department of Water Resources
Office of Water Use Efficiency
Post Office Box 942836
Sacramento, CA 94236-0001

Attn: Janet Coles
California State Library
Government Publications Section
Post Office Box 942837
Sacramento, CA 94237-0001

For your convenience, a compact disc containing a PDF file of the final Plan is provided should anyone require a copy in the future.

Thank you and your staff for the opportunity to assist you. If you have any questions, please do not hesitate to contact Mr. Wellington Yee at (530) 747-0650 extension 109 or Ms. Jennifer Chen at (530) 747-0650 extension 105.

Sincerely,

BROWN AND CALDWELL

Melanie Holton, P.E.
Engineer

Enclosures
JC:ds

cc: John Ainsworth, City of Merced
Jennifer Chen, Brown and Caldwell
Paul Selsky, Brown and Caldwell
Maria Suico, City of Merced
Wellington Yee, Brown and Caldwell

CITY OF MERCED

FINAL
2005 URBAN WATER MANAGEMENT PLAN

December 2005

Prepared by:

BROWN AND CALDWELL
10540 White Rock Road, Suite 180
Rancho Cordova, California 95670
(916) 444-0123

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LIST OF ACRONYMS AND ABBREVIATIONS

ac-ft	acre feet
ac-ft/yr	acre feet per year
Act	Urban Water Management Planning Act
ADWF	average dry weather flow
B/C	benefit to cost
bgs	below ground surface
BMPs	best management practices
CII	commercial, industrial, and institutional
City	City of Merced
CUWCC	California Urban Water Conservation Council
CVPIA	Central Valley Project Improvement Act
DBCP	dibromochloropropane
DHS	California Department of Health Services
DMMs	demand management measures
DWR	California Department of Water Resources
EIR	Environmental Impact Report
ETo	evapotranspiration
°F	degrees Fahrenheit
gal/capita/day	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
in	inch
IWTF	industrial wastewater treatment facility
MAGPI	Merced Area Groundwater Pool Interests
MCAG	Merced County Association of Governments
MCL	maximum contaminant level
MG	million gallons
mgd	million gallons per day
MID	Merced Irrigation District
MOU	Memorandum of Understanding
NPV	net present value
Plan	Urban Water Management Plan
PHG	public health goal
psi	pounds per square inch
SUDP	Specific Urban Development Plan
TCE	trichloroethane
UC Merced	University of California, Merced
µg/L	micrograms per liter
ULFT	ultra-low-flush toilet
WWTF	wastewater treatment facility

CHAPTER 1
INTRODUCTION

This 2005 Urban Water Management Plan (Plan) addresses the City of Merced (City), which provides water to approximately 19,000 connections, serving a population of approximately 73,600 people within the City's boundaries. The Plan is required by the Urban Water Management Planning Act (Act) (California Water Code, Division 6, Part 2.6, Sections 10610 through 10657) and serves as the long-term water supply plan for the City.

This chapter provides an overview of the Plan, public participation, and agency coordination. The 2005 Plan Checklist as provided by the California Department of Water Resources (DWR) is presented in Appendix A. The checklist is included to help facilitate the review of this Plan.

1.1 Urban Water Management Planning Act

One of the purposes of this Plan is to ensure the efficient use of available water supplies as required by the Act. The Act became part of the California Water Code with the passage of Assembly Bill 797 during the 1983–1984 regular session of the California legislature. Subsequent assembly bills between 1990 and 2004 have amended the Act. Most recently, the Act was amended on September 22, 2004 by Senate Bill 318.

The Act requires every urban water supplier providing water for municipal purposes to more than 3,000 customers or supplying more than 3,000 acre-feet (ac-ft) of water annually to adopt and submit a Plan every five years to DWR. As stated in the Act, urban water suppliers should make every effort to assure the level of reliability in its water service is sufficient to meet the needs of its various categories of customers during normal, single-dry, and multiple-dry years. The Act describes the required contents of the Plan and how the urban water suppliers should adopt and implement the Plan. It is the intention of the California legislature, in enacting this part, to permit levels of water management planning commensurate with the numbers of customers served and the volume of water supplied.

The Plan describes the availability of water and discusses water use, reclamation, and water conservation activities. The Plan concludes that the water supplies available to the City's customers are adequate over the next 20-year planning period.

1.2 Public Participation

The Act requires the encouragement of public participation and a public hearing as part of the Plan approval process. As required by the Act, prior to adopting this Plan, the City made the Plan available for public inspection and held a public hearing. This hearing provided an opportunity for the City's customers and all residents and employees in the service area to learn about the water supply situation and the plans for providing a reliable, safe, high-quality water supply for the future. The hearing was an opportunity for customers to ask questions regarding the current water system situation and the viability of future water supply plans.

A Notice of Public Hearing was published twice in the local newspaper and copies of the draft Plan were made available for public inspection at the City's Administration Building and at local public libraries (Government Code Section 6066). The public hearing was held at a regular meeting of the City Council. This Plan was finalized after the public hearing and adopted by the City Council. Copies of the published Notice of Public Hearing and adopted resolution are provided in Appendix B.

1.3 Agency Coordination

The Act requires the City to coordinate the preparation of its Plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable. The City is the sole water supplier and water management agency for the area, so the City did not participate in an area, regional, watershed, or basin wide Plan. However, the City does coordinate with other appropriate agencies to manage water resources. Table 1-1 provides a summary of agency coordination for Plan preparation.

Table 1-1. Agency Coordination

Coordination	City of Merced	Merced Irrigation District	County of Merced	UC Merced	Merced County Association of Governments
Participated in UWMP development	X				
Commented on draft Plan	X				
Attended public meetings	X				
Contacted for assistance	X				
Received copy of draft Plan	X				
Sent notice of intention to adopt	X	X	X	X	X
Not involved/no information					

1.4 Resource Maximization and Import Minimization

The City and cooperating agencies in the service area recognize the importance of maintaining sufficient groundwater levels and sustaining a high quality, reliable supply. The City is involved in joint efforts with the Merced Irrigation District (MID), the University of California, Merced (UC Merced), the County of Merced, and the Merced County Association of Governments (MCAG) to conserve the regional aquifer. Departments within the City, such as the Departments of Development Services and Public Works, work closely together and use water management tools to ensure efficient use of water supplies.

The following programs and documents were created from the cooperative efforts of these agencies and departments.

Merced Water Supply Plan and Merced Water Supply Plan Update – Developed as a result of a Memorandum of Understanding (MOU) between the City and MID to develop a long-range water resources plan. Prepared for the City, MID, and UC Merced. The study recommended that groundwater elevations be stabilized with recharge from the Merced River.

Merced Area Groundwater Pool Interests (MAGPI) – Association, of which the City is a member, created between agencies in the Merced groundwater basin with shared interests in the Merced Subbasin.

MAGPI was formed pursuant to the 1993 Groundwater Management Act (AB 3030). In 2001, MAGPI entered into an MOU with DWR to support conjunctive water use water management programs.

Merced Groundwater Basin Groundwater Management Plan – Published by MAGPI to address the Merced Subbasin's physical characteristics, water quality conditions, and implementation of the groundwater management plan. This report constitutes the City's groundwater management plan and describes methods to sustain groundwater reserves. The report is further discussed in Chapter 4.

The benefits of the programs described above and the documents developed as a result of these programs are water management tools that the City uses to maximize their water resources and minimize the need to import water.

CHAPTER 2
DESCRIPTION OF EXISTING WATER SYSTEM

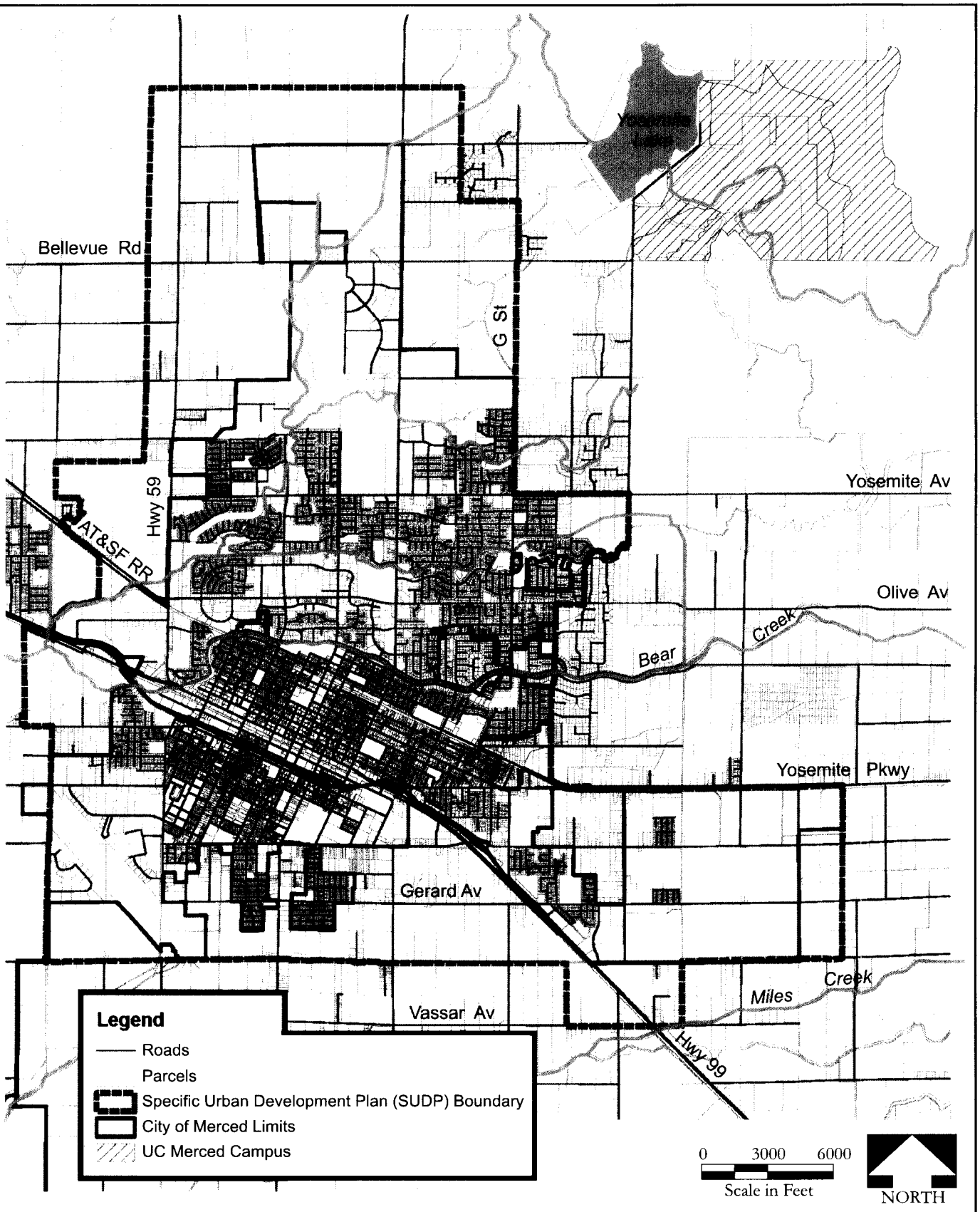
This chapter describes the City's water system. It includes a description of the service area and climate, the groundwater wells, storage facilities, and piping system.

2.1. Description of Service Area

The City serves a population of approximately 73,600 through approximately 19,000 active service connections. The City is located in eastern Merced County within the Central Valley of California, approximately 110 miles southeast of San Francisco and 310 miles northwest of Los Angeles. The City is located on Highway 99 and is also served by Highways 59 and 140. Two railroads, Union Pacific and Burlington Northern-Sante Fe, have main lines that pass through the City. The terrain is essentially flat.

Incorporated in 1889, the City operates under the Council-Manager form of government and serves as the County seat. The current service area is characterized by a mixture of residential, commercial, and industrial land use.

The City is the only water purveyor for the users within the City boundary. MID provides irrigation water to Golden Valley High School, agricultural users, and has plans to phase in water service to City parks. Currently, the City water service area is bounded by the City limits, the Specific Urban Development Plan (SUDP) boundary, and the UC Merced campus. The *Merced Vision 2015 General Plan* (City of Merced, 1997) describes growth area boundaries, which are referred to as SUDP boundaries or the urban expansion area. The SUDP boundary is recognized as the ultimate growth boundary of the City over the life of the *Merced Vision 2015 General Plan.* For the purposes of this Plan, the SUDP boundary will be used to describe the future City water system service area. The service area limits, including the SUDP boundary, current city limits, and the UC Merced campus are shown on Figure 2-1.



Source: City of Merced

BROWN AND CALDWELL	PROJECT 128906-300	SITE 2005 Urban Water Management Plan City of Merced, California	Figure 2-1
	DATE 11-8-05	TITLE City of Merced Service Area Boundaries	

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UC Merced opened in the Fall 2005. Construction of the campus will occur in phases, with buildout to occur in 2055 (UC Regents, 2001). The UC Merced campus is supplied water from the City and tied to the City sewer system so is considered within the SUDP. The adjacent UC Merced university community is not within the confines of the SUDP and not considered further in this Plan. The City service to UC Merced includes a potable water pipeline intertie, treatment of all the campus wastewater, and a municipal well and storage tank located on a City-owned site on campus. UC Merced has agreed to annex to the City in the future.

2.2. Local Climate

The City has cool, humid winters and hot, dry summers. The City's average monthly temperature ranges from 46 to 79 degrees Fahrenheit (°F), but the extreme low and high daily temperatures have been 15° F and 111° F, respectively (WRCC, 2005). As shown on Table 2-1, the historical annual average precipitation is approximately 12 inches. The rainy season begins in November and ends in April. Average monthly precipitation during the winter months (December, January, and February) is 2.2 inches. Records show that the monthly precipitation has been as high as 7.1 inches and as low as 0 inches. Relative humidity in the region ranges from 41 percent to 91 percent. Low humidity usually occurs in the summer months, from May through September. The combination of hot and dry weather during the summer results in high water demands during that period. The annual normal reference evapotranspiration is 54 inches (CIMIS, 2005). Table 2-1 summarizes the climatic conditions in the water service area.

Table 2-1. Climate Characteristics

Month	Normal reference ETo[a,b] (in)	Average precipitation (in)	Average air temperature[c] (°F)
January	1.01	2.47	45.8
February	1.83	2.16	50.7
March	3.67	1.92	54.8
April	4.86	1.06	60.1
May	6.94	0.44	67.1
June	7.94	0.08	73.6
July	8.39	0.02	78.7
August	7.60	0.03	77.2
September	5.72	0.17	72.9
October	3.64	0.67	64.3
November	1.68	1.53	53.2
December	1.07	1.89	45.6
Annual	54.35	12.44	62.0

[a] Data recorded from January 1999 to August 2005, City of Merced, Station 148, CIMIS, www.cimis.water.ca.gov.

[b] ETo = evapotranspiration, the loss of water from the soil both by evaporation and by transpiration from the plants growing thereon. Normal reference ETo is based on a surface of grass.

[c] Data from July 1, 1948 to March 31, 2005, Merced Airport, Station 55, Western Regional Climate Center, www.wrcc.dri.edu.

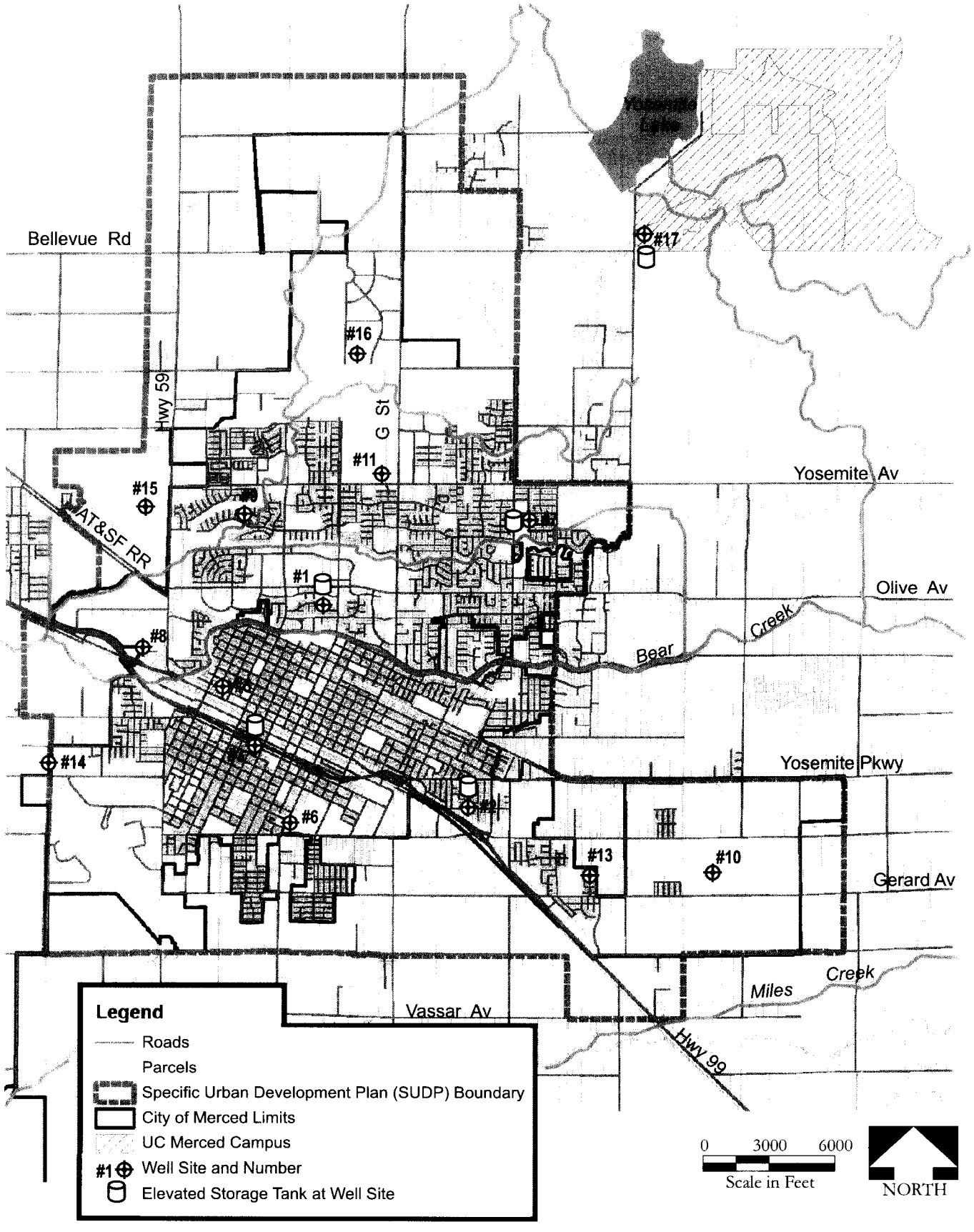
2.3. Water Supply Facilities

Groundwater is currently the only water supply source for the City. Nineteen active production wells, with a combined capacity of 49,500 gallons per minute (gpm), make up the City's total water supply. All of the wells pump directly into the distribution system and have chlorination facilities for disinfection. The capacity of the existing wells is summarized in Table 2-2 and the locations of the groundwater wells and storage facilities are illustrated on Figure 2-2. The active wells are fully operational and used on a regular basis for water supply within the City. The inactive Well 10B was taken offline in November 2004 due to the threat of trichloroethene contamination and replaced with Well 10-R2. Water production from Well 10-R2 began in May 2005. Destruction of Well 10B is scheduled with bid opening on November 8, 2005. Wells 15 and 16 were drilled in early 2005 and pump stations are currently under construction. These wells will be placed into service in 2006. Well 17 is located on a City-owned site within the UC Merced campus and 90 percent of its supply is to the campus with the remaining flow contributing to the City distribution system (Tucker, 2005).

Table 2-2. City of Merced System Wells

Well ID	Well capacity, gpm
1A	2,500
1B	2,200
1C	2,200
2A	2,500
2B	2,500
2C	3,000
3C	3,200
5B	3,000
6	1,000
7A	2,000
7B	2,200
7C	3,500
8	2,000
9	1,700
10B[a]	--
10-R2	3,000
11	3,000
13	3,000
14	4,000
15 (online in 2006)	3,000
16 (online in 2006)	3,000
17[b]	3,000
Total well capacity	55,500

Source: 2000 Plan (Brown and Caldwell, 2001).
[a]Scheduled for destruction in 2006.
[b]Well 17 information (Tucker, 2005).



Source: City of Merced

BROWN AND CALDWELL	PROJECT 128906-300	SITE 2005 Urban Water Management Plan City of Merced, California	Figure 2-2
	DATE 11-7-05	TITLE Water Supply Facilities	

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2.4. Distribution System

The City's distribution system consists of one pressure zone, four elevated storage tanks, and the piping system. The UC Merced tank is at ground level and receives water delivered from the City system. Water is then pumped to the UC Merced distribution system. The City does not operate the UC Merced water distribution system. The storage facilities and their capacities are shown in Table 2-3. The 1.75 million gallon (MG) total storage volume allows sufficient water to be available to meet peak hour demands and fire flows. All wells are equipped with variable frequency drives and emergency generators to provide peak and fire demands.

Table 2-3. City of Merced's System Storage

Name	Volume, gallons
St. Lawrence Dr.	300,000
Parsons Ave.	400,000
West 12th St.	300,000
McKee Rd.	500,000
UC Merced campus[a,b]	250,000
Total	1,750,000

Source: 2000 Plan (Brown and Caldwell, 2001).
[a] Storage tank information (Mian, 2005).
[b] Storage tank belongs to UC Merced.

The distribution system comprises of pipelines with diameters up to 16 inches in size. The entire distribution system consists of approximately 500 miles of pipe. The pipeline distributing water to UC Merced extends north on G Street and west on Bellevue Avenue to the UC Merced storage tank. This tank is also supplied by Well 17.

The system water mains are primarily cast iron and ductile iron pipe. The City currently has a three- to five-year program to replace existing failing polybutylene service connections with copper connections. The program is ongoing and has been active for four years, with approximately two-thirds of the piping replaced with copper connections. All of the wells are provided with alternating peak-drive emergency generators for fire protection and emergency operation.

CHAPTER 3
HISTORICAL AND PROJECTED WATER USE

Water demand projections provide the basis for sizing and staging future water facilities. Water use and production records, combined with projections of population, employment, and urban development, provide the basis for estimating future water requirements. This chapter presents an analysis of available demographic and water use data, customer connections, historical groundwater production, unit water use, and the resulting projections of future water needs for the City.

3.1. Population, Housing, and Employment

Population, housing, and employment data developed by MCAG and the City Planning Department were used to develop estimates of future City water use. The demographic projections are based on the SUDP growth area boundary from the *Merced Vision 2015 General Plan* (City of Merced, 1997). The new UC Merced campus lies within the SUDP boundary and will annex to the City in the future. The campus is supplied water from the City distribution system and discharges to the City sewer system. Water demand estimates for the campus are based on the *Long Range Development Plan* prepared for UC Merced (UC Merced, 2002).

In 1990 the population in the SUDP was approximately 60,900 people. It is estimated that the 2005 population in the SUDP is approximately 82,763 (81,263 people in the area excluding the campus and 1,500 on campus). Of this total, approximately 90 percent (74,487) are currently served by the City water system. The SUDP population is expected to reach 131,736 (114,867 within and surrounding the City and 16,869 at the UC Merced campus) by 2025. Population within the SUDP is expected to grow at an annual average growth rate of about three percent from years 2005 through 2025. A summary of the historic and projected population, housing, and employment data in the SUDP is presented in Tables 3-1 and 3-2. The portion attributed to the City and surrounding areas is shown in Table 3-1 and illustrated in Figure 3-1. The UC Merced campus population and housing portion of the SUDP is presented in Table 3-2.

Table 3-1. Historical and Projected Population, Housing, and Employment within the SUDP (excluding UC Merced)

Year	Single family dwelling units[a]	Multi-family dwelling units[a]	Employees[b]	Population[b]
1990	11,530	7,510	16,970	60,900
1995	12,489[c]	8,150[c]	19,860	65,727
2000	13,448	8,789	24,180	70,554
2005	15,576	10,207	28,570	81,263
2010	17,711	11,631	31,260	92,014
2015	19,438	12,782	34,711	100,706
2020	20,987	13,815	42,822	108,505
2025	22,346	14,721	51,383[d]	114,867[d]

Note: Dashed line represents division between historical and projected data.
[a]Housing data from *General Plan Land Use Capacity and Revised Population Projections* (City of Merced, 2001).
[b]Employment and population data from the *Merced Water Reuse Strategic Plan* (CH2MHill, 2001b). Employees are the sum of industrial, retail commercial, and office commercial employees.
[c]Single family and multi-family dwelling unit values for 1995 were interpolated from Years 1990 and 2000 data.
[d]Employee and population values for 2025 were interpolated from Years 2020 and 2030 data.

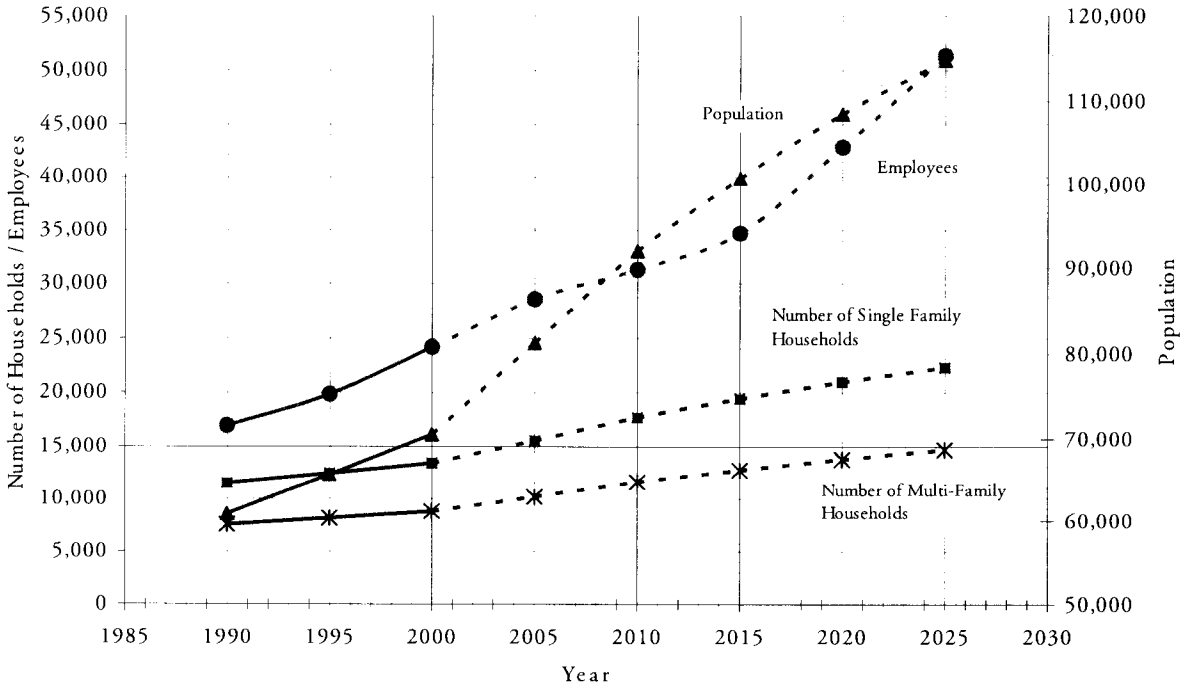


Figure 3-1. Historical and Projected Population, Housing, and Employment within the SUDP (excluding UC Merced)

Historical and projected housing figures, as presented in Table 3-1, are the total number of developed units within the SUDP (excluding UC Merced) from the *General Plan Land Use Capacity and Revised Population Projections Memorandum* (City of Merced, 2001). For Years 2000 through 2025, housing projections are based on the assumption that there are 3.02 persons per dwelling unit and that 60 percent of housing units are single-family and 40 percent are multi-family.

Historical and projected employment data presented in Table 3-1 assumed 5 to 15 employees per acre for industrial and retail commercial land use and assumed 8 to 15 employees per acre for office commercial land use. The historical employment data are based on Merced County employment projections, the UC San Joaquin Environmental Impact Report, the 1990 Census, and the 1987 Census of Manufacturing, Retail, Service, and Wholesale Trade (City of Merced, 1997).

Table 3-2. UC Merced Campus Population and Housing Projections

	Population				Housing available (No. of students)		
Year	Student	Faculty	Staff	Total	Students[a]	Faculty[a]	Total
2005	1,000	100	400	1,500	600	50	650
2010	5,214	316	1,232	6,762	2,607	158	2,765
2015	8,136	462	1,617	10,215	4,068	231	4,299
2020	10,786	613	2,144	13,542	5,393	306	5,699
2025	13,436	763	2,670	16,869	6,718	382	7,100

Source: *Long Range Development Plan* (UC Merced, 2002). Report assumed UC Merced campus would open in Fall 2004, so all projections were moved forward one year to match actual opening in Fall 2005.
Note: UC Merced campus ultimate buildout to occur in Year 2055.
[a]UC Merced goal is to provide housing for 50 percent of the student population and 50 percent of the faculty. At campus opening, housing for approximately 600 students will be available, with phased housing construction to maintain campus housing goal as practicable.

The housing projections for the UC Merced campus are derived based on the UC Merced goal of having on-campus housing available for 50 percent of the student and faculty population (UC Merced, 2002). As outlined in the *Long Range Development Plan*, UC Merced aimed to have housing available for 600 students by opening day and housing for an additional 1,600 students by the end of Phase I in 2008. Housing will be built in phases as is feasible to maintain the 50 percent campus housing goal.

The number of connections by customer classification, as counted by the City in 2005, is shown in Table

3-3. The City provides metered irrigation for parks and unmetered irrigation for street medians. The City's water system contains about 19,000 connections of which about 7,700 are metered connections. The single family connections are presented in two categories: unmetered (flat-rate) and metered connections. The City instituted water metering for all public parks and all multi-family dwelling units. Metered connections are required for all new single family dwelling units built after 1992. In 2005, approximately 31 percent of single family dwelling units were metered. The number of unmetered residential customers is approximately 11,150.

The projected connections for each sector from Years 2010 to 2025 in Table 3-3 are derived from normal year water demand projections for the same time period. To project the number of connections per sector, it was assumed that the percent increase in connections is equal to the percent increase in the projected water demands. The City is currently considering two meter retrofit programs as described in Chapter 6. For the purpose of these calculations, future projections assumed 10 percent of the unmetered connections would be retrofitted annually after 2006.

Table 3-3. City of Merced Connections by Customer Classification

	Historical connections			Projected connections[c]			
Customer classification	2001[a]	2004[b]	2005[b]	2010	2015	2020	2025
Single family							
Metered	3,300	4,153	5,030	10,283	13,981	16,687	18,707
Unmetered[d]	11,183	11,074	11,145	6,581	3,886	2,295	1,355
Multi-family	843	1,394	1,401	1,596	1,754	1,896	2,021
Commercial	689	1,109	1,124	1,230	1,366	1,685	2,022
Industrial	57	35	34	37	41	51	61
Landscape	9	112	118	124	131	138	145
Total	16,081	17,877	18,852	19,852	21,160	22,751	24,311

[a] 2001 data from 2000 UWMP (Brown and Caldwell, 2001). Multi-family, commercial, and institutional connections totaled 1,532, with 55 percent of total assumed to be multi-family connections, based on 2004 and 2005 proportions.

[b] December 2004 and October 2004 data, from Bill Hubkey's records from the City of Merced Department of Finance (Suico, 2005).

[c] New connections estimated based on annual demand growth rates by sector. For landscape irrigation, increase based on the growth rate from 2004 to 2005.

[d] Assume 10 percent of single family unmetered connections are retrofitted annually, with program starting in 2006. The City is considering the meter retrofit program so values may change in the future.

3.2. Historical Water Use

Records of historical water production obtained from the City serve as the basis for developing unit water demands. Water production is the volume of water measured at the source, which includes all

water delivered to residential and nonresidential customers as well as unaccounted-for water.

3.2.1. Annual Water Production

Annual groundwater production from 1978 to 2005 is presented in Table 3-4. Total water production in 2005 was estimated to be 30,118 acre-feet per year (ac-ft/yr). Historical water use by customer class or sector is not available because most of the City water system is not metered. Water production by customer categories can only be estimated, as discussed in the following sections.

Table 3-4. Historical Water Production

Year	Average water production (ac-ft/yr)
1978	11,500
1979	13,500
1980	14,000
1981	15,500
1982	17,000
1983	17,000
1984	19,500
1985	17,500
1986	17,000
1987	15,000
1988	16,000
1989	16,500
1990	16,500
1991	14,500
1992	16,000
1993	16,500
1994	18,000
1995	18,494
1996	20,649
1997	22,689
1998	20,990
1999	23,906
2000	21,018
2001	23,633
2002	23,659
2003	22,428
2004	23,779[a]
2005	30,118[b]

Source: 1978 to 2000 data from 2000 Plan (Brown and Caldwell, 2001).
2000 to 2004 data (Wegley, 2005).
[a] Water production for 1st quarter 2004 estimated from 2003 data.
[b] 2005 total production assumed to be expected annual water demand.

3.2.2. Unaccounted-for Water

Unaccounted-for water is from unmetered water uses such as fire protection and training, system and street flushing, sewer cleaning, construction, system leaks, and unauthorized connections. Unaccounted-for water can also result from meter inaccuracies. Because the City is not completely metered, data are unavailable for determining the percent of unaccounted-for water. Unaccounted-for water for this study is assumed to be 10 percent of total water production.

3.3. Unit Water Use

Unit water use factors are developed to estimate future water needs based on the housing and employment projections within the SUDP, not including UC Merced, as discussed previously. There are two main categories of water users used to estimate future water needs, residential and nonresidential. Future residential water needs are determined using the projection for dwelling units, coupled with a unit water use factor per dwelling unit type. Future nonresidential water needs are determined using the projections for employment, coupled with a unit water use factor per employee. Studies show there is a good correlation between nonresidential water use and the number of employees (California Urban Water Agencies, 1992).

The unit water use factors, as presented in Table 3-5, were established by comparing historical data for the number of single family and multi-family residential units and the number of employees within the SUDP boundary to total water production from 1990 through 2000. It was assumed that 90 percent of the historical SUDP area households and employees from Table 3-1 were within the City boundaries and served by the City's water system. Through an iterative process, unit water use factors were developed that, when multiplied by the number of historical City water system households and employees, best match the historical water production.

UC Merced was completed recently so campus figures were not available for determination of unit water use factors. Instead water demands for the campus were estimated based on water usage forecasted from the Environmental Impact Report (EIR) completed during the planning phase of the university, as discussed in the section below.

Table 3-5. Residential and Nonresidential Unit Water Use Factors for SUDP (excluding UC Merced)

Classification	Unit water use factor[a]
Residential	
Single family	825 gpd/unit
Multi-family	325 gpd/unit
Commercial/Industrial	
Employee	350 gpd/employee

[a] Factors include unaccounted-for water.
gpd = gallons per day

3.4. Projected Water Demands by Water Year Type

This section presents the projected water demands for three water year scenarios: normal year, single-dry year, and multiple-dry years. The demands for all water year scenarios are projected through 2025.

3.4.1. Projected Normal Year Water Demands

Normal year water demands through 2025 for the SUDP area excluding UC Merced are estimated based on the unit water use factors (Table 3-5) and the housing and employment projections (Table 3-1). These annual water demand projections by water use sector are provided in Table 3-6 and illustrated on Figure 3-2. Water demands projected in the 2000 Plan (Brown and Caldwell, 2001; Brown and Caldwell, 2002) are also included in Table 3-6 for comparison. This Plan applies methodologies and population projections consistent with the 2000 Plan.

Normal year water demands for UC Merced are listed as a separate line item in Table 3-6. For UC Merced, campus buildout is projected for the Year 2055. The projected water use for the campus in the Year 2030 was forecasted to be approximately 20,000 ac-ft/yr in the EIR (CH2MHill, 2001a). Water demands for Years 2005 to 2025 were estimated from the projected populations provided in the *Long Range Development Plan* and an estimated per capita flowrate calculated from the UC Merced Year 2030 projected water demand. In the future, UC Merced has plans to supplement its water supply with recycled water generated on-campus. The projects will be phased with the developing campus but plans are not yet in place to provide water demand estimates.

Table 3-6. Projected Normal Year Water Demands by Water Use Sector in SUDP

Sector	2005 (ac-ft/yr)	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Single family[a]	12,954	14,729	16,166	17,454	18,584
Multi-family	3,344	3,811	4,188	4,526	4,823
Commercial/Industrial/Institutional	10,080	11,029	12,247	15,109	18,129
Landscape irrigation[b]	10	58	105	153	200
Water sales	0	0	0	0	0
Saline barriers	0	0	0	0	0
Groundwater recharge	0	0	0	0	0
Conjunctive use	0	0	0	0	0
Raw water	0	0	0	0	0
Recycled water for urban use[c]	0	50	133	217	300
UC Merced campus[d]	718	3,236	4,889	6,481	8,073
Unaccounted-for water[e]	3,012	3,657	4,192	4,882	5,568
Total	30,118	36,570	41,919	48,821	55,677
Percent of Year 2005	100	121	139	162	185
2000 Plan projection	29,309	32,855	36,222	41,209	--

Note: Water savings from future water conservation is not included in demand projections.

[a] Single family water demand estimates are based on the proportion of metered and unmetered customers.

[b] Landscape irrigation estimated to increase linearly from 10 ac-ft/yr to 200 ac-ft/yr from 2005 to 2025 (Tucker, 2005).

[c] Recycled water for urban use estimated to increase linearly from 50 ac-ft/yr in 2010 to 300 ac-ft/yr in 2025 (Tucker, 2005).

[d] UC Merced campus water use for Years 2005 to 2025 was projected using the estimated Year 2030 water use of 20,000 ac-ft/yr from the *Merced Water Supply Plan Update, Final Status Report* (CH2MHill, 2001a) and projected populations for Years 2005 to 2025 from the *Long Range Development Plan* (UC Merced, 2002).

[e] Unaccounted-for water is assumed to be 10 percent of total water production.

By 2025, water demands are expected to increase by approximately 85 percent, from 30,118 ac-ft/yr in 2005 to 55,677 ac-ft/yr in 2025. A significant proportion of the water demand increase is a direct result from UC Merced growth. Impacts to water use due to any conservation measures implemented in the future are not reflected in the projected water demands.

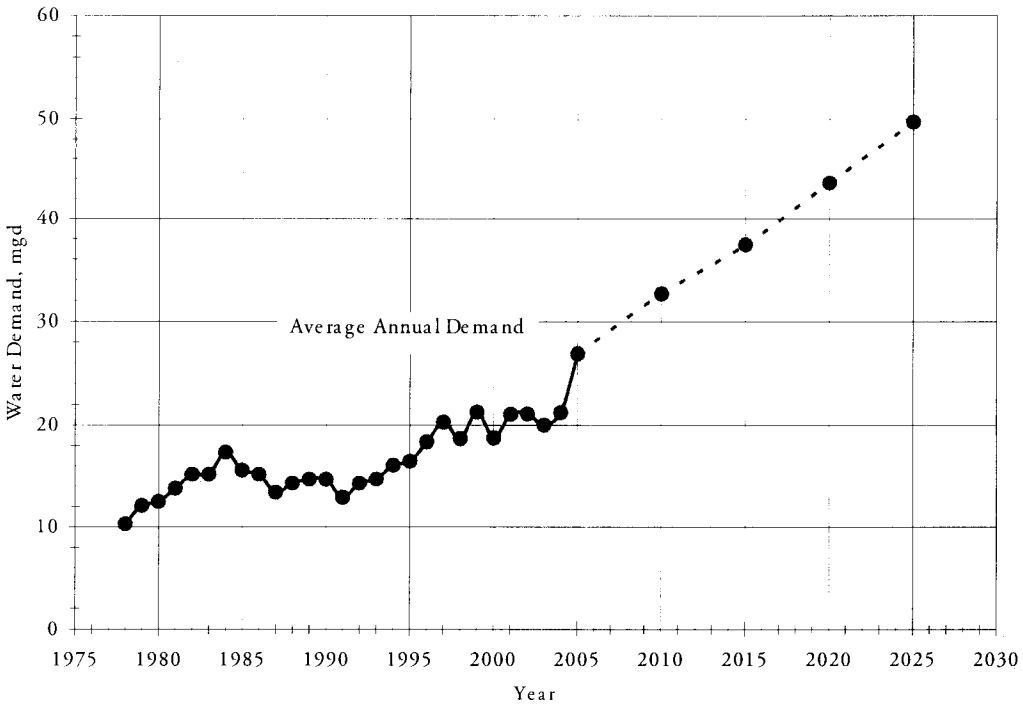


Figure 3-2. Historical and Projected Water Demands in SUDP

3.4.2. Projected Single-Dry Year Water Demands

Water use patterns change during dry years. During dry years some water agencies cannot provide their customers with 100 percent of what they deliver during normal water years. One way to analyze the change in demand is to document expected changes to water demand by sector. Expected changes in demand may include increased demands due to increased irrigation needs and demand reductions resulting from rationing programs and policies. Because groundwater is the sole source of supply for the City, it is assumed overall demands will not change during a single-dry year. The City and MID have plans to use surface water for urban irrigation in the future. It is assumed that the groundwater can supplement the supply and meet any water demand changes that may occur. Any demand reductions due to future water conservation measures are not included in the single-dry year demand estimates. Table 3-7 provides an estimate of the projected single-dry year water demands.

Table 3-7. Projected Single-Dry Year Water Demands

Water demand	2005 (ac-ft/yr)	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Total demand	30,118	36,570	41,919	48,821	55,677
Percent of projected normal[a]	100	100	100	100	100

Note: Water savings from future water conservation is not included in demand projections.
[a] Projected normal from Table 3-6.

3.4.3. Projected Multiple-Dry Year Water Demands

This section projects the impact of a multiple-dry year period for each five-year period during the 20-year study period. Because groundwater is the sole source of supply for the City, it is assumed that overall demands will not change during a multiple-dry year. Any demand reductions due to future water conservation measures are not included in the multiple-dry year demand estimates. Tables 3-8 to 3-11 provide estimates of the projected multiple-dry year water demands for each five-year period.

Table 3-8. Projected Multiple-Dry Year Water Demands, Period Ending 2010

Water demand	2006 (ac-ft/yr)	2007 (ac-ft/yr)	2008 (ac-ft/yr)	2009 (ac-ft/yr)	2010 (ac-ft/yr)
Total demand	31,408	32,698	33,989	35,279	36,570
Percent of projected normal[a]	100	100	100	100	100

Note: Water savings from future water conservation is not included in demand projections.
[a] Projected normal from Table 3-6.

Table 3-9. Projected Multiple-Dry Year Water Demands, Period Ending 2015

Water demand	2011 (ac-ft/yr)	2012 (ac-ft/yr)	2013 (ac-ft/yr)	2014 (ac-ft/yr)	2015 (ac-ft/yr)
Total demand	37,640	38,709	39,779	40,849	41,919
Percent of projected normal[a]	100	100	100	100	100

Note: Water savings from future water conservation is not included in demand projections.
[a] Projected normal from Table 3-6.

Table 3-10. Projected Multiple-Dry Year Water Demands, Period Ending 2020

Water demand	2016 (ac-ft/yr)	2017 (ac-ft/yr)	2018 (ac-ft/yr)	2019 (ac-ft/yr)	2020 (ac-ft/yr)
Total demand	43,299	44,680	46,060	47,440	48,821
Percent of projected normal[a]	100	100	100	100	100

Note: Water savings from future water conservation is not included in demand projections.

[a] Projected normal from Table 3-6.

Table 3-11. Projected Multiple-Dry Year Water Demands, Period Ending 2025

Water demand	2021 (ac-ft/yr)	2022 (ac-ft/yr)	2023 (ac-ft/yr)	2024 (ac-ft/yr)	2025 (ac-ft/yr)
Total demand	50,192	51,563	52,934	54,306	55,677
Percent of projected normal[a]	100	100	100	100	100

Note: Water savings from future water conservation is not included in demand projections.

[a] Projected normal from Table 3-5.

CHAPTER 4
WATER SUPPLY

The City currently uses groundwater as its sole source of supply. This chapter describes the groundwater basin, quantities, supply constraints, and the water quality of the supply source. In addition, this section describes current and projected water supplies and water supply reliability and vulnerability. Recycled water use is discussed in Chapter 5 of this Plan. The City does not have current or future plans to receive or provide wholesale water to outside agencies. The City and MID has plans to phase in surface water use for agricultural and landscape irrigation.

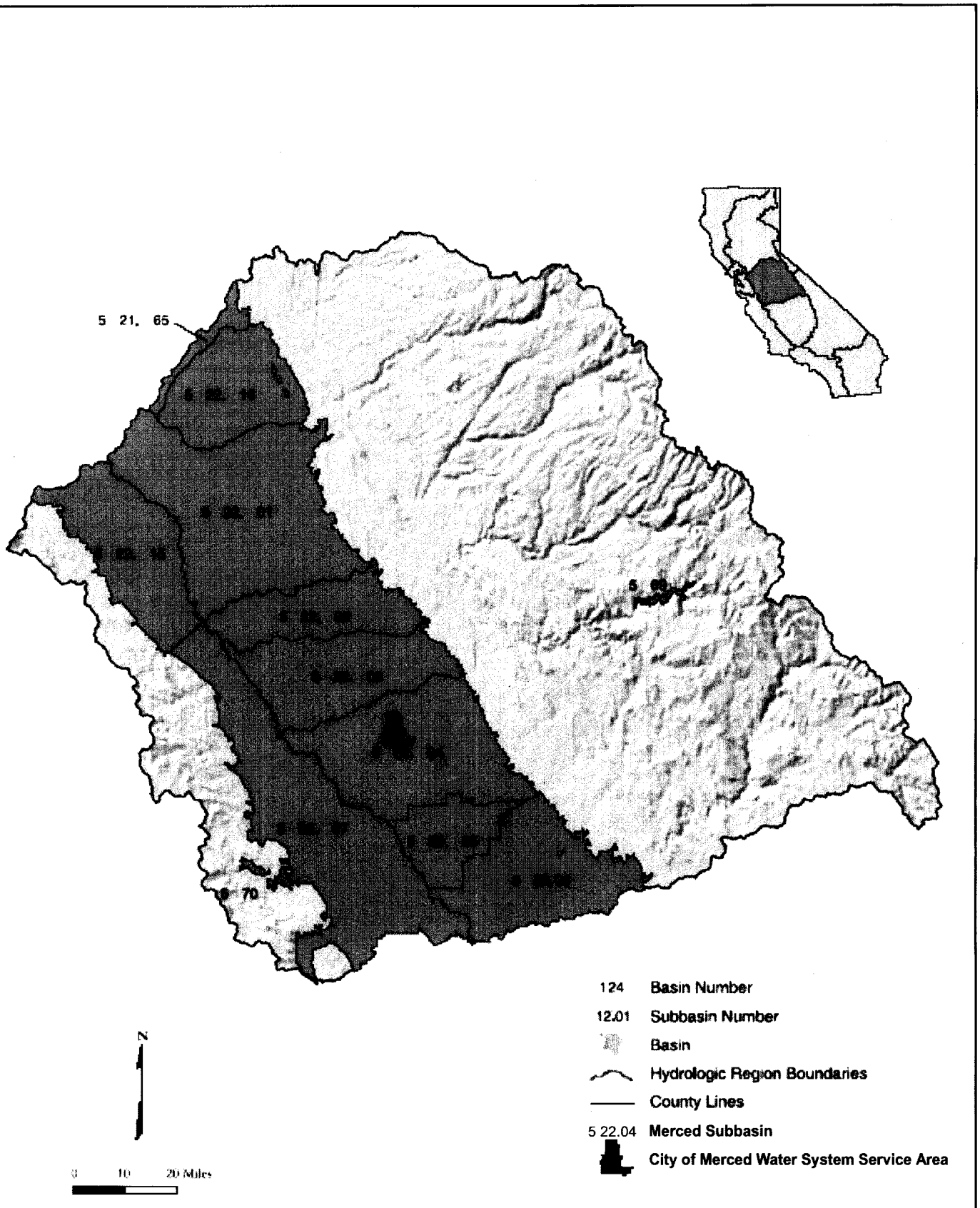
4.1. Groundwater

This section describes the City's groundwater supply as well as the physical and legal constraints of this supply. Over the last 20 years, groundwater use has increased from 17,500 ac-ft/yr in 1985 to approximately 30,118 ac-ft/yr in 2005.

4.1.1. Description

The City is located within the geomorphic province known as the Central Valley, which is divided into the Sacramento Valley and the San Joaquin Valley. The City, as is the new UC Merced campus, is entirely dependent on groundwater for its supply (DWR, 2003). The groundwater underlying the City is part of the larger San Joaquin Valley Groundwater Basin within the San Joaquin River Hydrologic Region. The San Joaquin Valley Groundwater Basin is further subdivided into nine subbasins, of which the Merced Subbasin is one. The groundwater basin in the service area occurs under unconfined and semi-confined conditions.

The City lies specifically within the Merced Subbasin (Subbasin 5-22.04), as shown on Figure 4-1 (DWR, 2003). The Merced Subbasin includes lands south of the Merced River between the San Joaquin River on the west and the Sierra Nevada foothills on the east. The basin boundary on the south stretches westerly along the Madera-Merced County line and the southern boundary of the Le Grand-Athlone Water District, then along the northern boundaries of Chowchilla Water District and



Source: DWR, California's Groundwater Bulletin 118, Update 2003

BROWN AND CALDWELL	PROJECT 128906-300	SITE 2005 Urban Water Management Plan City of Merced, California	Figure 4-1
	DATE 10-13-05	TITLE San Joaquin River Hydrologic Region	

X:\2800\128906-Merced_UWMP\2005_UWMP_files\2005 figures

the former El Nido Irrigation District which was consolidated into MID in April 2005. The southern boundary then follows the western boundary of the former El Nido Irrigation District south to the northern boundary of the Chowchilla Groundwater Basin (DWR, 2003).

The Central Valley is a large, northwestward-trending, asymmetric structural trough that has been filled with several miles of thick sediment (USGS, 1986). Sediments of the San Joaquin Valley consist of interlayered gravel, sand, silt, and clay derived from the adjacent mountains and deposited in alluvial-fan, floodplain, flood-basin, lacustrine, and marsh environments. Hydrogeologic units in the Merced Subbasin include both consolidated rocks and unconsolidated deposits. The unconsolidated deposits include (1) continental deposits, (2) lacustrine and marsh deposits, (3) older alluvium, (4) younger alluvium, and (5) flood-basin deposits. The continental deposits and older alluvium are the main water-yielding units in the unconsolidated deposits. The consolidated rocks include: (1) the Ione Formation, (2) the Valley Springs Formation, and (3) the Mehrten Formation. The consolidated rocks generally yield small quantities of water to wells except for the Mehrten Formation, which is an important productive aquifer (DWR, 2005b). The Mehrten Formation is the most productive fresh water-bearing unit in the eastern Sacramento Valley.

Annual groundwater extraction from a basin over a long period of time above the annual perennial yield is defined as overdraft. In wet years, recharge in developed groundwater basins tends to exceed extractions. Conversely, in dry years, groundwater basin recharge tends to be less than groundwater basin extraction. By definition, overdraft is not a measure of these annual fluctuations in groundwater storage volume. Instead, overdraft is a measure of the long-term trend associated with these annual fluctuations (CH2MHill, 2001a; DWR, 1998).

The Merced Subbasin has not been adjudicated, but most of the statewide increase in overdraft occurred in the San Joaquin and Tulare Lake regions (DWR, 2003). The surface water supplies in these two regions have been reduced in recent years by Delta export restrictions, Central Valley Project Improvement Act (CVPIA) implementation, and Endangered Species Act requirements. Central Valley Project contractors who rely on Delta exports for their surface water supply have experienced supply

deficiencies of up to 50 percent subsequent to implementation of export limitations and CVPIA requirements. Many of these contractors have turned to groundwater pumping for additional water supplies (DWR, 1998).

The groundwater levels also fluctuate over time depending on precipitation, aquifer recharge, and pumping demands. Static groundwater levels have stabilized within the past few years at approximately 70 feet below ground surface (bgs) in the winter with recovery to approximately 50 feet bgs in early spring.

While groundwater has provided the City a reliable water supply for many years, rapid growth has motivated the City to evaluate its groundwater supply. In 1992, the City and MID entered into a MOU to develop a long-range water resources plan (CH2MHill, 2001a). In response, the *Merced Water Supply Plan* was completed in 1995, which included goals for managing groundwater resources and to provide high quality, reliable supply for cities. In September 2001, the *Merced Water Supply Plan Update, Final Status Report,* was prepared for the City, MID, and UC Merced (CH2MHill, 2001a). The 1995 *Merced Water Supply Plan* and the 2001 *Merced Water Supply Plan Update, Final Status Report* identified the factors contributing to groundwater overdraft and recommended actions to restore the aquifer. These studies also recommended that groundwater elevations be stabilized at the 1999 levels by recharging the groundwater basin with imported surface water from the Merced River. The City and MID are working cooperatively to implement the water supply plan (City of Merced and MID, 2005).

The declining groundwater basin is a result of the groundwater extraction by all groundwater users in the area. This includes groundwater pumping by other stakeholders including cities, private well owners, and by the City. The City anticipates some increase in groundwater use by agricultural users, as well as by the UC Merced campus, which places further demands on the groundwater basin. The groundwater recharge program will determine the location of groundwater recharge facilities, the agency or agencies which will operate and maintain recharge facilities, and cost sharing. Currently, studies are being conducted on a pilot groundwater recharge basin. However, more investigation is needed on the feasibility and effectiveness of utilizing spreading basins or deep aquifer injection wells (City of Merced and MID, 2005). MID has undertaken a strong effort to encourage surface water use by agricultural

users (City of Merced, 1997). The City is undertaking projects to convert park irrigation to surface water.

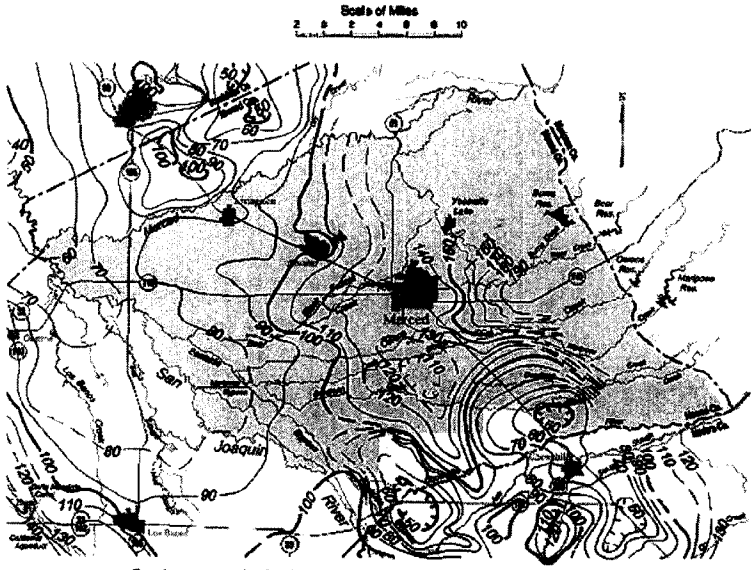
The cooperating agencies of the *Merced Water Supply Plan*, the City, UC Merced, and MID, have recognized the importance of maintaining sufficient water levels and have agreed on developing a strategy to maintain groundwater levels at 1999 levels, which is approximately 160 feet above mean sea level. Figure 4-2 illustrates Merced Subbasin groundwater contour maps from Spring 1999 and Spring 2004 developed by DWR (DWR, 2005a).

As part of the 2001 *Merced Water Supply Plan Update, Final Status Report*, a groundwater model and a land use model were developed for use in planning. The groundwater model provided simulations of aquifer level changes and the amount of recharge required to stabilize groundwater levels. Development of a new model is needed for implementation level decisions
(City of Merced and MID, 2005).

4.1.2. Physical Constraints

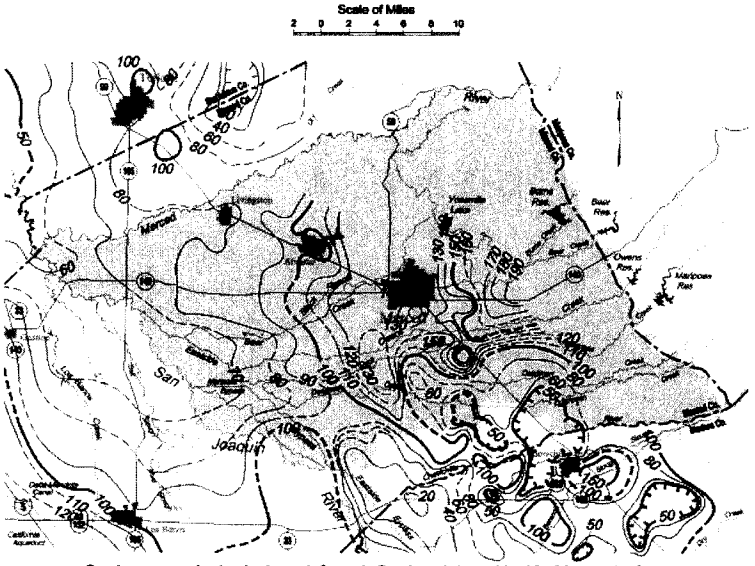
The City's water system currently has 19 active wells, with a total pumping capacity of 49,500 gpm, that draw water primarily from the Mehrten Formation. Two additional wells, Wells 15 and 16, will come online in 2006 and contribute an additional 6,000 gpm. The City groundwater supply is limited by the pumping capacities of the existing wells. The fact that the groundwater basin is stressed means that in the long-term, the groundwater supply is less than the current annual pumping rate unless recharge is undertaken. However, there are currently no physical constraints on the groundwater supply due to adequate pumping capacity of the existing wells. The City is responsible for only a small part of the groundwater pumping occurring in the eastern Merced Subbasin; City pumping accounts for approximately 5 percent relative to the 95 percent attributed to agricultural pumping.

Spring 1999, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10 feet.

Spring 2004, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer



Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

(feet above mean sea level)

Source: www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm (DWR, 2005a)

Figure 4-2. Merced Subbasin Groundwater Contours for 1999 and 2004

4.1.3. Legal Constraints

There are no legal constraints on groundwater pumping. In California, the State is not authorized by the Water Code to manage groundwater. California landowners have a correlative right to extract groundwater for beneficial use. As a municipal water supplier, the City acts on behalf of the overlying landowners, who rescind their water rights to the City when the landowner develops the land.

The City is a participant in the following voluntary regulations to manage the groundwater resources in the service area. Pursuant to the 1993 Groundwater Management Act (AB3030), several agencies within the Merced Subbasin, including the City, adopted an MOU creating an association identified as the Merced Area Groundwater Pool Interests (MAGPI). In December 1997, MAGPI published the *Merced Groundwater Basin Groundwater Management Plan.* The *Merced Groundwater Basin Groundwater Management Plan* addressed the basin's physical and hydrologic characteristics, water quality conditions, groundwater management plan elements, and groundwater management plan implementation (CH2MHill, 2001a). This report constitutes the City's groundwater management plan and describes methods the City will undertake to manage its groundwater resources. A copy of the *Merced Groundwater Basin Groundwater Management Plan* is included in Appendix C.

On June 6, 2001, MAGPI entered into an MOU with DWR in an effort to support the implementation of conjunctive use water management programs through the DWR Integrated Storage Investigations Program. The MOU states that any water developed as a result of the conjunctive water management program will be under the control of local agencies. The priority will be in-basin water needs with local agencies having jurisdiction over out-of-basin transfers.

4.2. Desalination

As shown in Table 4-1, there are no opportunities for the development of desalinated water within the City's service area as a future source of supply. City wells extract water from above 800 feet bgs and have experienced good quality water. Salinity has not been an issue on the eastern side of the San Joaquin Valley.

Table 4-1. Opportunities for Desalinated Water

Sources of water	Opportunities
Ocean water	None
Brackish ocean water	None
Brackish groundwater	None

4.3. Groundwater Quality

This section describes the water quality of the existing water supply sources within the City and the manner in which water quality affects water management strategies and the water supply.

The quality of existing groundwater supply sources over the next 20 years is expected to be adequate. All groundwater supplies in the City meet or exceed all current drinking water standards, including secondary standards regulated for aesthetic qualities. There are no significant changes expected in the water quality of the City's groundwater sources. The City currently treats the groundwater by chlorination and adds fluoridation at each well site.

Dibromochloropropane (DBCP) was a chemical previously used by farmers in the service area to control nematodes in vineyards and other crops. The chemical was prohibited from further use in California in 1977, but is still present in trace levels in some groundwater supplies. The maximum contaminant level (MCL) for DBCP has been set at 0.2 micrograms per liter (µg/L). DBCP was detected in only one of the City's wells, with concentrations of DBCP ranging from 0.061 to 0.098 µg/L, well below the MCL.

The City's well site 10B was threatened with contamination by trichloroethene (TCE) although the concentration never reached the TCE primary drinking water limitation of 5 µg/L. A new well, 10-R2, was drilled in 2002 and placed online in August 2005. Production water from Well 10-R2 has not detected TCE. Well 10B is scheduled for proper well destruction in 2006. The shallower, contaminated aquifer around the 10B well site is being remediated by the General Electric Company. The City is also monitoring tetrachloroethylene, also known as perchloroethylene, contamination at seven former dry cleaner locations, but these groundwater contamination sources do not currently pose a threat to the

City water supply.

The drinking water standard for arsenic will be reduced from 50 µg/L to 10 µg/L, effective January 23, 2006 (DHS, 2005; EPA, 2005). The City water supply currently meets the arsenic MCL of 10 µg/L. The California Department of Health Services (DHS) is required to set a constituent's MCL at a level as close as practicable to its public health goal (PHG). The PHG for arsenic is currently 0.004 µg/L (EPA, 2004). If the arsenic MCL is reduced to close to the PHG limit, arsenic could potentially be a future water quality concern for the City. As there are no immediate plans to further reduce the arsenic drinking water limitation, arsenic does not pose a threat to the City groundwater supply.

Water quality influences the City's water management strategies and its efforts to comply with Federal and State drinking water regulations. These regulations require rigorous water quality testing, source assessments, and treatment compliance. No other special water management strategies due to water quality effects are necessary.

It is anticipated that the City will continue to depend on groundwater as a reliable water supply. Water supply changes due to water quality are not expected, as provided in Table 4-2.

Table 4-2. Current and Projected Water Supply Changes Due to Water Quality

Water supply sources	2005 (%)	2010 (%)	2015 (%)	2020 (%)	2025 (%)
Groundwater	0	0	0	0	0
Recycled water	0	0	0	0	0
Desalinated water	0	0	0	0	0

4.4. Current and Projected Normal Year Water Supplies

The current and projected sustainable water supply for the City's system during a normal water year is summarized in Table 4-3. As described earlier, the Merced Subbasin is in a mild overdraft condition and a groundwater recharge program is being developed. The Merced Subbasin is the sole source of the City's water supply. As stated in Chapter 3 of this Plan, the City water supply demands are expected to

increase from 30,118 ac-ft/yr in 2005 to 55,677 ac-ft/yr in 2025.

The new well installed on the UC Merced campus (Well 17) produced an average of 300 ac-ft/yr in 2005, with a maximum pumping capacity of 4,840 ac-ft/yr. Newly installed Wells 15 and 16 have the same pumping capacity as Well 17. Production at these three wells will incrementally increase as the SUDP supply needs increase. The development of the City's groundwater supply will be phased to meet the demands of the developing City and campus. In the future, the on-campus water supply may be supplemented with recycled water generated from the campus for use in toilets, cooling towers, or landscape irrigation. As the UC Merced campus grows, development of the groundwater supply will be coordinated with recommendations from the City and MID, using the *Merced Water Supply Plan* as a guide. Current and potential future recycled water supply is addressed in Chapter 5. Loss of water supply due to water quality is not anticipated.

Table 4-3. Normal Year Water Supply

Sustainable water supply	2005 (ac-ft/yr)	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Surface water[a]	10	58	105	153	200
Groundwater[b,c]	31,000	37,000	42,000	49,000	56,000
Recycled water	0	0	0	0	0
Desalinated water	0	0	0	0	0
Total	31,010	37,058	42,105	49,153	56,200

[a] The City and MID plan to phase in use of surface water from MID for landscape irrigation.
[b] Water supply estimated based on projected water demands. Assumed groundwater supply can be sufficiently increased to meet water demands.
[c] Production from newly installed Wells 15, 16, and 17 will increase incrementally to meet increased water demands. Wells 15 and 16 will be online in 2006.

4.5. Water Supply Reliability

This section describes the reliability of the water supply and its vulnerability to seasonal or climatic shortages. A water supply reliability comparison is made in Table 4-4 for the Year 2025, considering three water supply scenarios: average/normal water year, single-dry water year, and multiple-dry water years.

Table 4-4. Water Supply Reliability for 2025

Sustainable water supply	Normal year (ac-ft/yr)	Single-dry year (ac-ft/yr)	Multiple-dry years		
			Year 1 (ac-ft/yr)	Year 2 (ac-ft/yr)	Year 3 (ac-ft/yr)
Surface water	200	200	200	200	200
Groundwater	56,000	56,000	56,000	56,000	56,000
Recycled water	0	0	0	0	0
Desalinated water	0	0	0	0	0
Total	56,200	56,200	56,200	56,200	56,200
Percent of normal year supply	100%	100%	100%	100%	100%

Although groundwater levels have declined at a greater rate during drought periods, the annual quantity of groundwater available does not vary significantly in relation to wet or dry years. The reliability does not change due to seasonal or climatic shortages and groundwater quantity is assumed to be generally unaffected by short-term drought conditions. Water quality issues are not anticipated to have significant impact on water supply reliability.

Groundwater is a consistent source, so no replacement plan is needed. However, the City and MID are cooperating on a long-range plan to stabilize groundwater levels and on investigating the potential of recharge with imported surface water from the Merced River. The City has adequate groundwater supply to provide water supply during single-dry and multiple-dry years. The water shortage contingency plan was implemented in 1993 in response to the drought in the late 1980s and remains in effect. Water demand management measures would reduce water demands and thereby reduce water supply needs. The water shortage contingency plan is presented in Appendix D. Chapter 6 of this Plan describes the City's current demand management measures.

4.5.1. Projected Single-Dry Year Water Supplies

The projected single-dry year water supplies are provided in Table 4-5. The projected supplies take into account expected changes to the water demand by sector.

Table 4-5. Projected Single-Dry Year Water Supplies

Water supply sources	2005 (ac-ft/yr)	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Total supply[a]	31,010	37,058	42,105	49,153	56,200
Percent of normal year supply	100%	100%	100%	100%	100%

[a] Production from newly installed Wells 15, 16, and 17 will increase incrementally to meet increased water demands. Wells 15 and 16 will be online in 2006.

4.5.2. Projected Multiple-Dry Year Water Supplies

This section projects the impact of a multiple-dry year period for each five-year period during the 20-year projection interval for this Plan. Tables 4-6 through 4-9 provide an estimate of the projected multiple-dry year water supplies for each five-year period.

Table 4-6. Projected Multiple-Dry Year Water Supplies, Period Ending 2010

Water supply sources	2006 (ac-ft/yr)	2007 (ac-ft/yr)	2008 (ac-ft/yr)	2009 (ac-ft/yr)	2010 (ac-ft/yr)
Total supply[a]	32,220	33,429	34,639	35,848	37,058
Percent of normal year supply	100%	100%	100%	100%	100%

[a] Production from newly installed Wells 15, 16, and 17 will increase incrementally to meet increased water demands. Wells 15 and 16 will be online in 2006.

Table 4-7. Projected Multiple-Dry Year Water Supplies, Period Ending 2015

Water supply sources	2011 (ac-ft/yr)	2012 (ac-ft/yr)	2013 (ac-ft/yr)	2014 (ac-ft/yr)	2015 (ac-ft/yr)
Total supply[a]	38,067	39,077	40,086	41,096	42,105
Percent of normal year supply	100%	100%	100%	100%	100%

[a] Production from newly installed Wells 15, 16, and 17 will increase incrementally to meet increased water demands. Wells 15 and 16 will be online in 2006.

Table 4-8. Projected Multiple-Dry Year Water Supplies, Period Ending 2020

Water supply sources	2016 (ac-ft/yr)	2017 (ac-ft/yr)	2018 (ac-ft/yr)	2019 (ac-ft/yr)	2020 (ac-ft/yr)
Total supply[a]	43,515	44,924	46,334	47,743	49,153
Percent of normal year supply	100%	100%	100%	100%	100%

[a] Production from newly installed Wells 15, 16, and 17 will increase incrementally to meet increased water demands. Wells 15 and 16 will be online in 2006.

Table 4-9. Projected Multiple-Dry Year Water Supplies, Period Ending 2025

Water supply sources	2021 (ac-ft/yr)	2022 (ac-ft/yr)	2023 (ac-ft/yr)	2024 (ac-ft/yr)	2025 (ac-ft/yr)
Total supply[a]	50,562	51,972	53,381	54,791	56,200
Percent of normal year supply	100%	100%	100%	100%	100%

[a] Production from newly installed Wells 15, 16, and 17 will increase incrementally to meet increased water demands. Wells 15 and 16 will be online in 2006.

4.6. Water Supply Projects

This section provides a description of the water supply projects and water supply programs that will and may be undertaken by the City to meet the total projected water use and provide system reliability. The campus was opened in 2005 and is currently served by City Well 17 and a 250,000 MG storage tank. Although it is premature to project the campus water supply projects in the immediate future, the City and UC Merced are cooperating on planning water and wastewater facilities for future phases of campus development to meet the demands of the growing campus (UC Merced, 2002; Mian, 2005). In the future, groundwater may be supplemented with recycled water generated from the campus for cooling tower use and landscape irrigation.

City Wells 15 and 16 are scheduled to be placed into service in 2006. Well 18 will be placed into service in 2007 and several additional wells are planned for 2008 through 2011 to meet the water needs of the growing City and campus. The City and MID are working on programs to recharge the groundwater aquifer with surface water as well as plans to phase in surface water use for irrigation. These are future projects not yet in the planning stages, so water supply estimates are not available. The water supply projects and water supply programs in progress or planned for the near future are presented below in Table 4-10.

Table 4-10. Future Water Supply Projects and Projected Water Supply Contribution

Project name	Normal year (ac-ft/yr)	Single-dry (ac-ft/yr)	Multiple-dry years		
			Year 1 (ac-ft/yr)	Year 2 (ac-ft/yr)	Year 3 (ac-ft/yr)
Well 15	4,840	4,840	4,840	4,840	4,840
Well 16	4,840	4,840	4,840	4,840	4,840
Well 18	4,840	4,840	4,840	4,840	4,840
Additional wells	NA	NA	NA	NA	NA
Groundwater recharge and conjunctive use	NA	NA	NA	NA	NA

NA = Not available

4.7. Transfer and Exchange Opportunities

The City and MID are considering a long-term transfer opportunity, whereby the City will phase in surface water use for City park irrigation with water imported from the Merced River, as shown in Table 4-11. As presented earlier in Table 4-3, surface water use is tentatively projected to increase from 10 ac-ft/yr in Year 2005 to 200 ac-ft/yr by Year 2025. Although the water supply source for the 20-year planning period is sufficient and capable of meeting anticipated demands, conjunctive use is beneficial to the City by reducing groundwater pumping demands. MID currently provides irrigation water to Golden Valley High School and agricultural users.

There are no opportunities for exchanges, nor are there facilities to receive or deliver exchanged water.

Table 4-11. Transfer and Exchange Opportunities

Source transfer agency	Transfer or exchange	Short-term	Proposed quantities	Long-term	Proposed quantities
MID	Transfer	--	--	20 years	Up to 200 ac-ft/yr
Total	--	--	--	20 years	Up to 200 ac-ft/yr

Note: Long-term refers to water transfers or exchanges lasting for a period of more than one year.

CHAPTER 5

RECYCLED WATER

The purpose of this chapter is to provide information on recycled wastewater and its potential for use as a water resource in the City. The elements of the chapter are (1) the quantity of wastewater generated in the service area, (2) a description of the collection, treatment, and disposal/reuse of that wastewater, (3) the current plans for water recycling, and (4) the potential for water recycling in the service area.

5.1. Recycled Water Plan Coordination

The City is the sole agency responsible for collecting, treating, and recycling wastewater in the area. The City developed the recycled water plan for the service area and understands that reuse is an important element of integrated water supply planning and supports the development of further reuse supply components. As shown in Table 5-1, no other local water, wastewater, groundwater, or planning agencies within the service area participated in the development of the City's recycled water plan. UC Merced is within the SUDP and the City anticipates coordination with the campus regarding recycled water use in the future. As the campus grows, it will have potential recycling opportunities in the future.

Table 5-1. Agency Participation in Reuse Planning

Participating Agency	Role
City of Merced	Sole agency responsible for wastewater collection, treatment, and recycling. Developed recycle water plan for service area.
UC Merced	Potential future on-campus recycling opportunities.

5.2. Wastewater Quantity, Quality, and Current Uses

The following section describes the estimated wastewater generated in the City's service area, treatment process, and the current wastewater reuse methods in the area.

Two types of wastewater is collected, treated, and recycled by the City, municipal wastewater and process water. Municipal wastewater is generated in the service area from a combination of residential,

commercial, and industrial sources. It is collected and treated at the City's Wastewater Treatment Facility (WWTF) and the treated effluent is discharged to Hartley Slough and a wildlife management wetland for reuse. Process water generated from the Unilever Best Foods, North America cannery is conveyed via a separate pipeline to the Industrial Wastewater Treatment Facility (IWTF) adjacent to the WWTF during the tomato processing season and land applied to City-owned land.

5.2.1. Wastewater Generation

Municipal wastewater is generated in the service area from a combination of residential, commercial, and industrial sources. The quantities of wastewater generated are proportional to the population and water use in the service area. Estimates of average wastewater flows for the present and future SUDP conditions are based on the methodologies and projections in the *Merced Water Reuse Strategic Plan* and are presented in Table 5-2 (CH2MHill, 2001b). Residential flows were based on the population projections in Tables 3-1 and 3-2 and a per capita unit flow of 100 gal/capita/day, up to a population of 70,000, and 85 gal/capita/day above a population of 70,000. Industrial and commercial flows were estimated using the land use method in the *Merced Water Reuse Strategic Plan* and the employee projections from the *Merced Vision 2015 General Plan* and the UC Merced *Long Range Development Plan.* The *Merced Water Reuse Strategic Plan* originally assumed that the UC Merced campus and University community were outside the SUDP and not part of the City service area. With the completed campus now discharging to the City sewer system, the residential SUDP wastewater flow estimates were revised to include the UC Merced campus contribution using the projected campus populations from the *Long Range Development Plan.* For campus industrial and commercial wastewater flows, estimates were calculated assuming the campus contributes only office commercial flows. The University community will not be serviced by the City water supply or sewer system.

In Table 5-2, the recycled water standard refers to the Title 22 standards for drinking water. Most of the WWTF treated effluent is currently discharged to Hartley Slough for agricultural use and not used as a potable water source. Therefore, the wastewater effluent water quality is required to meet the City's National Pollutant Discharge Elimination System (NPDES) permit limitations instead. After

completion of the planned WWTF improvements, the wastewater will undergo tertiary treatment and meet Title 22 standards as discussed further in the following section.

Table 5-2. Wastewater Collection and Treatment in SUDP

Year	SUDP wastewater ADWF (excluding UC Merced) (ac-ft/yr)	UC Merced campus ADWF[a] (ac-ft/yr)	SUDP total wastewater ADWF (ac-ft/yr)	Quantity that meets recycled water standard[b] (ac-ft/yr)
2005	9,742	157	9,898	0
2010	10,866	678	11,544	11,544
2015	11,794	1,019	12,813	12,813
2020	12,716	1,330	14,046	14,046
2025	13,532	1,676	15,208	15,208

Source: Wastewater flow calculation methodologies and estimates from *Merced Water Reuse Strategic Plan* (CH2MHill, 2001b).
ADWF = Average dry weather flow
[a] Assumes UC Merced campus has only office commercial and no industrial or retail commercial.
[b] Upgrade to tertiary treatment scheduled for completion in 2008.

5.2.2. Wastewater Collection and Treatment

The City owns, operates, and maintains the wastewater system that serves the community. The sewer system consists of up to 48-inch diameter gravity sewers, pumping stations, and force mains to collect wastewater from residential, industrial, and commercial connections. The wastewater is collected and discharged to trunk sewers and interceptors that convey the wastewater to the City's WWTF for treatment.

The City-owned and -operated WWTF is located two miles south of the Merced Municipal Airport and provides service to the City and UC Merced campus. Currently, wastewater at the WWTF undergoes conventional secondary treatment with activated sludge and chlorination/dechlorination. The WWTF has a capacity to treat 10 million gallons per day (mgd) or 11,200 ac-ft/yr of wastewater. In 2005, approximately 9 mgd (9,875 ac-ft/yr) of wastewater is projected to be treated at the WWTF.

The City has two incremental expansion plans for the existing WWTF, each increasing the capacity by 5 mgd (Tucker, 2005). The increase should provide sufficient capacity until sometime between 2025 and

2035. The designs for both projects are being developed concurrently, but the City has not made a decision on whether the construction for both will occur simultaneously. Construction to increase the plant capacity by 5 mgd will begin in the Summer 2006. The completion schedule for the second expansion, increasing capacity by another 5 mgd, has not been determined.

The treatment process will be upgraded from secondary to tertiary treatment with ultra-violet disinfection to meet Title 22 requirements, with completion scheduled for 2008. The enhancements will include improved sludge handling as well as dewatering and solar drying the digested solids to produce Class A biosolids for use as fertilizer. In the interim before these expansion projects are complete, construction will begin in the Summer 2006 for a small increase in plant capacity to 11.5 mgd as well as significant wastewater treatment improvements (Tucker, 2005).

Industrial tomato process water from the Unilever Best Foods, North America cannery is transported in a separate trunk line than the WWTF during the tomato harvest season. The cannery was formerly owned by Lipton Foods. The process water is recycled through land application from July to November. Approximately 331 ac-ft/yr of process water is produced by the cannery each season. The process water is applied directly to the land at the 580-acre IWTF south of the wastewater treatment plant. The IWTF land application site is owned by the City. This land application provides water for agricultural crops, which are harvested by the City. Cannery wastewater produced during the remainder of the year and all other industrial wastewater within the City is discharged to the domestic sewer system.

5.3. Water Recycling Current Uses

Treated effluent from the WWTF is discharged to a gravity channel that conveys the treated effluent to Hartley Slough and a wildlife management area wetland. The primary source of water for Hartley Slough is treated effluent from the WWTF. Water from the Slough is subsequently used for agricultural irrigation. Approximately 1.2 mgd (1,344 ac-ft/yr) of treated effluent is pumped from the gravity channel to an adjacent 380-acre wildlife management area wetland to create a series of percolation/evaporation ponds. Most of the treated effluent from the WWTF is recycled for irrigation

and wetland use within the Merced Subbasin. During the winter months when peak flows and water levels are high, a portion of the water is discharged to the San Joaquin River. Recycled water use does not replenish the quantity of water pumped by the City, but does reduce the agricultural pumping demand for groundwater within the groundwater basin.

Most treated effluent is recycled for agricultural irrigation, wildlife habitat enhancement, and wetlands, with the existing quantities shown in Table 5-3.

Table 5-3. Existing Recycled Water Uses

Type of use	Treatment level	2005 (ac-ft/yr)
Agricultural irrigation		
Hartley Slough[a]	Secondary	8,554
Process water[b]	Screening	331[c]
Landscape	--	--
Wildlife habitat[d]	Secondary	1,344
Wetlands	--	--
Industrial	--	--
Groundwater recharge	--	--
Total	--	10,230

[a] Treated effluent discharged from WWTF to Hartley Slough, with subsequent use for agricultural irrigation.
[b] Tomato process water, conveyed in a separate pipeline to IWTF for land application on City-owned land during the processing season (July through November).
[c] 2002 processing season total.
[d] 380 acre wildlife management area wetland to create percolation/evaporation ponds.

5.4. Potential and Projected Use of Reclaimed Water

This section presents the projected potential uses and methods to optimize water reuse in the future.

5.4.1. Potential Use of Reclaimed Water

The agricultural and environmental reuse of treated effluent via Hartley Slough and wetlands does not replace the groundwater pumped by the City. However, it does reduce the groundwater use in the area by reducing groundwater pumping for agricultural irrigation. Having the treated wastewater as an additional resource offsets part of the agricultural demand for groundwater and can be viewed as a form

of indirect recycling.

The 2001 *Merced Water Reuse Strategic Plan* identified reuse alternatives for the WWTF to accommodate future flows based on secondary and tertiary treatment of wastewater. Secondary treatment reuse alternatives included limited agricultural reuse (some crops), discharge to a private wetland or duck club, and continued discharge to the wildlife management area wetland and Hartley Slough. Tertiary treatment reuse alternatives included unlimited agricultural reuse (all crops), urban landscape irrigation (with centralized and satellite treatment), industrial reuse, and discharge to a public access wildlife refuge. The Stakeholders Advisory Group, consisting of community members representing agriculture, land development, wildlife and environmental, industry, commerce, and wastewater customers, recommended continued discharge of treated effluent to the City's wetland and Hartley Slough and increasing the treatment capacity of the WWTF to 15 mgd. Because the WWTF has had treatment performance and reliability issues since 1995, the selection of this alternative was based on it being the most expeditious to implement as well as the least expensive. Since this alternative provides for essentially 100 percent agricultural reuse and provides an alternative to groundwater pumping, it was also considered of maximum benefit to the environment.

Expansion of the WWTF to 11.5 mgd will begin in 2006, followed by two more WWTF capacity increases to 15 mgd and 20 mgd, respectively, and the implementation of tertiary treatment. The treated effluent will continue to be used for agricultural irrigation and discharged to the wildlife management area. After inception of tertiary treatment, the effluent may also be used for urban landscape irrigation in the future, though there are currently no plans to do so. Table 5-4 presents the projected potential recycled water uses.

Table 5-4. Potential Recycled Water Uses

Type of use	Treatment level	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Agriculture	Screening[a]	331	331	331	331
	Secondary[b]	10,200	11,469	12,702	13,864
	Tertiary	0	0	0	0
Landscape	Tertiary	0	0	0	0
Wildlife habitat	Secondary[c]	1,344	1,344	1,344	1,344
	Tertiary	0	0	0	0
Wetlands	Secondary	0	0	0	0
Industrial	Tertiary	0	0	0	0
Groundwater recharge	Tertiary	0	0	0	0
Total	--	11,875	13,144	14,378	15,540

[a] Tomato processing water, conveyed in a separate pipeline to IWTF for land application on City-owned land during the processing season (July through November).

[b] Treated effluent discharged from WWTF to Hartley Slough, with subsequent use for agricultural irrigation.

[c] 380 acre wildlife management area wetland to create percolation/evaporation ponds.

5.4.2. Projected Future Use of Reclaimed Water

It is anticipated that the WWTF expansion and improvements (Phases 1 through 3) outlined in the *Merced Water Reuse Strategic Plan* will serve the needs of the City until sometime between 2025 and 2035. After completion of the tertiary treatment system, the WWTF effluent may also be used for urban landscape irrigation in the future. However, there are no current plans to construct the transmission lines and pumping stations needed to return treated wastewater to the water utility service area for urban landscape irrigation or industrial reuse in the near future. For the purposes of this report, no recycled water for urban use within the City's service area is assumed for the next 20 years. The future use of recycled water within the City is still being evaluated, and this assumption may change in the future. Table 5-5 shows the projected future use of recycled water for the planning period.

Other future uses of reclaimed water include opportunities on the UC Merced campus. As the campus begins to develop, the UC Merced long-range plan is to maximize recycled water generated on-campus. Specifically, the potential uses of recycled water include toilet flushing, cooling tower use, or landscape irrigation (UC Merced, 2002).

Table 5-5. Projected Future Use of Recycled Water

Type of use	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Agriculture[a,b]	10,531	11,800	13,034	14,196
Landscape	0	0	0	0
Wildlife habitat[c]	1,344	1,344	1,344	1,344
Wetlands	0	0	0	0
Industrial	0	0	0	0
Groundwater recharge	0	0	0	0
Total	11,875	13,144	14,378	15,540

[a] Treated effluent discharged from WWTF to Hartley Slough, with subsequent use for agricultural irrigation.
[b] Tomato processing water, conveyed in a separate pipeline to IWTF for land application on City-owned land during harvest season (July through November).
[c] 380 acre wildlife management area wetland to create percolation/evaporation ponds.

5.5. Optimizing the Use of Reclaimed Water

The City supports use of reclaimed water in the service area where economically feasible, though there are no current plans to do so. The City has, however, taken steps to promote and expand the use of reclaimed water and promote awareness among City stakeholders. The majority of the potential use of recycled water consists of agricultural demands and none are planned for urban reuse. As shown in Table 5-6, the actual recycled water usage for 2005 was higher than projected. With the opening of UC Merced, additional wastewater will be collected, treated, and recycled. The total wastewater volume will continue to increase as the UC Merced campus population grows to the anticipated capacity.

Table 5-6. Recycled Water Uses – 2005 Projection versus Actual

Type of Use	2000 projection for 2005 (ac-ft/yr)	2005 actual use (ac-ft/yr)
Agriculture[a,b]	8,737	8,886
Landscape	0	0
Wildlife habitat[c]	1,344	1,344
Wetlands	0	0
Industrial	0	0
Groundwater recharge	0	0
Total	10,081	10,230

[a] Treated effluent discharged from WWTF to Hartley Slough, with subsequent use for agricultural irrigation.
[b] Tomato processing water, conveyed in a separate pipeline to WWTF for land application on City-owned land during harvest season (July through November).
[c] 380 acre wildlife management area wetland to create percolation/evaporation ponds.

The City does not provide or maintain incentives to use reclaimed water, as shown in Table 5-7. The City currently promotes recirculating uses of water within the service area. This is demonstrated in the City's water shortage contingency plan (Appendix D) which requires ornamental fountains to use a recirculating water system during water shortages.

Table 5-7. Methods to Encourage Recycled Water Uses

Actions	Projected water use as a result of this action			
	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Financial incentives	0	0	0	0
Other	0	0	0	0
Total	0	0	0	0

CHAPTER 6

WATER CONSERVATION BEST MANAGEMENT PRACTICES

Water conservation is a method available to reduce water demands, thereby reducing water supply needs for the City. This chapter describes the City's current conservation program, presents an economic analysis of water conservation best management practices (BMPs), and describes the methods and assumptions used to conduct the analysis. The demand management measures (DMMs) described in the Act are typically referred to as BMPs.

The unpredictable water supply and ever increasing demand on California's complex water resources have resulted in a coordinated effort by DWR, water utilities, environmental organizations, and other interested groups to develop a list of urban BMPs for conserving water. This consensus-building effort resulted in a *Memorandum of Understanding Regarding Urban Water Conservation in California*, as amended March 10, 2004, which formalized an agreement to implement these BMPs and makes a cooperative effort to reduce the consumption of California's water resources. The BMPs, as defined by this MOU, are presented in Table 6-1. The MOU is administered by the California Urban Water Conservation Council (CUWCC). The City is not a signatory of the MOU.

Table 6-1. Water Conservation Best Management Practices

No.	BMP Name
1	Water survey programs for single family residential and multi-family residential customers.
2	Residential plumbing retrofit.
3	System water audits, leak detection, and repair.
4	Metering with commodity rates for all new connections and retrofit of existing connections.
5	Large landscape conservation programs and incentives.
6	High-efficiency washing machine rebate programs.
7	Public information programs.
8	School education programs.
9	Conservation programs for commercial, industrial, and institutional accounts.
10	Wholesale agency programs.
11	Conservation pricing.
12	Water conservation coordinator.
13	Water waste prohibition.
14	Residential ultra-low-flush toilet (ULFT) replacement programs.

The value to the City of signing the MOU, which is a voluntary agreement, cannot be quantified. Being a signatory of the MOU may be a future requirement to receive water project grant and loan funding

from the State.

The MOU requires that a water utility implement only the BMPs that are economically feasible. If a BMP is not economically feasible, the water utility may request an economic exemption for that BMP.

6.1. Current Water Conservation Program

The City has an ongoing water conservation program and has had a water conservation ordinance since 1993. Water conservation in the City is supported by the City Council. The current program consists mainly of public education, school education programs, outdoor watering restrictions enforced by code enforcement personnel, an alternate watering schedule, and metering of all new services installed after January 1992.

BMP 1. Water survey programs for single family residential and multi-family residential connections.

Description: The City is not currently implementing this BMP because it is not cost effective to the City. An economic evaluation of this BMP is provided in Appendix E of this Plan and discussed in Section 6.2 of this Chapter.

Schedule: Not applicable. The City is not currently implementing this BMP.

Evaluation of BMP Effectiveness: Not applicable. The City is not currently implementing this BMP.

BMP 2. Residential plumbing retrofit.

Description: The City is not currently implementing this BMP. An economic evaluation of this BMP was performed that concluded that the benefit to cost ratio for employing this BMP is equal to 1.0. This means that it is cost effectively neutral for the City, i.e. the total benefits equal the total costs to implement. The City is currently considering this BMP but has not made plans to implement it. The

economic evaluation is provided in Appendix E of this Plan and discussed further in Section 6.2 of this chapter.

Schedule: Not applicable. The City is not currently implementing this BMP.

Evaluation of BMP Effectiveness: Not applicable. The City is not currently implementing this BMP.

BMP 3. System water audits, leak detection, and repair.

Description: A system water audit, leak detection, and repair program consists of ongoing leak detection and repair within the system, focused on the high probability leak areas. This may also include meter calibration and replacement for all production and distribution meters.

The City's program involves leak detection and repair, focusing primarily on the high probability areas. The program does not involve an annual system-wide audit at this time and the City has no knowledge of when the last system-wide water audit was conducted. The water distribution consists of approximately 500 miles of pipe. The City repairs approximately 800 leaks per year from polymer pipe, which consumes the greatest part of the City's leak repair manpower. All other leaks are repaired in a timely manner, whether they are residential or main-line leaks up to 16-inches. The City still has a large inventory of sand-cast water mains in the system which they try to replace whenever the street is upgraded. The City has completed approximately two-thirds of its three- to five- year program to replace the existing polybutylene service connections with copper connections. Once the replacement program is complete, leak repairs are expected to return to the typical rate of one to two leak repairs per day. As part of the replacement program, pipelines nearby to the failing polybutylene service connections are also surveyed and repaired as needed.

Schedule: The City has an ongoing leak repair and detection program where they repair all leaks in a timely manner. The City also has a three- to five- year program to replace polybutylene service connections with copper units.

Evaluation of BMP Effectiveness: Effectiveness of this BMP will be evaluated by tracking leak detection and repair and by comparing prior and future water use. The City is not completely metered

so water savings can only be estimated. The estimated water savings and expenditures for past years and projected for the future are presented in Tables 6-2 and 6-3.

Table 6-2. Actual Conservation Activities, Expenditures, and Water Savings BMP 3: System water audits, leak detection, and repair.

Year	2001	2002	2003	2004	2005 (proj)
Percent unaccounted-for water[a]	10%	10%	10%	10%	10%
Number of leaks repaired[b]	800	800	800	800	800
Water savings[c], ac-ft/yr	628	654	680	706	731
Expenditures, $/yr	NA	NA	NA	NA	NA

NA = Data not available

[a] Unaccounted-for water is assumed to be 10 percent of total water production.

[b] Typically, an estimated 1 to 2 leaks are repaired each day (Wegley, 2005). Assumed polybutylene pipe replacement program to be completed in 2007.

[c] Leak repairs assumed to reduce water usage by 20 percent of total unaccounted-for water. Water savings for BMP 3 is typically non-quantifiable and assumption was based on professional judgment.

Table 6-3. Projected Conservation Activities, Expenditures, and Water Savings BMP 3: System water audits, leak detection, and repair.

Year	2006	2007	2008	2009	2010
Percent unaccounted-for water[a]	10%	10%	10%	10%	10%
Number of leaks repaired[b]	800	800	550	550	550
Water savings[c], ac-ft/yr	753	774	796	817	838
Expenditures, $/yr	NA	NA	NA	NA	NA

NA = Data not available

[a] Unaccounted-for water is assumed to be 10 percent of total water production.

[b] Typically, an estimated 1 to 2 leaks are repaired each day (Wegley, 2005). Assumed polybutylene pipe replacement program to be completed in 2007.

[c] Leak repairs assumed to reduce water usage by 20 percent of total unaccounted-for water. Water savings for BMP 3 is typically non-quantifiable and assumption was based on professional judgment.

BMP 4. Metering with commodity rates for all new connections and retrofit of existing connections.

Description: The City requires installation of meters on all new service connections installed after 1992 (CH2M Hill, 1999). All multi-family dwelling units are presently metered and the City has recently begun metering water use for all public parks. Commodity metering rates apply to all multi-family residential, commercial, and industrial services regardless of whether they were installed after 1992. The City requires meters for all new single-family dwelling units, with approximately 30 percent of all single family connections currently metered. The number of unmetered residential structures is approximately 11,145 (Suico, 2005).

The City is considering two meter retrofit options described in the *Merced Water Supply Plan Update, Final Status Report* (CH2MHill, 2001a). One retrofit option is for the City to install meters at existing unmetered connections. This retrofit program would be financed through increased residential water rates and would require adoption of a new city ordinance. Assuming $600 per retrofitted meter, obtaining full metering of single-family dwelling units would approach $7 million. This option would burden the public in terms of higher water rates and meter installation disruptions. On the other hand, the retrofit program would be completed in a timely and certain manner.

The second option involves the adoption of a new City ordinance requiring meter retrofitting at the time of title transfer of a residence. The cost of retrofitting would be absorbed by the homeowner and be included in the purchase of the residence. The City estimates that in eight years, 80 percent of residences would change ownership and, thus, become metered. This option requires further investigation, but is attractive in terms of the reduced financial burden to the City and the general public (CH2MHill, 2001a).

The City is currently considering the meter retrofit options but has not made plans to implement either.

Schedule: Metering with commodity rates for all new connections is an ongoing City program. The two options for retrofitting existing connections are currently under evaluation by the City. Implementation of either option can begin once the new City ordinance is adopted.

Evaluation of BMP Effectiveness: If the new City ordinance is adopted, effectiveness of this BMP can be evaluated by tracking the number of newly metered connections and comparing prior and future water use and water savings. Current and projected water savings and expenditures are shown in Tables 6-4 and 6-5.

Table 6-4. Actual Conservation Activities, Expenditures, and Water Savings BMP 4: Metering with commodity rates for all new connections and retrofit of existing connections.

Year	2001	2002	2003	2004	2005 (proj)
# of unmetered accounts[a,b]	11,183	11,147	11,110	11,074	11,145
# of retrofit meters installed	0	0	0	0	0
# of accounts without commodity rates	11,183	11,147	11,110	11,074	11,145
Expenditures, $/yr	0	0	0	0	0
Water savings, ac-ft/yr	0	0	0	0	0

[a] The change in the number of unmetered accounts is due to home sales. When an unmetered account changes ownership, it is not currently retrofitted with a metered.

[b] 2002 and 2003 data linearly extrapolated from available 2001 and 2004 data.

Table 6-5. Projected Conservation Activities, Expenditures, and Water Savings BMP 4: Metering with commodity rates for all new connections and retrofit of existing connections.

Year	2006	2007	2008	2009	2010
# of unmetered accounts	10,031	9,027	8,125	7,312	6,581
# of retrofit meters to be installed[a]	1,115	1,003	903	812	731
# of accounts without commodity rates	10,031	9,027	8,125	7,312	6,581
Expenditures, $/yr	NA	NA	NA	NA	NA
Water savings[b], ac-ft/yr	1,256	1,308	1,360	1,411	1,463

NA = Data not available

[a] Assumed 10 percent of existing unmetered connections are retrofitted annually, beginning in 2006.

[b] Estimated that metering results in a 20 percent reduction in demand (CUWCC, 2005).

BMP 5. Large landscape conservation programs and incentives.

Description: The City is not currently implementing this BMP. An economic evaluation of this BMP was performed that concluded that the benefit to cost ratio for employing this BMP is greater than 1.0, which means that it is cost effective for the City to implement. The City is currently considering this BMP but has not made plans to implement it. The economic evaluation is provided in Appendix E of this Plan and discussed further in Section 6.2 of this chapter.

Schedule: Not applicable. The City is not currently implementing this BMP.

Evaluation of BMP Effectiveness: Not applicable. The City is not currently implementing this BMP.

BMP 6. High-efficiency washing machine rebate programs.

Description: The City coordinates with MID, an energy service provider in the City service area, on conservation efforts. Under the residential rebate program operated by MID, a $75 rebate is offered to customers who purchase high-efficiency washing machines (those labeled with the Energy Star). The program began in fiscal year 2004-2005 and resulted in awarding 66 rebates. There are no other high-efficiency washing machine rebate programs offered within the City service area. As an energy provider, MID is concerned with, and therefore only tracks, energy savings. A high efficiency washing machine is expected to reduce water usage by 1,170 gallons per year per washer (CUWCC, 2005), so water savings for the program in fiscal year 2004-2005 was estimated to be 77,220 gallons.

The City is coordinating with MID and not currently implementing this BMP because it not cost effective to the City. An economic evaluation of this BMP is provided in Appendix E of this Plan and discussed in Section 6.2 of this Chapter.

Schedule: Not applicable. The City is not currently implementing this BMP.

Evaluation of BMP Effectiveness: Not applicable. The City is not currently implementing this BMP.

BMP 7. Public information programs.

Description: Public information is an ongoing component of the City's water conservation program. The City also coordinates with other government agencies, industry, and public interest groups and media on conservation programs, such as the high-efficiency washing machine rebate program with MID. The City's public education program consists of declaring a water awareness month, offering conservation-oriented curriculum to the local school system, issuing press releases to local radio and newspaper outlets, printing utility bill stuffers and educational flyers, issuing inexpensive water conservation kits, and establishing demonstration gardens that feature low water use plants. City utility bills include a comparison of the customer's current water usage to the previous year's usage. Examples of the water conservation materials and informational leaflets are included in Appendix F.

Local public outreach events include attending farmers' markets and other special events, such as the

annual open house hosted by the City. Staff converse with event visitors about the City's water conservation program and answer questions visitors might have concerning water issues. The City distributes information sheets and conservation kits at these events.

Schedule: The City's public information program is an ongoing annual program.

Evaluation of BMP Effectiveness: Water savings from this program cannot be directly quantified. The activities performed in this program as well as current and projected expenditures are not tracked by the City.

BMP 8. School education programs.

Description: School education is an ongoing component of the City's water conservation program. The City participates in school education programs by speaking at various local grade schools when requested and attending Career Day festivities at various local middle schools, high schools, and the Community College. During Career Day, speakers from the City's Departments of Operations, Laboratory, Environmental Control, and Maintenance provide information on their job duties and how the required skills may be acquired. Topics requested for presentations at grade schools include wastewater treatment, drinking water treatment, pollution prevention, and water conservation. Various publications from DWR and the U.S. Coast Guard are distributed during the presentations.

Schedule: The City's school education program is an ongoing annual program.

Evaluation of BMP Effectiveness: Savings from this program cannot be directly quantified. The activities performed in this program as well as current and projected expenditures are not tracked by the City.

BMP 9. Conservation programs for commercial, industrial, and institutional accounts.

Description: The City coordinates with MID, an energy service provider in the City service area, on

conservation efforts. MID operates a commercial and industrial energy conservation program, the Energy Retrofit and New Construction Program, which is offered to MID commercial and industrial customers. An indirect impact of more energy efficient projects is water conservation. Under the program, rebates are issued for projects that show an overall wattage reduction. MID will consider payment for conservation based either on total kilowatt hour saved over one year at a rate of $0.06 or 50 percent of the installation cost, whichever is lowest, up to $125,000 per year. MID budgets an amount each year for the projects and approves projects up to the budget limit. Water savings for the commercial and industrial program are not available since MID, as an energy provider, tracks only energy savings.

The City is not currently implementing this BMP. An economic evaluation of this BMP was performed that concluded that the benefit to cost ratio for employing this BMP is greater than 1.0, which means that it is cost effective for the City to implement. The City is currently considering this BMP but has not made plans to implement it. The economic evaluation is provided in Appendix E of this Plan and discussed further in Section 6.2 of this chapter.

Schedule: Not applicable. The City is not currently implementing this BMP.

Evaluation of BMP Effectiveness: Not applicable. The City is not currently implementing this BMP.

BMP 10. Wholesale agency programs.

This BMP is not applicable to the City because the City is not a wholesale agency.

BMP 11. Conservation pricing.

Description: The City currently implements conservation pricing for all its metered customers. All of the City's commercial, industrial, and multi-family customers are metered. Uniform quantity charge is considered to meet the definition of conservation pricing. Tiered rates are implemented for residential customers as they become metered.

The City requires all services installed on or after January 1, 1992 to be equipped with meters and charged for water based on a metered rate. Only those services that include single-family residences, churches, schools, public parks, and fire protection that were installed prior to January 1, 1992, may be charged for water on a flat-rate schedule provided the use is not expanded or changed. Metered rates apply to all multi-family residential, commercial, and industrial services whether or not they were installed before or after January 1, 1992. A discussion of account types that apply to the City is provided in Table 6-6.

Schedule: The City's conservation pricing program is ongoing.

Evaluation of BMP Effectiveness: The water savings from this BMP cannot be directly quantified. Effectiveness of this BMP will be evaluated by comparing City water use prior to and following the implementation of conservation pricing.

Table 6-6. Description of District Rate Structures
BMP 11: Conservation pricing.

Account type	Definition
Residential	
Water rate structure	Tiered conservation rate structure for metered customers, flat rate for unmetered customers.
Year rate became effective	Tiered rate structure becomes effective shortly after a customer receives a water meter.
Commercial, Industrial, Institutional	
Water rate structure	Tiered conservation rate structure (seasonal).
Year rate became effective	Tiered rate structure becomes effective shortly after a customer receives a water meter.
Irrigation (dedicated meter)	
Water rate structure	Tiered conservation rate structure (seasonal).
Year rate became effective	Tiered rate structure becomes effective shortly after a customer receives a water meter.

BMP 12. Water conservation coordinator.

Description: The City does not currently employ a water conservation coordinator. Instead, water conservation monitoring is part of the responsibilities of the code enforcement patrol staff, which consists of four full-time employees whose duties are to enforce the provisions outlined in the City

Municipal Code. Approximately 10 percent of the patrol staff time is dedicated to the water conservation monitoring activities. Due to the effectiveness of the code enforcement patrol staff and the large coverage area monitored, the City plans to hire an additional patrol staff employee in 2006 and another in 2007.

Ordinance No. 1842 (Appendix D), which also constitutes the City's water shortage contingency plan, outlines the water conservation measures and water waste prohibitions enforced by the City. These include prohibition of water waste, provision for dissemination of information and advice to aid water customers, notices of violation issuance for water wasting, and levying fines. Prohibited uses of City water include washing driveways and sidewalks, non-recirculating fountains, washing houses and trailer homes (unless they are being prepared for painting), and automobile washing without an automatic shut-off nozzle. When water wasting is observed, the customer is fined and given the water waste ordinance information pamphlets. A water waster could potentially be metered if they continue to violate the ordinance. Working in conjunction with the City's Finance Department, water service to connections can be activated or terminated, as needed.

Schedule: The City's water conservation program is ongoing. The code enforcement patrol staff continuously monitors the activities in the service area.

Evaluation of BMP Effectiveness: Water savings from this program cannot be directly quantified. Effectiveness of this BMP can be evaluated by the success of the City's water conservation program. Estimates for current and future program expenditures are shown in Tables 6-7 and 6-8.

Table 6-7. Actual Conservation Activities and Water Savings
BMP 12: Water Conservation Coordinator

Item	2001	2002	2003	2004	2005 (proj)
Full-time positions	3	3	3	4	4
Part-time staff	0	0	0	0	0
Position supplied by other agency	0	0	0	0	0
Expenditures[a,b], $	$20,376	$20,376	$20,376	$27,168	$27,168

[a] Assumed to be 10 percent of staff salary and fringe since 10 percent of patrol staff time is dedicated to water conservation monitoring activities. Annual salary for a Level 5 Code Enforcement Specialist is $45,280 based on the salary listings on the City of Merced website, updated August 29, 2005 (City of Merced, 2005). A 1.5 multiplication factor was applied to the annual salary to estimate the total of annual salary and fringe benefits.

[b] Total combined expenditures for BMPs 12 and 13.

Table 6-8. Projected Conservation Activities and Water Savings
BMP 12: Water Conservation Coordinator

Item	2006	2007	2008	2009	2010
Full-time positions	5	6	6	6	6
Part-time staff	0	0	0	0	0
Position supplied by other agency	0	0	0	0	0
Expenditures[a,b], $	$33,961	$40,753	$40,753	$40,753	$40,753

[a] Assumed to be 10 percent of staff salary and fringe since 10 percent of patrol staff time is dedicated to water conservation monitoring activities. Annual salary for a Level 5 Code Enforcement Specialist is $45,280 based on the salary listings on the City of Merced website, updated August 29, 2005 (City of Merced, 2005). A 1.5 multiplication factor was applied to the annual salary to estimate the total of annual salary and fringe benefits.

[b] Total combined expenditures for BMPs 12 and 13.

BMP 13. Waste water prohibition.

Description: The City's Ordinance No. 1842 includes mandatory water usage prohibitions designed to discourage water waste and encourage conservation for the greatest public benefit. Prohibitions include limited landscape irrigation, exterior washing of buildings and structures, surface cleaning of sidewalks and driveways, and use of ornamental fountains without recirculating systems. Landscape irrigation is managed by an alternate watering schedule for sprinkling, watering, and irrigation, which is based on the street address of the residence or business. Those water users whose addresses end in an even number can water on Tuesday, Thursday, and Saturday, except between the hours of 11 a.m. and 7 p.m. Odd-numbered addresses can water on Wednesday, Friday, and Sunday, except between 11 a.m. and 7 p.m. No landscape watering is allowed on Monday. Watering day reminders have been periodically included in the utility bills, on local radio stations, and announced in the local newspapers. This ordinance also

constitutes the City's water shortage contingency plan and a copy is included in Appendix D.

Statistical reports regarding the quantity of cease-desist orders issued, the amount of funds collected for water conservation violations, including how many 48-hour notices were issued, are maintained. As described in the discussion for BMP 12, water conservation monitoring is part of responsibilities of the code enforcement patrol staff, whose duties are to enforce the provisions outlined in the City Municipal Code. Approximately 10 percent of the patrol staff time is dedicated to the water conservation monitoring activities. When water wasting is observed, the customer is fined and given the water waste ordinance information pamphlets. A water waster could potentially be metered if he continues to violate the ordinance. Other penalties include termination of water service and levying a reconnection fee.

Schedule: The implementation of this BMP is ongoing. The City ordinance was adopted on January 19, 1993.

Evaluation of BMP Effectiveness: Water savings from this program cannot be directly quantified. Expenditures and activities for this BMP are shown in Tables 6-9 and 6-10.

Table 6-9. Actual Conservation Activities and Water Savings
BMP 13: Water waste prohibition

Item	2001	2002	2003	2004	2005 (proj)
Waste ordinance in effect	Ord. No. 1842	Ord. No. 1842	Ord. No. 1842	Ord. No. 1842	Ord. No. 1842
Onsite visits	8	8	8	8	8
Water softener ordinance	None	None	None	None	None
Expenditures[a,b], $	$20,376	$20,376	$20,376	$27,168	$27,168

[a] Assumed to be 10 percent of staff salary and fringe since 10 percent of patrol staff time is dedicated to water conservation monitoring activities. Annual salary for a Level 5 Code Enforcement Specialist is $45,280 based on the salary listings on the City of Merced website, updated August 29, 2005 (City of Merced, 2005). A 1.5 multiplication factor was applied to annual salary to estimate annual salary and fringe benefits.

[b] Total combined expenditures for BMPs 12 and 13.

Table 6-10. Projected Conservation Activities and Water Savings
BMP 13: Water waste prohibition

Item	2006	2007	2008	2009	2010
Waste ordinance in effect	Ord. No. 1842	Ord. No. 1842	Ord. No. 1842	Ord. No. 1842	Ord. No. 1842
Onsite visits	8	8	8	8	8
Water softener ordinance	None	None	None	None	None
Expenditures[a,b], $	$33,961	$40,753	$40,753	$40,753	$40,753

[a] Assumed to be 10 percent of staff salary and fringe since 10 percent of patrol staff time is dedicated to water conservation monitoring activities. Annual salary for a Level 5 Code Enforcement Specialist is $45,280 based on the salary listings on the City of Merced website, updated August 29, 2005 (City of Merced, 2005). A 1.5 multiplication factor was applied to annual salary to estimate annual salary and fringe benefits.

[b] Total combined expenditures for BMPs 12 and 13.

BMP 14. Residential ultra-low-flush toilet (ULFT) replacement programs.

Description: The City is not currently implementing this BMP because this BMP is not cost effective to the City. An economic evaluation of this BMP is provided in Appendix E of this Plan and discussed in Section 6.2 of this chapter.

Schedule: Not applicable. The City is not currently implementing this BMP.

Evaluation of BMP Effectiveness: Not applicable. The City is not currently implementing this BMP.

6.2. Economic Analysis Results

Economic evaluations were performed for the BMPs that are currently not implemented by the City (BMPs 1, 2, 5, 6, 9, and 14) in order to determine if they are economically feasible. The economic analysis was completed in terms of the benefit to cost (B/C) ratio, simple pay-back period, net present value (NPV), total benefits, and water savings.

The results of the economic analysis are summarized in Table 6-11. As presented, the B/C ratio for BMPs 1, 2, 6, and 14 are less than or equal to one, which indicates that these BMPs are either not economically feasible or are cost effectively neutral for the City. The evaluations for BMPs 5 and 9 determined that they are cost effective for the City to implement. Evaluations were not performed for the remaining BMPs because the City has either implemented the BMP or is considering the BMP for

implementation. The detailed economic evaluations for the BMPs are provided in Appendix E and definitions of the terms used in the analysis are also included. All comparisons are based on 2005 dollars.

The economic analyses were performed using Microsoft® Excel 2003, a spreadsheet program. A separate, customized worksheet for each BMP is presented in Appendix E. Each BMP economic analysis spreadsheet projects, on an annual basis, the water savings and the dollar values of the benefits and costs that would result from implementing the BMP. Industry experience-based "common" assumptions and inputs from data provided by the City are used in the economic analysis and are noted for each respective use.

Assumptions used in the economic analysis for each BMP are described in Appendix E. Directly beneath each assumption is a brief description of the rationale and/or supporting evidence for that assumption. Common assumptions for all BMPs are the value of conserved water ($360/ac-ft) and the real discount rate (6.15 percent). The value of conserved water is made up of three costs. The operational cost of pumping groundwater (electricity and chemicals) is $160 per ac-ft. The capital cost of a well is approximately $100 per ac-ft ($500,000 capital cost, 0.08 capitalization factor, 1,000 gpm, 25 percent usage). This gives a total groundwater pumping cost of $260 per ac-ft. The third cost component is the current cost of water for the Calfed environmental water account. This $100 per ac-ft cost is considered for this analysis a good valuation of the environmental portion of the avoided water supply cost. Combining the Calfed environmental water account cost with the cost of new groundwater gives a total avoided cost of water of $360 per ac-ft. The real discount rate was calculated from the assumed real cost of money (8.82 percent) and the assumed long-term inflation rate (2.52 percent) using the precise conversion method (A&N Technical Services, 2000, pg. A-2).

Table 6-11. BMP Economic Analysis Results

Economic analysis	BMP 1: Water survey programs for single- and multi-family residential customers	BMP 2: Residential plumbing retrofit	BMP 5: Large landscape conservation programs and incentives	BMP 6: High efficiency washing machine rebate program	BMP 9: Conservation programs for CII accounts	BMP 14: Residential ULFT replacement program
Benefit/cost (B/C) ratio	0.96	1.0	4.1	0.1	1.1	0.9
Real discount rate	6.15%	6.15%	6.15%	6.15%	6.15%	6.15%
Total present value cost, $	$144,600	$146,500	$348,100	$160,000	$139,600	$409,100
Total present value benefits, $	$138,200	$148,400	$1,411,000	$20,000	$157,900	$360,300
Total water saved, ac-ft	620	620	5,190	120	780	1,950
Total present value cost of water, $/ac-ft	$235	$235	$67	$1,369	$179	$210
Time horizon	2006-2018	2006-2019	2007-2019	2006-2025	2007-2024	2006-2025

Notes: Economic analysis based on annual BMP activities outlined in MOU guidelines as if City has signed the MOU in 2005.
Calculations performed in 2005 dollars.

6.3. Additional Issues

This section describes additional issues required to be addressed by the Act. Non-economic factors, including environmental, social, health, customer impacts, and technological, are not thought to be significant in deciding which BMPs to implement.

Most water efficiency programs rely on plumbing and appliance retrofits and other predictable customer water uses. Because new housing developments in the City are required to use water saving technologies and appliances, water savings as a result of BMPs have a small effect in further reducing demand. The majority of the water savings from implementing BMPs are seen in older pre-existing homes built prior to 1992. As these older homes are retrofitted with water conservation devices, further reductions in demand as a result of existing water conservation measures may be limited and the City's ability to further increase efficiency and respond to water shortages may be also reduced, i.e. "demand hardening," may occur.

The City has the legal authority to implement the BMPs.

CHAPTER 7
WATER SUPPLY VERSUS DEMAND COMPARISON

This chapter provides a comparison of projected water supplies and demands, describes water shortage expectations, and discusses water shortage revenue and expenditure impacts. The water shortage contingency plan and its anticipated effect on water demand management is included.

7.1. Current and Projected Water Supplies vs. Demand

This section provides a comparison of normal, single-dry, and multiple-dry water year supply and demand for the City. Water demands are addressed in Chapter 3, water supply is addressed in Chapter 4, and recycled water supply is addressed in Chapter 5 of this Plan.

7.1.1. Current and Projected Normal Year Water Supplies vs. Demand

The normal water year current and projected water supplies and demands for the City are compared in Table 7-1.

Table 7-1. Normal Year Water Supply and Demand Comparison

Item	2005 (ac-ft/yr)	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Supply totals	31,010	37,058	42,105	49,153	56,200
Demand totals	30,118	36,570	41,919	48,821	55,677
Difference (supply minus demand)	892	488	186	332	523
Difference as a percent of supply	3%	1%	<1%	1%	1%
Difference as a percent of demand	3%	1%	<1%	1%	1%

7.1.2. Current and Projected Single-Dry Year Water Supplies vs. Demand

The current and projected water supplies are compared to the demands for a single-dry year in Table 7-2.

Table 7-2. Single-Dry Year Water Supply and Demand Comparison

Item	2005 (ac-ft/yr)	2010 (ac-ft/yr)	2015 (ac-ft/yr)	2020 (ac-ft/yr)	2025 (ac-ft/yr)
Supply totals	31,010	37,058	42,105	49,153	56,200
Demand totals	30,118	36,570	41,919	48,821	55,677
Difference (supply minus demand)	892	488	186	332	523
Difference as a percent of supply	3%	1%	<1%	1%	1%
Difference as a percent of demand	3%	1%	<1%	1%	1%

7.1.3. Projected Multiple-Dry Year Water Supplies vs. Demand

The projected water supplies are compared to the demands for multiple-dry years for the City in Tables 7-3 through 7-6.

Table 7-3. Multiple-Dry Year Water Supply and Demand Comparison Period Ending in 2010

Item	2006 (ac-ft/yr)	2007 (ac-ft/yr)	2008 (ac-ft/yr)	2009 (ac-ft/yr)	2010 (ac-ft/yr)
Supply totals	32,220	33,429	34,639	35,848	37,058
Demand totals	31,408	32,698	33,989	35,279	36,570
Difference (supply minus demand)	811	731	650	569	488
Difference as a percent of supply	3%	2%	2%	2%	1%
Difference as a percent of demand	3%	2%	2%	2%	1%

Table 7-4. Multiple-Dry Year Water Supply and Demand Comparison Period Ending in 2015

Item	2011 (ac-ft/yr)	2012 (ac-ft/yr)	2013 (ac-ft/yr)	2014 (ac-ft/yr)	2015 (ac-ft/yr)
Supply totals	38,067	39,077	40,086	41,096	42,105
Demand totals	37,640	38,709	39,779	40,849	41,919
Difference (supply minus demand)	427	367	307	246	186
Difference as a percent of supply	1%	1%	1%	1%	<1%
Difference as a percent of demand	1%	1%	1%	1%	<1%

Table 7-5. Multiple-Dry Year Water Supply and Demand Comparison Period Ending in 2020

Item	2016 (ac-ft/yr)	2017 (ac-ft/yr)	2018 (ac-ft/yr)	2019 (ac-ft/yr)	2020 (ac-ft/yr)
Supply totals	43,515	44,924	46,334	47,743	49,153
Demand totals	43,299	44,680	46,060	47,440	48,821
Difference (supply minus demand)	215	244	274	303	332
Difference as a percent of supply	<1%	1%	1%	1%	1%
Difference as a percent of demand	<1%	1%	1%	1%	1%

Table 7-6. Multiple-Dry Year Water Supply and Demand Comparison Period Ending in 2025

Item	2021 (ac-ft/yr)	2022 (ac-ft/yr)	2023 (ac-ft/yr)	2024 (ac-ft/yr)	2025 (ac-ft/yr)
Supply totals	50,562	51,972	53,381	54,791	56,200
Demand totals	50,192	51,563	52,934	54,306	55,677
Difference (supply minus demand)	370	408	447	485	523
Difference as a percent of supply	1%	1%	1%	1%	1%
Difference as a percent of demand	1%	1%	1%	1%	1%

7.2. Water Shortage Expectations

Short-term and long-term groundwater supply shortages through to 2025 are not expected. Groundwater is a consistent source with reliability that does not change due to seasonal or climatic shortages. Although groundwater levels have declined at a greater rate during drought periods as a result of overdraft, the annual quantity of groundwater available does not vary significantly in relation to wet or dry years. As discussed earlier, however, the overdraft condition required the City to take steps to manage overall groundwater extraction and recharge. Continuing decline of groundwater levels could result in the need to deepen the existing supply wells.

The water demands presented in Table 3-6 were compared with the projected water supplies in Table 4-3 and summarized in Tables 7-1 to 7-6. Projected future supplies appear to meet the future demands, including the growing demands of the planned UC Merced campus development. In 2005, the campus is served by a City water supply intertie and by City Well 17 with a 250,000 MG storage tank. To meet future campus water demands, the UC Merced long-range plan proposes to develop the groundwater supply to coincide with the growth of the campus (UC Merced, 2002).

7.3. Water Shortage Contingency Plan

The City adopted water conservation practices within its Municipal Code and provides funding for educating the public on water conservation issues and policies (CH2MHill, 2001b). In response to the emergency water shortage due to the drought of 1987 to 1991, the City adopted Chapter 15.42 to Municipal Code, Division II on January 19, 1993 to regulate water usages. These regulations were

revised in 2000, but never repealed, and now constitute the City's water shortage contingency plan. A copy of Ordinance No. 1842, which added Chapter 15.42 to the Municipal Code and contains the water shortage contingency plan, is included in Appendix D.

As described in Chapter 4, the Merced Subbasin is in a mild overdraft condition. As a result, the water conservation regulations were not repealed and the water conservation practices mandated in the City's water shortage contingency plan have continued to be implemented.

The City's water shortage contingency plan provides the stages of action to be carried out when a water shortage and emergency exists within the water source and service area. The water shortage contingency plan may be enacted when there is any shortage of water due to prolonged drought and the City Council finds that the ordinary demands and requirements of water consumers cannot be satisfied without depleting the water supply to the extent that there would be insufficient water for human consumption, sanitation, and fire protection (Ord. No. 1842). It necessitates that it is imperative to the public well-being that those uses of water which are not essential to public health, safety, or welfare be either prohibited or restricted. The water shortage contingency plan contains prohibited water uses, including mandatory prohibitions and penalties for violating those prohibitions.

Consumption reduction methods are provided in the water shortage contingency plan in Appendix D as prohibited uses (Ord. No. 1842, Sec. 15.42.040) and mandatory prohibited uses (Ord. No. 1842, Sec. 15.42.090).

7.3.1. Stages of Action

A water emergency was declared due to the drought in the late 1980s, necessitating the adoption of Chapter 15.42 to the Municipal Code. These regulations were never repealed due to the mild overdraft situation of the Merced Subbasin and now act as the water shortage contingency plan for the City. Due to the declaration of a water emergency, escalating stages of action were not defined and the water shortage contingency plan is currently active, as shown in Table 7-7. Emergency actions are

implemented by the City Public Works Department and Utility Division on a case-by-case basis.

Table 7-7. Water Shortage Contingency Plan Stages

Stage	Water supply conditions	Percent shortage
Stage 1 - Normal water supply	Supplies available to meet all demands.	0
Stage 2 - Water emergency	Major failure of a supply, storage, or distribution system - overdraft condition of groundwater basin or drought.	--[a]

[a] Water emergency stage currently in effect due to previous drought and overdraft. Percent shortage triggering water emergency was not determined.

7.3.2. Three-Year Minimum Water Supply

The three-year minimum water supply is presented in Chapter 4. Groundwater is the sole source of supply for the City service area. The estimated minimum water supply is summarized below in Table 7-8.

Table 7-8. Estimated Minimum Water Supply

Source	2006 (ac-ft/yr)	2007 (ac-ft/yr)	2008 (ac-ft/yr)	2010 Normal Year (ac-ft/yr)
Groundwater	32,220	33,429	34,639	37,058
Total	32,220	33,429	34,639	37,058

7.3.3. Catastrophic Supply Interruption Plan

A catastrophic supply interruption plan details actions to be undertaken by the City to prepare for, and implement during, catastrophic supply interruptions such as a power outage or earthquake. The City has not developed a catastrophic supply interruption plan. Alternatively, the City has developed a municipal water system with wells that have overlapping spheres of influence. Consequently, no geographic area is solely dependent on any single well. The City has previously made improvements to water facilities to minimize loss of these facilities during catastrophic interruptions. All of the City's wells are fitted with a redundant power supply; emergency diesel-powered generators are used during power outages, thus increasing the reliability of supply. Emergency actions are implemented by the Public Works Department and Utilities Division on a case-by-case basis; catastrophic interruption may result in delivery of potable water by tanker trucks and bottled water to the affected communities.

7.3.4. Prohibitions, Consumption Reduction Methods, and Penalties

Mandatory prohibitions, mandatory consumption reduction methods, and penalties in the City's water shortage contingency plan are presented in Appendix D and summarized in Tables 7-9 through 7-11. The regulations and penalty rate structure are designed to discourage violations and non-essential or wasteful uses, encourage conservation, minimize demand on City facilities, and conserve the water supply for the greatest public benefit. The projected reduction percentages for each water conservation method cannot be accurately estimated since the City is not completely metered.

Table 7-9. Mandatory Prohibitions

Prohibitions	Stage when prohibition becomes mandatory
Sidewalk, driveway, or outdoor surface cleaning	Water emergency - currently in effect
Exterior washing of buildings, trailers, or structures	Water emergency - currently in effect
Ornamental fountains without recirculating pump system	Water emergency - currently in effect
Using hoses without an automatic shut-off device	Water emergency - currently in effect
Use of City water supply when alternate source available (i.e. reclaimed, well, or spring water)	Water emergency - currently in effect
Indiscriminate water use in a wasteful manner without reasonable purpose	Water emergency - currently in effect
Uncorrected plumbing leaks	Water emergency - currently in effect
Flooding of premises	Water emergency - currently in effect
Uses of non-potable water without Public Works Dept. permission	Water emergency - currently in effect

Table 7-10. Mandatory Consumption Reduction Methods

Examples of consumption reduction methods	Stage when method takes effect	Projected reduction (%)
Limited landscape irrigation[a]	Water emergency - currently in effect	--[c]
Irrigation allowed only during off-peak hours[b]	Water emergency - currently in effect	--[c]

[a] Watering prohibited on Mondays. Alternate day schedule for sprinkling, watering, and irrigation based on street address. Persons with even numbered addresses may water Tuesday, Thursday, and Saturday, persons with odd numbered addresses may water on Sunday, Wednesday, and Friday.

[b] For gardens and landscaping, irrigation is not allowed between 11:00 am and 7:00 pm.

[c] Projected reduction can not be accurately determined since the City is not completely metered.

Table 7-11. Penalties and Charges

Examples of penalties and charges	Stage when penalty takes effect
Financial penalty with escalating fees for subsequent violation	Water emergency - currently in effect
Termination of service and reconnection fee	Water emergency - currently in effect
Installation of meter at violator's expense	Water emergency - currently in effect

7.3.5. Analysis of Revenue Impacts of Reduced Sales during Shortages

The impact from reduced sales on revenues and expenditures during a water shortage would be minimal. A water shortage would result in a reduction in expenditures. As the quantity of sales decreases, the City would decrease the amount of groundwater pumped, thereby reducing the demand for and cost of energy as presented in Table 7-12.

Table 7-12. Actions and Conditions that Impact Expenditures

Category	Anticipated cost
Increase staff cost	NA
Increased operations and maintenance cost	NA
Increased cost of supply and treatment	NA
Decreased groundwater pumping and demand for energy	Cost reduction

NA = Not available

A water shortage would result in a slight reduction in revenue. Because approximately 60 percent of the City's customers are made up of single family residential customers charged a flat-rate, revenue impacts from decreasing supply and consumer use would be minimal. Only the quantity charge portion of the bill to metered customers would experience a reduction as presented in Table 7-13. As the City's metered connections increase, revenue impacts would become more significant since revenues from metered customers would be reduced.

Table 7-13. Actions and Conditions that Impact Revenues

Type	Anticipated revenue reduction
Reduced sales	Minimal

The extent of any revenue and expenditure imbalance and any proposed measure to overcome impacts to City revenues and expenditures will be evaluated and defined soon after the water shortage has started. The City may consider measures such as developing a reserve fund, changing the rate structure, reducing overhead, decreasing capital expenditures, or revising budget estimates, as presented in Tables 7-14 and 7-15.

Table 7-14. Proposed Measures to Overcome Revenue Impacts

Names of measures	Summary of Effects
Rate adjustment	Revenue increase
Development of reserve fund	Revenue supplement

Table 7-15. Proposed Measures to Overcome Expenditure Impacts

Names of measures	Summary of Effects
Decrease capital expenditures	Expenditure reduction
Revise budget estimates	Expenditure reduction
Reduce overhead	Expenditure reduction

7.3.6. Reduction Measuring Mechanisms

The City would use the well production meters to determine actual water use reductions. The following Table 7-16 summarizes the City's procedures for monitoring its various water shortage mechanisms for effectiveness.

Table 7-16. Reduction Measuring Mechanisms

Mechanism for determining actual reduction	Type and quality of data expected
Well production volume	Daily production will be monitored from the well production meters. Production meters are maintained and calibrated by the Utility Division.
Customer records	Data will be evaluated daily to monthly depending on situation. Data is based on customer meters which are maintained and calibrated by the Utility Division. With the City's billing system, customer accounts can be grouped by type or by specific customers to monitor usage.

CHAPTER 8

REFERENCES

A & N Technical Services, Inc. 2000. Guide to Data and Methods for Cost-Effectiveness Analysis of Urban Water Conservation Best Management Practices. Prepared for the California Urban Water Conservation Council.

American Water Works Association. 1999. Manual M36, Water Audits and Leak Detection. Second edition.

Brown and Caldwell. 2001. 2000 Urban Water Management Plan. Prepared for the City of Merced. October.

Brown and Caldwell. 2002. Paul Selsky response to comments from Mr. Greg Smith, Department of Water Resources, Office of Water Use Efficiency. December 26.

California Department of Finance. 2000. Report E-5, Table 2 "City/County Population and Housing Estimates." January 1.

California Department of Health Services. 2005. Website: www.dhs.ca.gov/ps/ddwem/chemicals/arsenic/newmcl.html.

California Irrigation Management Information System. 2005. Website: Historical Monthly Climate Summaries, www.cimis.water.ca.gov.

California Urban Water Agencies. 1992. Evaluating Urban Water Conservation Programs: A Procedures Manual.

California Urban Water Conservation Council. 2005. Website: www.cuwcc.org. November.

CH2MHill. 1995. Merced Water Supply Plan.

CH2MHill. 1999. City of Merced Water Rate Study. Prepared for City of Merced.

CH2MHill. 2001a. Merced Water Supply Plan Update, Final Status Report. Prepared for City of Merced, Merced Irrigation District, and University of California, Merced. September.

CH2MHill. 2001b. Merced Water Reuse Strategic Plan. July.

City of Merced. 1997. Merced Vision 2015 General Plan.

City of Merced. 2001. General Plan Land Use Capacity and Revised Population Projections Memorandum. January.

City of Merced. 2005. Website: http://ci.merced.ca.us/employment/employment.htm. November.

City of Merced and Merced Irrigation District. 2005. Accomplishments, Needs and Opportunities for Integrated Regional Management of Groundwater Resources in Eastern Merced County - Draft. October.

Department of Water Resources. 1998. The California Water Plan Update: Bulletin 160-98. pp. 3-50 to 51. November.

Department of Water Resources. 2003. California's Groundwater Bulletin 118: Update 2003. p. 169. October.

Department of Water Resources. 2005a. Website: www.sjd.water.ca.gov/groundwater/basin_maps/index.cfm.

Department of Water Resources. 2005b. Website: www.dpla.ca.gov.

Merced County Association of Governments. 2004. Regional Transportation Plan – Merced County. August 19.

Mian, Sajid (UC Merced). 2005. Jennifer Chen (Brown and Caldwell) telephone conversation. October 12.

Pekelney, D.M., T.W. Chesnutt, and W.M. Hanemann. 1996. Guidelines for Preparing Cost Effective Analysis of Urban Water Conservation Best Management Practices. Prepared for the California Urban Water Conservation Council. September 1996.

Suico, Maria (City of Merced). 2005. Jennifer Chen (Brown and Caldwell) personal correspondence. Bill Hubkey's (City of Merced Department of Finance) service connections record for January 2004 to October 2005. November.

Tucker, Dave (City of Merced). 2005. Jennifer Chen (Brown and Caldwell) personal correspondence. October.

U.S. Environmental Protection Agency. 2005. Website: www.epa.gov/safewater/arsenic.html.

U.S. Environmental Protection Agency. 2004. Public Health Goals for Chemicals in Drinking Water, Arsenic. 2004.

University of California, Merced. 2002. Long Range Development Plan. January.

University of California Regents. 2001. Long Range Development Plan, Draft Environmental Impact Report.

United States Geological Survey. 1986. Geology of the Fresh Groundwater Basin of the Central Valley, California, with Texture Maps and Sections.

Wegley, Michael (City of Merced). 2005. Jennifer Chen (Brown and Caldwell) personal correspondence. November.

Western Regional Climate Center. 2005. Website: Western U.S. Historical Climate Summaries, Climatogolical Data Summaries, www.wrcc.dri.edu.