



CITY OF HESPERIA



Final Report

Recycled Water Master Plan

July 2008

 **carollo**
Engineers...Working Wonders With Water™

July 30, 2008
7287A.00

City of Hesperia
9700 Seventh Avenue
Hesperia, CA 92345

Attention: Mr. Scott Priester, AICP
Director of Development Services

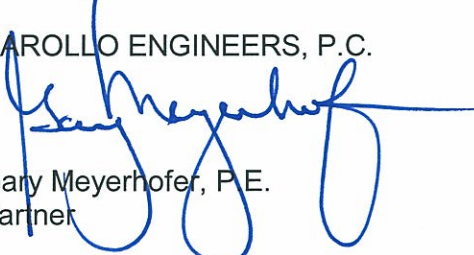
Subject: Final Recycled Water Master Plan

Dear Mr. Priester:

Enclosed is a copy of the final Recycled Water Master Plan. Thank you for the opportunity to work with the City on this project. We enjoyed working with you and your staff and look forward to continuing our relationship with the City. Please feel free to contact me if you have any questions on this Plan.

Sincerely,

CAROLLO ENGINEERS, P.C.


Gary Meyerhofer, P.E.
Partner

GM:alh



Enclosures: Final Recycled Water Master Plan Report

WATER REUSE MASTER PLAN

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RECYCLED WATER MASTER PLAN

ES.1 INTRODUCTION

The City of Hesperia (City) lies within an area that is commonly referred to as the high desert in Southern California. It is located in the northern portion of San Bernardino County (County), California, approximately 30 miles north of the City of San Bernardino. The City encompasses an area of approximately 74 square miles.

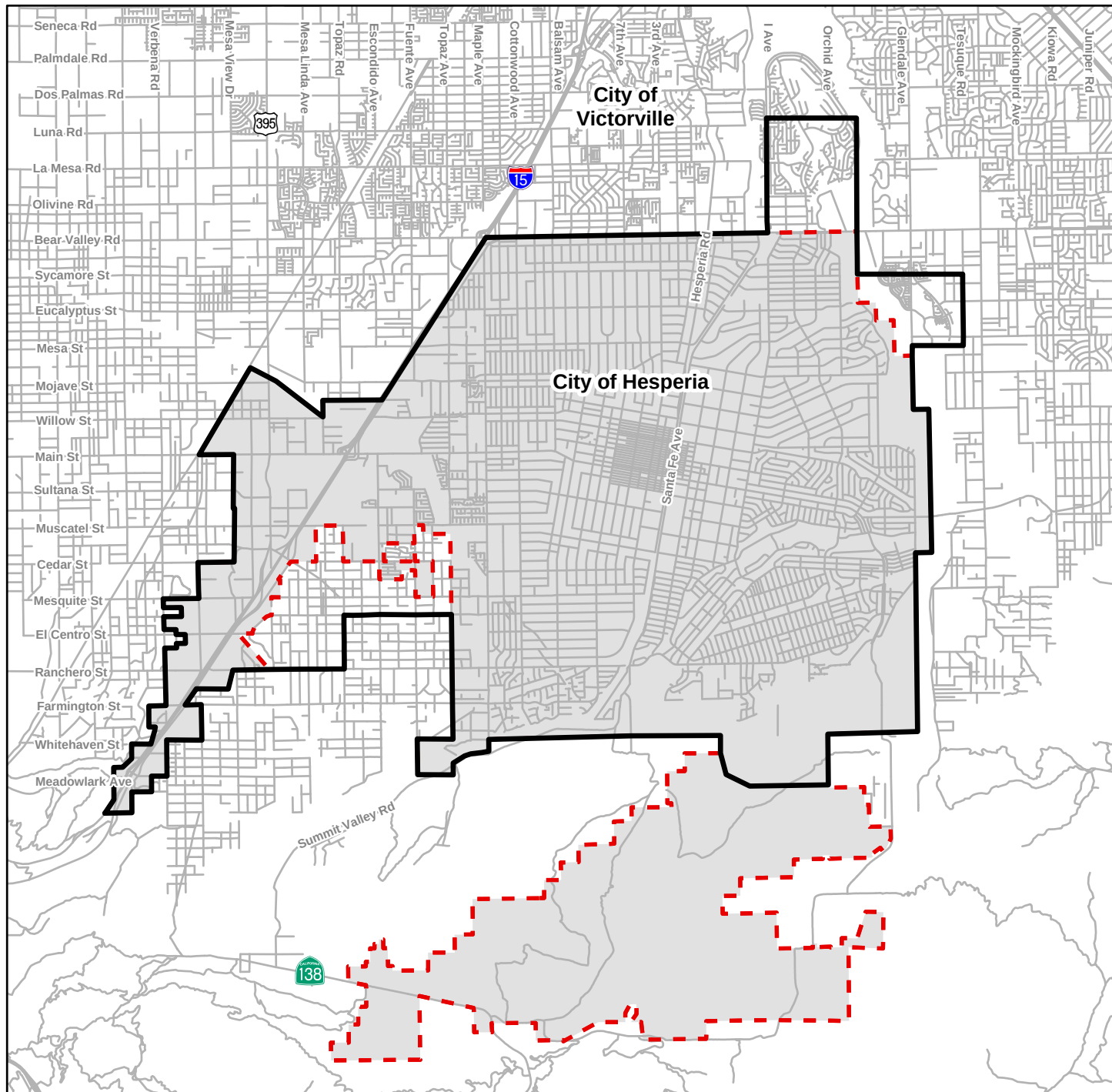
The study area for this Recycled Water Master Plan (Master Plan) is shown on Figure ES.1. As shown on this figure, the study area includes the majority of the City with the exception of the area south of Whitehaven Street, which includes the future developments North Summit Valley, Rancho Las Flores, and Summit Valley Ranch. The study area does include two areas outside the City boundary that are located near the northwest corner of the City. These two areas were added to the study area to include two potential large recycled water customers (golf courses) in this Master Plan.

Through a formal selection process, Carollo Engineers (Carollo) was selected to prepare this Master Plan to aid in the planning of a recycled water system. This report makes up one portion of a four-system study that includes the Urban Water Management Plan, the Water Master Plan, and the Wastewater Master Plan, which are presented in separate reports.

ES.2 RECYCLED WATER SUPPLY

The City currently does not have a recycled water system or any customers that are served with recycled or non-potable water. The City's wastewater is treated by the Victor Valley Wastewater Reclamation Authority (VWRA), which owns and operates a 12.5-mgd wastewater reclamation plant in the City of Victorville, approximately 15 miles north of the northern City boundary. Due to the far distance, the City does not readily have access to recycled water from this plant.

The location, the projected average dry weather flow (ADWF) for various planning years, and the plant capacities of the three WRPs are summarized in Table ES.1. It should be noted that another 3.7-mgd WRP is planned within the Rancho Las Flores development, which is located south of the City boundary and is outside the study area of this Master Plan. The Wastewater Master Plan includes more details on the location evaluation and sizing of these plants.



Legend

- Roadways
- ▭ Study Area
- - - City Boundary



0 1.5 3 Miles



carollo
engineers

FIGURE ES.1 STUDY AREA

RECYCLED WATER
MASTER PLAN

CITY OF HESPERIA

Table ES.1 Projected Recycled Water Supply from WRPs Recycled Water Master Plan City of Hesperia					
Plant	Location	Projected ADWF⁽¹⁾ 2012 (mgd)	Projected ADWF⁽¹⁾ 2022 (mgd)	Projected ADWF⁽¹⁾ 2032 (mgd)	Plant Capacity 2032 (mgd)
WRP-1	Near the intersection of Main Street and west of Cataba Road.	2.3	4.8	5.7	7.4
WRP-2	Near the intersection of Osbrink Drive and Santa Fe East Avenue.	N/A ⁽²⁾	5.1	6.5	8.5
WRP-3	In the northern portion of the RLF development, about 2 miles south of Ranchero Road.	N/A ⁽²⁾	2.9	3.7	4.7
Totals⁽³⁾		2.3	12.8	15.9	20.6
Notes: (1) ADWF = Average Dry Weather Flow. (2) WRP-2 and WRP-3 are not planned to be on-line until year 2017. (3) Totals exclude flows from the area south of Whitehaven Street (also indicated as Planning Areas 15 and 16 in the Wastewater Master Plan).					

ES.3 RECYCLED WATER DEMANDS

The primary objective of implementing a recycled water system is the reduction in potable water use, which is necessary because of the rapid population growth in the City, as well as to provide a drought-resistant supply.

However, only a portion of the overall potable water market can be served by recycled water due to a variety of reasons, including, but not limited to, process water requirements and health-related restrictions. To determine the feasibility of a recycled water system, customer locations and their associated demands were identified as part of this Master Plan.

The recycled water market assessment consisted of the evaluation of historical water usage data, aerial photos, road maps, and lists of City parks. Through this process, a list of 57 potential recycled water customers was generated and demand estimates were prepared for each customer. The locations of these 57 potential customers are shown in Figure ES.2, while a summary of customer demands by user category is presented in Table ES.2.

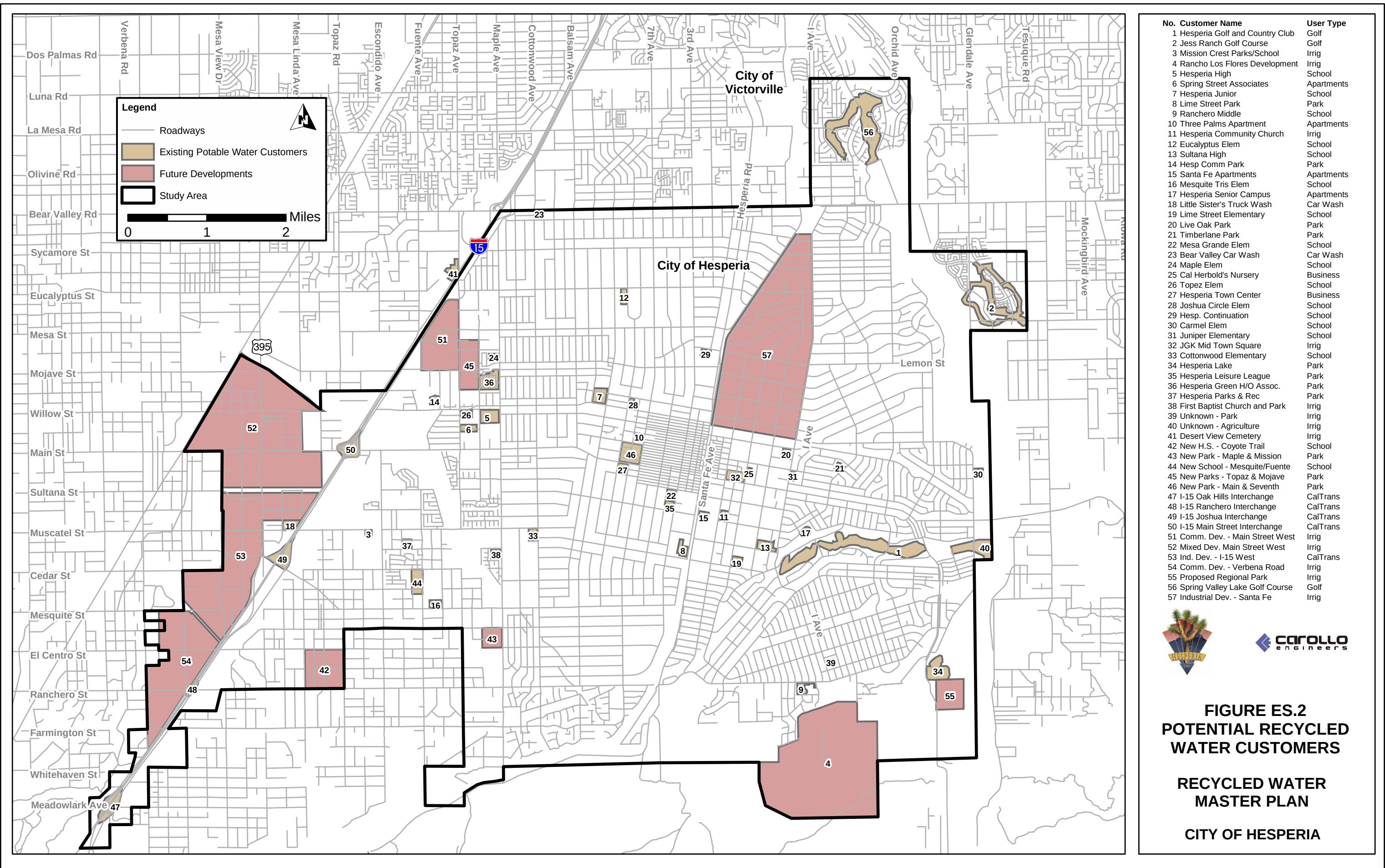


Table ES.2 Potential Recycled Water Customers Summary Recycled Water Master Plan City of Hesperia					
Customer Category	ADD⁽¹⁾ (mgd)	MDD/ADD⁽²⁾ Peaking Factor	MMD⁽¹⁾ (mgd)	PHD/MMD^(2,3) Peaking Factor	PHD (gpm)
Parks, Cemetery	0.8	1.9	1.7	2	70,530
Golf Courses with Lakes	1.2	1.9	2.4	1	1,633
Golf Courses without Lakes	0.8	1.9	1.5	3	3,060
Schools	0.7	1.9	1.3	2	1,857
Highway and Medians	0.1	1.9	0.2	2	265
Future Development	1.4	1.9	2.7	2	3,714
Other Irrigation	0.4	1.9	0.8	2	1,061
Commercial	0.04	1.9	0.1	2	106
Total	5.4	N/A	10.4	N/A	82,230
Notes: (1) Based on Table 3.10. (2) Based on Table 3.2 (3) PHD/MMD = 3.0 for users with 8-hour irrigation, PHD/MMD = 2.0 for users with 12-hour irrigation, and PHD/MDD = 1.0 for users with a flat 24-hour delivery.					

As shown in Table ES.2, the estimated average day demand (ADD) of the 57 potential customers is 5.4 mgd, while the maximum month demand (MMD) is estimated to be 10.4 mgd. The peaking factors listed in this table and the respective diurnal demand patterns are presented in more detail in Chapter 3.

ES.4 RECYCLED WATER MODEL

A recycled water hydraulic model was developed as part of this Master Plan to size the future recycled water system pipelines and facilities. This model was created using H₂ONET[®] Version 6.0. Details on the model development as well as the evaluation and sizing criteria are described in Chapter 4.

The locations of the potential 57 recycled water customers and the WRPs guided the layout of the proposed recycled water system. The system was divided into seven pressure zones based on the pressure criteria, the customer locations, and the City's topography. The City's topology slopes from the northwest to southeast. Therefore, zones with the highest hydraulic grade lines (HGLs) are located in the northwest, while zones with lower HGLs are located in the southeast. This is consistent with the potable water system zoning. The HGLs, pressure ranges, and the primary source of supply of each zone are listed in Table ES.3.

Table ES.3 Pressure Zone Summary Recycled Water Master Plan City of Hesperia						
Pressure Zone	Zone HGL (ft-msl)	Maximum Elevation (ft-msl)	Minimum Elevation (ft-msl)	Maximum Pressure (psi)	Minimum Pressure (psi)	Supply Sources
1A	2,950	2,870	2,603	150	35	WRP-2 by gravity
1	3,200	3,061	2,853	150	60	WRP-2
2A	3,400	3,069	3,271	150	60	WRP-2
2B	3,400	3,053	3,261	150	60	WRP-3
3	3,560	3,421	3,213	150	60	WRP-1 by gravity
4	3,740	3,602	3,394	150	60	WRP-1
5	3,950	3,811	3,603	150	60	WRP-1
6	4,280	4,140	3,841	190	61	WRP-1

Once the pressure zones were established, the location of reservoirs, booster stations, pressure reducing stations, and the most optimum pipeline alignments could be identified. The pipelines were aligned to achieve the shortest route to the potential recycled water customers. The total system pipeline length to connect all potential customers is approximately 57 miles. The potential system also contains six reservoir sites with a combined storage volume of 10.5 million gallons (MG), four booster pump stations, and two pressure reducing stations. A system layout of the potential recycled water system is shown on Figure ES.3.

ES.5 RECYCLED WATER SYSTEM ANALYSIS

It should be noted that the potential recycled water system shown on Figure ES.3 is the ultimate system that connects to all 57 customers, without the consideration of cost. To include cost considerations, a feasibility analysis was conducted to determine the unit costs for some of the smaller dead-end distribution pipelines that connect to relatively small customers. The findings of this feasibility study were used to select which pipeline components are relatively costly and were therefore excluded from the proposed recycled system as presented in the Capital Improvement Program (CIP).

Based on the results of this feasibility analysis it was concluded that the pipelines serving Customers 12, 23, 29, 33, 38, 47, 48, and 54 were not cost-effective. The elimination of these eight customers from the potential recycled water system, resulted in the following:

- A reduction of the overall system demand of only 181 acre-ft/yr.
- A reduction of 11 miles of pipeline.

- A reduction of one 100-hp booster station.
- A reduction of \$7.5 million in capital cost.
- A reduction of the overall system unit cost from \$931/acre-ft to \$890/acre-ft.

Details of this feasibility analysis are presented in Chapter 5, while the eliminated pipelines are shown as dashed pipelines on Figure ES.4. The *potential* recycled water system that incorporates the findings of the feasibility analysis is referred to as the *proposed* recycled water system, which is used to establish the CIP.

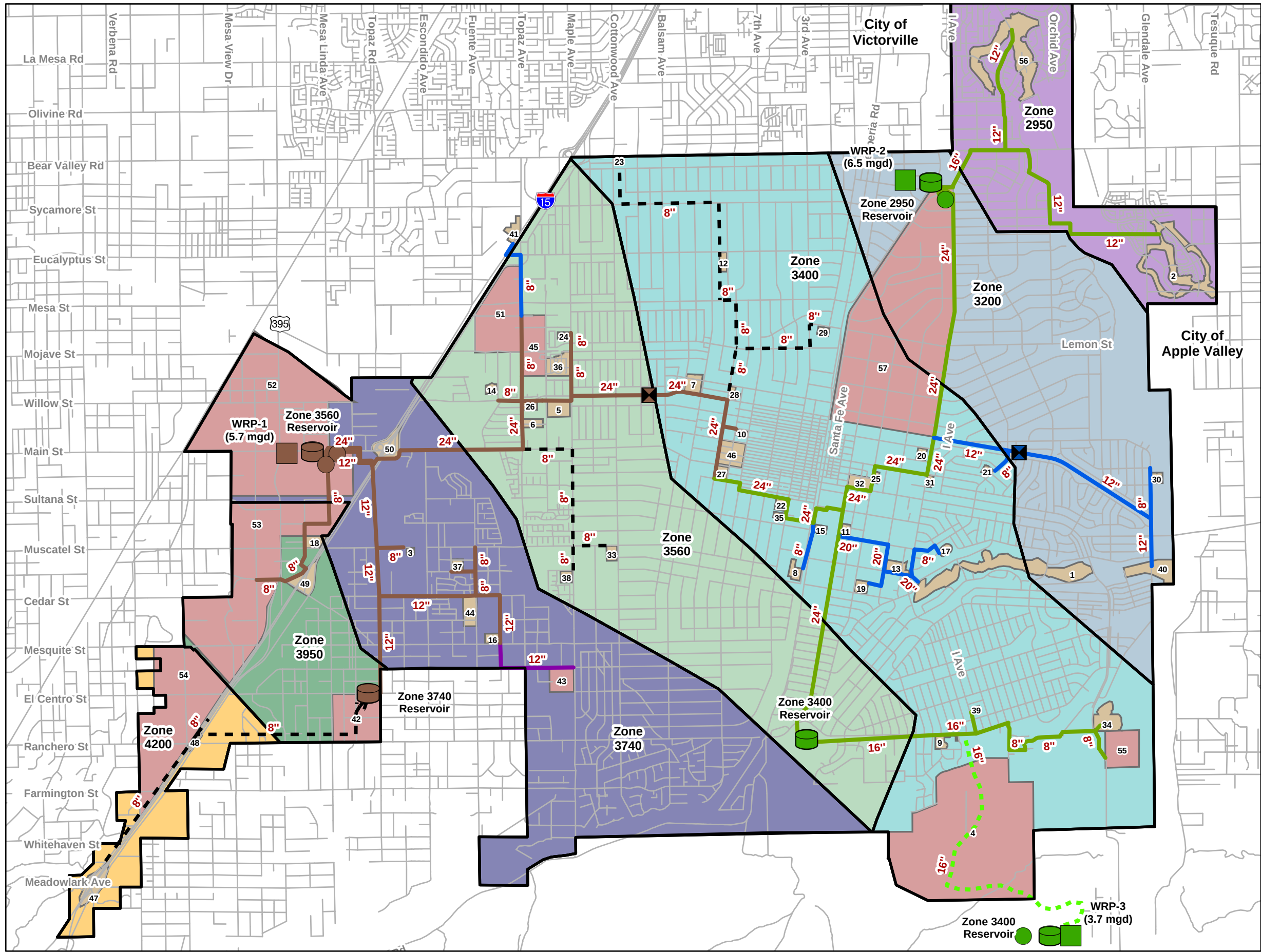
ES.6 CAPITAL IMPROVEMENT PROGRAM

The phasing of the proposed recycled water system is based on the projected wastewater flows at each of the WRPs. The pipeline projects and facilities were phased such that a maximum amount of recycled water demand is served based on the available recycled water supply. Larger customers are typically phased first, while smaller and more remotely located customers are phased later.

Similar to the water and wastewater CIPs that are prepared concurrently, the project was divided into the following four phasing periods.

- Phase 1, 2007 – 2012: No recycled water service. Construction of WRP-1.
- Phase 2, 2013 – 2017: Construction of WRP-2 and WRP-3. WRP-1 recycled water service of up to 2.3 mgd.
- Phase 3, 2018 – 2022: Construction of pipes in Zones 3200 and 3400. Combined WRP-1 and WRP-2 recycled water service of up to 7.9 mgd. The recycled water from WRP-3 is projected to reach up to 2.5 mgd.
- Phase 4, 2023 – 2032: Expansion of system due to flow increases. The combined recycled water supply from WRP-1 and WRP-2 is projected to reach up to 12.7 mgd. The recycled water from WRP-3 is projected to reach up to 3.7 mgd.

The cost for each of the phasing periods is summarized in Table ES.4. As shown, the period 2013 to 2017 requires the highest capital investment of all phases with \$48 million. Pipelines are the most costly by component with \$55 million, or 54 percent of the total capital cost. Figure ES.5 presents the distribution of capital cost by component.



Legend

Proposed Water Reclamation Plant (WRP)

- WRP 1 (2012)
- WRP 2/WRP 3 (2017)

Proposed RW Pump Station

- 2012
- 2017
- 2022

Proposed RW Tank

- 2012
- 2017

Proposed RW PRV

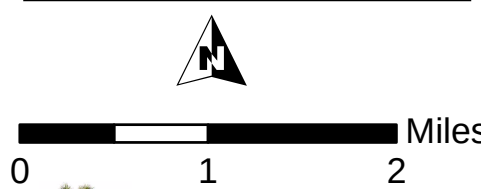
- 2012
- 2022

Potential Recycled Water System

- 2012
- 2017
- 2022
- 2032
- RLF Pipeline
- Eliminated Pipelines Per Feasibility Study

Pressure Zone

- 2950
- 3200
- 3400
- 3560
- 3740
- 3950
- 4200
- Existing Potable Water Customers
- Future Developments
- Roadways
- Study Area



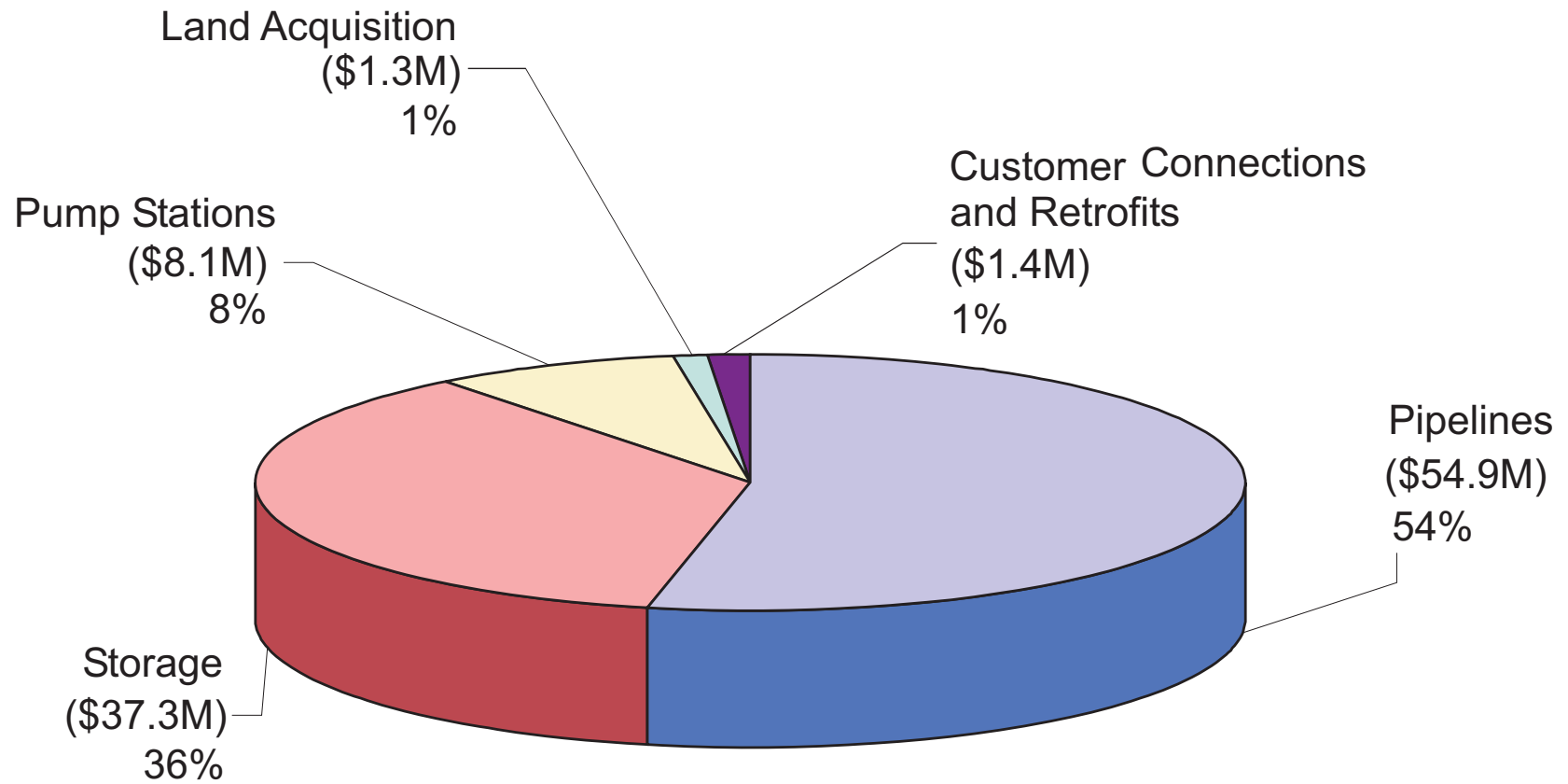


**FIGURE ES.4
PROPOSED RECYCLED
WATER SYSTEM
BY PHASE
RECYCLED WATER
MASTER PLAN
CITY OF HESPERIA**

Table ES.4 Phasing of Capital Costs Recycled Water Master Plan City of Hesperia					
System Component	2007-2012 (\$M)	2013-2017 (\$M)	2018-2022 (\$M)	2023-2032 (\$M)	Total (\$M)
Pipelines	\$16.7	\$24.3	\$13.1	\$0.84	\$54.9
Storage	\$15.7	\$21.6	-	-	\$37.3
Pump Stations	-	\$1.31	\$6.10	\$0.70	\$8.1
Land Acquisition	\$0.50	\$0.81	-	-	\$1.3
Customer Connections and Retrofits	\$0.50	\$0.35	\$0.50	\$0.03	\$1.4
Totals	\$33.4	\$48.3	\$19.7	\$1.6	\$103.0

As shown in Table ES.5, the unit cost of the recycled water system decreases over time from \$4,415/acre-ft to \$913/acre-ft by 2032. The unit costs are initially very high due to the high up-front cost required for the construction of the backbone system. Once the backbone facilities are in place, new customers can be added with relatively low investments, while increasing the overall system demand.

Table ES.5 Phasing of Unit Costs Recycled Water Master Plan City of Hesperia				
System Component	2007-2012	2013-2017	2018-2022	2023-2032
Capital Cost by Phase (\$M)	\$33.4	\$48.3	\$19.7	\$1.6
Cumulative Capital Cost (\$M)	\$33.4	\$81.7	\$101.4	\$103.0
Recycled Water Demand by Phase (acre-ft/yr)	-	1,014	2,996	2,047
Cumulative Recycled Water Demand (acre-ft/yr)	-	1,014	4,011	6,058
Unit Cost (\$/acre-ft) ⁽¹⁾	-	\$2,610	\$360	\$42
Cumulative Unit Cost (\$/acre-ft) ⁽¹⁾	-	\$4,415	\$1,385	\$913
Notes: (1) Based on the present worth value using a depreciation period of 50 years and a 5-percent interest rate.				



Total Capital Cost = \$103.0 M

**FIGURE ES.5
DISTRIBUTION OF
CAPITAL COST**



INTRODUCTION**1.1 INTRODUCTION**

The City of Hesperia (City) is planning to increase recycled water use to lessen the use of potable groundwater water supplies for non-potable demand uses. These groundwater supplies can then be used to accommodate growth and increase the reliability of the City's long-term water supply. The City's intent to increase recycled water use is discussed in City policy documents, including the 2005 Urban Water Management Plan.

The City retained Carollo Engineers (Carollo) to prepare this Recycled Water Master Plan (RWMP) to evaluate the City's potential of recycled water demand, the system requirements, and the feasibility of such a system. This plan has a 25-year planning horizon through year 2032 and is prepared in conjunction with the Water Master Plan (WMP) and the Wastewater Master Plan (WWMP).

1.2 STUDY AREA

The City is located in the northern portion of San Bernardino County, California, and is approximately 90 miles northeast of Los Angeles. The City lies within the southern part of the Mojave Desert region and encompasses an area of approximately 75 square miles. The study area of this RWMP includes the majority of the City, with the exception of the area south of Whitehaven Street. The study area also includes some areas outside the City boundary northeast of the City to include some potential large recycled water customers (golf courses). The study area is shown in Figure 1.1.

1.3 BACKGROUND**1.3.1 Background Reports**

Several existing reports and studies were reviewed to provide general background information for development of this report. These reports are used throughout the Master Plan as reference materials and to provide consistency with other City and the Victor Valley Wastewater Reclamation Authority (VWRA) reports and documents. All reports used for the preparation of this Master Plan are listed in Appendix A.

1.3.2 Water Purveyors

The City currently uses local groundwater from the Alto Subarea subbasin of the Mojave River Groundwater Basin as its sole source of supply. The City's municipal water system extracts all of its water supply from the underground aquifers through 15 active groundwater wells located throughout the City. The maximum instantaneous capacity of the City's

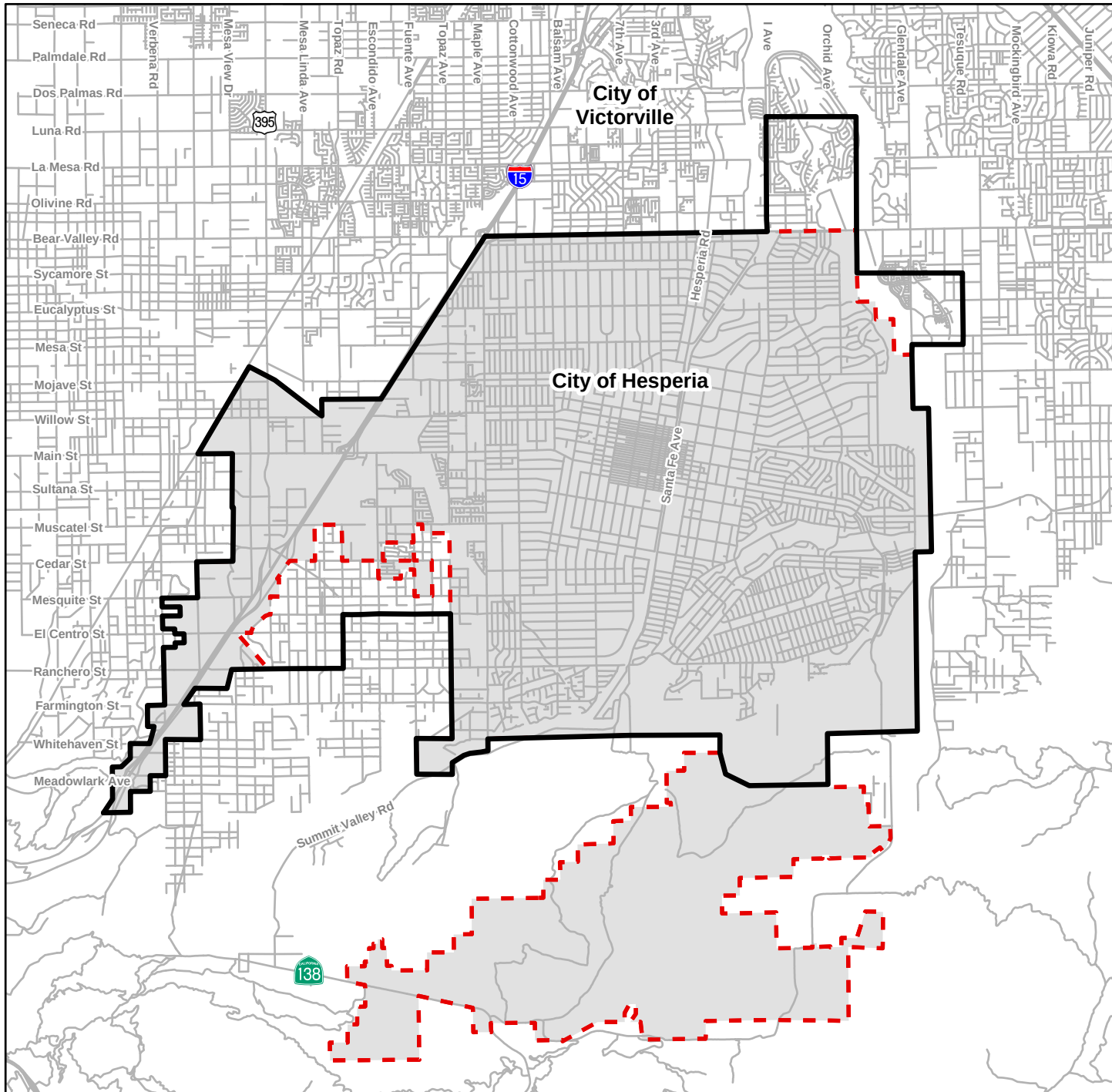


FIGURE 1.1
STUDY AREA
RECYCLED WATER
MASTER PLAN
CITY OF HESPERIA

existing wells total approximately 33.3 million gallons per day (mgd). This is sufficient to meet the City's current maximum day demand (MDD) of 26.1 mgd. However, the Final Draft WMP [14] projects that the MDD will increase to 90.4 mgd by 2032, a time at which the average day demand (ADD) is estimated to be 52.0 mgd. Based on this projection it is anticipated that the MDD will exceed the City's pumping rights in the future. The City is therefore looking for opportunities to develop a recycled water system to offset the use of groundwater for non-potable demand uses.

1.3.3 Wastewater Treatment

Currently, the City's wastewater is treated by the VVWRA, a joint powers authority that operates regional wastewater collection and treatment facilities. This plant is located within the City of Victorville, which is approximately 15 miles north of the northern boundary of the City.

The VVWRA is a Joint Powers Authority that treats wastewater from the City, the City of Victorville, the Town of Apple Valley, and County Service Areas 42 and 64. The VVWRA operates and maintains a 12.5-mgd wastewater treatment plant, 40.5 miles of interceptor sewer, and two pump stations. There are plans in progress to expand the plant to 18 mgd.

The VVWRA treatment plant processes consist of primary clarification, activated sludge secondary treatment, secondary clarification, coagulation/flocculation, sand filtration, and chlorine disinfection. To create a local recycled water source, the City or the VVWRA could construct wastewater treatment plants within the City that would treat wastewater to tertiary standards. Based on the Final Draft WWMP [12], it is assumed that three local plants will be constructed within the City's service area to provide a local recycled water supply source.

Another option to create a recycled water source would be to expand VVWRA's tertiary treatment capacity and construct a 15-mile recycled water pipeline from the VVWRA plant to the City's service area. Although this option was not part of the study presented in this Master Plan, it is recommended that the City conduct a separate feasibility study to evaluate the cost-effectiveness of this option.

1.3.4 Recycled Water Use

The City currently does not provide recycled water to any customers due to the far distance (15 miles) between the VVWRA plant and the City. The only recycled water customer served from the VVWRA plant is the Westwinds Golf Course, which uses approximately 1.5 mgd for irrigation.

The VVWRA has plans to construct a 4.0-mgd sub-regional reclamation facility in the period 2010 to 2012. The reclaimed water produced by the facilities will be discharged into nearby percolation basins when irrigation and customer demand is low. Construction of a second 4.0-mgd facility in Hesperia is planned for the period 2014 to 2016.

1.4 PURPOSE OF STUDY

The purpose of this study is to develop a RWMP for the City that evaluates the feasibility and identifies the system requirements to develop a recycled water system within the study area, including a capital improvement program (CIP).

1.5 ORGANIZATION OF THIS REPORT

This report has been structured to help City staff easily locate and identify information regarding the City's recycled water system. The following list provides a brief description of the information provided in each section:

1. Chapter 1 describes the Master Plan objectives and background.
2. Chapter 2 identifies and describes pertinent recycled water regulations.
3. Chapter 3 identifies the potential recycled water customers and demands.
4. Chapter 4 describes the hydraulic computer model development and analysis.
5. Chapter 5 presents the system recommendations and the CIP.

1.6 ABBREVIATIONS

To conserve space and improve readability, the following is a list of abbreviations used in this report:

ADD	Average day demands
ADWF	Average dry weather flow
CEQA	California Environmental Quality Act
City	City of Hesperia
CIP	Capital Improvement Program
CWA	Clean Water Act
DHS	Department of Health Services
EC	Electrical conductivity
EDC	Endocrine disrupting compounds
EIS	Environmental Impact Statement
EIR	Programmatic Environmental Impact Report
EPA	Environmental Protection Agency
ET _L	Evapotranspiration of landscaped areas
ET ₀	Reference Evapotranspiration
F	Fahrenheit
gpm	Gallons per minute

HWD	Hesperia Water District
K _L	Landscaped area crop coefficient
MDD	Maximum day demands
mgd	Million gallons per day
NPDES	National Pollutant Discharge Elimination System
PDWF	Peak dry weather flow
PUC	Public Utilities Code
RWMP	Recycled Water Master Plan
RWQCB	Regional Water Quality Control Boards
SWRCB	State Water Resources Control Board
VVWRA	Victor Valley Wastewater Reclamation Authority
WRP	Wastewater Reclamation Plant
WMP	Water Master Plan
WWMP	Wastewater Master Plan
WWTP	Wastewater Treatment Plant

1.7 ACKNOWLEDGEMENTS

1.7.1 City of Hesperia Council

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Mike Leonard, Mayor Pro Tem.

Tad Honeycutt, Council Member.

Thurston Smith, Council Member.

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2.1 INTRODUCTION

The purpose of this chapter is to identify the major existing and proposed federal, state, and regional regulatory requirements governing the existing and future reuse of wastewater in the City of Hesperia (City). Wastewater discharges are governed by both federal and state requirements. The primary laws regulating water quality are the Clean Water Act (CWA) and the California Water Code.

Under the CWA, the Environmental Protection Agency (EPA) or a delegated state agency regulates the discharge of pollutants into waterways through the issuance of National Pollutant Discharge Elimination System (NPDES) permits. NPDES permits set limits on the amount of pollutants that can be discharged into the waters of the United States. The California Water Code and the Porter-Cologne Act, a provision of the Code, require the State to adopt water quality policies, plans, and objectives for the protection of the state's waters. The State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs) implement NPDES permits in California. The City and the Victor Valley Wastewater Reclamation Authority (VWVRA) are located in the area that falls under control of the Lahontan RWQCB. The SWRCB and RWQCBs also have regulatory authority along with the California Department of Health Services (DHS) over projects using recycled water. The interagency involvement between the SWRCB, Lahontan RWQCB, and DHS is discussed below.

2.1.1 Water Recycling Overview

The fastest growing water supply in California is recycled water. Water, including recycled water, is a precious resource in both Northern and Southern California. The total amount of wastewater reused in California in the year 2003 was estimated to be 525,500 acre-feet, approximately two-thirds of which was used for agricultural land use types and landscape irrigation. The total amount of water recycled in California in 2003 is summarized in Table 2.1. Region 6 (the Lahontan Region) is the region that includes the City of Hesperia.

Some of the appropriate uses for recycled water include the following:

- Irrigation of farms, parks, golf courses, roadway landscaping, and residential and commercial landscaping.
- Industrial cooling.
- Construction.
- Firefighting.

Table 2.1 Recycled Water Use in California Recycled Water Master Plan City of Hesperia												
Types of Reuse	Volume of Recycled Water Use Within Each RWQCB Region in Acre-Feet/Year											
	1	2	3	4	5F	5R	5S	6 ⁽¹⁾	7	8	9	Total
Agricultural Irrigation	12,694	8,318	22,110	3,752	110,046	1,314	35,349	8,588	2,951	30,795	5,033	240,950
Landscape Irrigation and Impoundments	2,675	10,114	3,152	26,229	80	51	1,431	8,418	6,624	28,135	24,191	111,100
Industrial Use	-	4,865	26	22,376	-	61	264	65	-	199	-	27,856
Ground Water Recharge	-	-	-	46,247	-	-	2,500	-	-	-	286	49,033
Seawater Barrier	-	-	-	10,651	-	-	-	-	-	15,000	-	25,651
Recreational Impoundment	-	-	-	24,429	111	-	-	7,347	-	-	1,216	33,103
Wildlife Habitat or Miscellaneous Enhancement	1,977	6,198	5	6,437	-	-	1,009	-	172	4,361	41	20,200
Geysers/Energy Production	-	-	-	2,198	-	-	-	-	-	-	-	2,198
Other or Mixed Types	-	25	-	9,997	-	-	-	-	-	5,159	188	15,369
TOTAL	17,346	29,520	25,293	152,316	110,237	1,426	40,553	24,418	9,747	83,649	30,955	525,460
Notes: (1) The RWQCB Region 6 is the Lahontan Region, which includes the City of Hesperia.												

- Seawater intrusion barriers.
- Groundwater recharge.
- Fisheries enhancement.
- Wildlife habitat maintenance and development.
- Recreational lakes.
- Toilet flushing.

2.1.2 Key Water Recycling Concerns

Although recycled water use is widespread, numerous issues and concerns still surround its use, such as customer, public, legal, and institutional concerns. These issues are often interdependent as discussed below.

2.1.2.1 Customer Concerns

Customer concerns with recycled water use include water quality, quantity, delivery, reliability, and price. Customers are concerned about receiving the amount of water they require without interruption and at a competitive price. A primary water quality concern is whether the quality of the recycled water meets the requirements for the intended use. For example, many irrigation uses require low salt and specific ranges of mineral concentrations to allow best growth of turf grasses and crops. Another water quality concern is what the potential long-term impacts of using recycled water are for the community. Customers are concerned about possible land degradation from the recycled water. In addition, customers are concerned about how the public may feel about the use of recycled water being used at their location or for their products. Chapter 3 includes a more detailed discussion of irrigation water quality.

2.1.2.2 Public Concerns

Public concerns over the use of recycled water are predominantly health related. To be amenable to a reuse project, the public must be assured that no short-term or long-term adverse health impacts will result from the use of recycled water. The potential human health impacts associated with recycled water include direct or indirect contact with recycled water at its point of use. Adverse environmental impacts are also a common public concern regarding the use of recycled water. Public acceptance of recycled water is often dependent on the level of treatment that is provided. Therefore, public acceptance can be increased by the successful implementation of a public awareness program, which emphasizes community education and benefits regarding the use of recycled water.

2.1.2.3 Legal Concerns

Legal concerns regarding recycled water stem from the issue of water rights. Water rights issues are predominately covered in the California Water Code and/or by the SWRCB. One legal concern is the ownership of the treated wastewater produced by the wastewater treatment plant. If the treated wastewater is discharged to a surface water (e.g., river, stream, etc.), approval must be obtained prior to a change in the place or purpose of use or point of discharge of the treated effluent. Another concern is in regard to the adoption of a groundwater management plan by a local agency. These issues are outlined and authorized by the California Water Code. Should legal concerns regarding the ownership of the effluent arise, the City can contract with a water rights attorney to obtain their legal opinion as to the ownership of the treated effluent.

2.1.2.4 Institutional Concerns

Institutional concerns include regulatory and contractual requirements. A water recycling project must be permitted by the RWQCB and comply with DHS regulations. Also, contracts may be required with local water purveyors and irrigation districts to be allowed to provide recycled water within their service areas.

An institutional concern regarding the use of recycled water is the duplication of a utility, as discussed in the Service Duplication Act of the Public Utilities Code (PUC), Sections 1501 to 1507. Existing law prohibits a sanitary district from providing recycled water service to any part of the sanitary district's service area that is part of a city, water district, or other local agency that provides water service without that agency's prior consent. The PUC also allows for compensation for damages that the utility may suffer due to the City extending their facilities into the service area of the privately owned public utility. As the City governs the Hesperia Water District, this concern only applies to areas outside City boundary.

Another institutional issue concerns the potential loss of revenue incurred by converting a user from potable water to recycled water. Recycled water is often delivered free of charge or at a reduced rate, while potable water is charged at a fee that covers the full cost of delivery. Similarly, this concern only applies to areas outside the City limits.

Customer agreements will also need to be obtained from the end users. The customer agreements can initially consist of letters of intent from end users stating their intention to use recycled water under stated conditions once it becomes available, followed by formal customer contracts which clearly identify the divisions of responsibility between the recycled water wholesaler (producer), retailer, and end-use customer.

Obtaining easements or access agreements for recycled water pipelines is also considered an institutional concern. Easements, or some form of access, may need to be obtained for the entire length of the pipelines. Land acquisition may also be required for pump stations, storage reservoirs, or other facilities, unless the facility is constructed on property already owned by the agency.

2.2 EXISTING REGULATORY REQUIREMENTS

2.2.1 NPDES Permit

The VVWRA currently operates under Waste Discharge Requirements Order No. 6-99-58 and NPDES Permit No. CA 0102822, issued by the Lahontan RWQCB in November 1999. The RWQCB also issued Order No. R6V-2003-028, Water Recycling Requirements for VVWRA at the City of Victorville's Westwinds Golf Course. Requirements for recycled water customers within the City will be similar to those established for Westwinds Golf Course. Waste Discharge Requirements will be issued for each subregional facility in the City, covering treatment requirements and percolation discharge requirements.

2.2.2 Lahontan Basin Plan

The California Water Code and the federal CWA require the adoption of water quality control plans (basin plans) for each of the nine regions of California. The basin plans establish the beneficial uses, water quality objectives, and implementation plans for the water bodies within each region.

The RWQCB adopted the most recent revision of the Water Quality Control Plan for the Lahontan Basin (Lahontan Basin Plan) in 2002 [8]. This Basin Plan identifies the beneficial uses for the major water bodies within the study area and identifies water quality objectives for the study area. This Basin Plan encourages water recycling and includes wastewater reclamation requirements that the Lahontan RWQCB utilizes in the issuance of water reclamation requirements. These requirements are implemented via the VVWRA's water discharge requirements.

2.3 RECYCLED WATER REGULATIONS

2.3.1 Water Recycling Regulations

All of the potential uses of recycled water listed herein are highly regulated. Several agencies have regulatory authority or jurisdiction over potential projects using recycled water. The major state agencies include the DHS, the SWRCB, and the RWQCB. In addition to state regulatory agencies, there may also be involvement by county and local authorities. There are currently no federal regulations pertaining to water recycling.

The DHS is the primary state agency responsible for public health, whereas the SWRCB and the RWQCB are the primary state agencies charged with protection, coordination, and control of water quality. These agencies work together to develop discharge permits for recycled water projects. Generally, the DHS interprets the laws dictated by the California Code of Regulations applicable to reclamation and makes recommendations on individual projects to the RWQCB, which is overseen by the SWRCB. The RWQCB issues the final permit for water reclamation projects.

California's DHS provides a compilation of California regulations regarding recycled water in the *Regulations and Guidance for Recycled Water* [7]. The history of these regulations is summarized in Table 2.2.

Table 2.2 Summary of California Recycled Water Regulations Recycled Water Master Plan City of Hesperia		
Description	Date	Status
Future Regulations		
Groundwater Recharge Reuse	January 4, 2007	Draft
Adopted Regulations		
California Health Laws Related to Recycled Water	June 2001	Update
Guidance Documents		
Preparation of an Engineering Report for the Production, Distribution and Use of Recycled Water	March 2001	
Analysis of Total Organic Carbon at Low Levels for Groundwater Recharge Reuse Projects	April 2003	
Non-Target Volatile Organic Chemicals	September 10, 2003	Draft
Non-Target Semi-Volatile Organic Chemicals	September 10, 2003	Draft
Other Reports		
Treatment Technology Report for Recycled Water	January 2007	
<u>Notes:</u> Source: <i>Regulations and Guidance for Recycled Water</i> [7]		

The existing water recycling regulations, which dictate wastewater treatment processes and effluent quality criteria, are contained in the California Code of Regulations, Title 22, Division 4, Chapter 3, Sections 60301 through 60355. The DHS regulations define four types of recycled water determined by the treatment process, coliform bacteria, and turbidity levels. The approved applications and the Total Coliform Standards for the four wastewater treatment levels are summarized in Table 2.3.

A detailed compilation of the water recycling regulations can also be found in The Purple Book [9]. The intent of these regulations is "...to establish acceptable levels of constituents of recycled water and to prescribe means for assurance of reliability in the production of recycled water in order to ensure that the use of recycled water for the specified purposes does not impose undue risks to health...". The most recent revision to these regulations came into effect in 2001.

Table 2.3 Recycled Water Treatment Regulations Recycled Water Master Plan City of Hesperia		
Treatment Level	Approved Uses	Total Coliform Standard (Median)
Disinfected Tertiary Recycled Water	Spray Irrigation of Food Crops Landscape Irrigation ⁽¹⁾ Non-Restricted Recreational Impoundment	2.2/100 ml
Disinfected Secondary – 2.2 Recycled Water	Surface Irrigation of Food Crops Restricted Recreational Impoundment	2.2/100 ml
Disinfected Secondary – 23 Recycled Water	Pasture for Milking Animals Landscape Irrigation ⁽²⁾ Landscape Impoundment	23/100 ml
Undisinfected Secondary Recycled Water	Surface Irrigation of Orchards and Vineyards ⁽³⁾ Fodder, Fiber. and Seed Crops	N/A
Notes: Source: California Code of Regulations, Title 22, Division 4, Chapter 3. (1) Includes unrestricted access golf courses, parks, playgrounds, school yards, and other landscaped areas with similar access. (2) Includes restricted access golf courses, cemeteries, freeway landscapes, and landscapes with similar public access. (3) No fruit is harvested that has come in contact with irrigating water or the ground.		

2.3.2 Groundwater Recharge

No current regulations are in effect regarding intentional replenishment of groundwater sources with recycled water. However, the DHS issued Draft Groundwater Recharge Reuse Regulations in July 2003 [10], that contain treatment requirements that have been implemented for projects with an indirect potable reuse or recharge component.

As the City does not have access to recycled water and is not currently planning to construct recharge facilities, these regulations are not discussed in further detail. When the City operates its own wastewater treatment facilities and has access to recycled water supplies, it is recommended that the City evaluate the governing regulations and investigate opportunities for groundwater recharge. This evaluation should include, but is not limited to:

- A geotechnical evaluation to determine the ground water recharge capabilities and infiltration rates.
- Ground water quality evaluation.

- The development of a groundwater model to determine the most effective groundwater recharge site.
- Cost-effectiveness evaluation.

MARKET ASSESSMENT AND DEMAND ESTIMATES

3.1 INTRODUCTION

The principle objective of implementing water reuse is the reduction in potable water use. A reduction in potable water use is necessary because of the rapid population growth in the City of Hesperia (City) is experiencing as well as to provide a drought resistant water supply. However, only a portion of the overall water market can be served by recycled water. Due to a variety of reasons, including process water requirements and health related restrictions; the developable market for recycled water is a subset of this specific portion of the water market. Within the developable portion of the market, the uses of recycled water can vary greatly, from irrigation to use in cooling towers. To determine the feasibility of a recycled water system, customer locations and their associated demands need to be identified. This section details the process and results of the City's recycled water market assessment and demand estimates.

3.2 IRRIGATION USE PROJECTIONS

The primary use of recycled water is irrigation, including both agricultural and landscape irrigation. Annual irrigation requirements are estimated based on average climate conditions. The following sections detail how the water use projections are calculated.

3.2.1 Climate

The climate within the City is typical of a desert climate, which includes hot, dry summers, cool winters, and minimal rainfall. Temperatures in the summer months vary between an average low of 60 degrees Fahrenheit and an average high of 99 degrees Fahrenheit. In the winter months, the average low and high temperature extremes are 34 and 63 degrees Fahrenheit, respectively. The average annual precipitation for the City is 5.6 inches.

3.2.2 Landscape Irrigation Requirements

The amount of irrigation required for the potential irrigation customers is directly dependent on precipitation (rainfall) quantities and evapotranspiration in the region.

Landscape irrigation requirements of existing potable water customers in the City were based on historical billing records of the existing water usage data. For future customers, or for customers without usage data, landscape requirements were based on the average evapotranspiration determined for the study area per the following formula:

$$ET_L = K_L * ET_0$$

Where:

ET_L = Evapotranspiration of landscaped areas (in inches).

K_L = Landscaped area crop coefficient.

ET_0 = Reference Evapotranspiration (in inches).

The ET_0 , the reference evapotranspiration, was obtained from the California Irrigation Management Information System (CIMIS) evapotranspiration zoning map. The K_L , the landscaped area crop coefficient, was estimated using information contained in the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California by the California Department of Water Resources [11]. The landscaped area crop coefficient is the product of an average species factor (k_s), density factor (k_d), and microclimate factor (k_{mc}). These were estimated to be 0.6, 1, and 1, respectively. As defined by the formula, the average landscape Evapotranspiration (ET_L) for the study area was calculated by multiplying the landscape coefficient (K_L) by the reference evapotranspiration (ET_0).

The amount of precipitation, evapotranspiration, and irrigation required for the potential irrigation customers are listed in Table 3.1.

Table 3.1 Average Annual Landscape Irrigation Requirements Recycled Water Master Plan City of Hesperia				
Month	Evapotranspiration (inches)⁽¹⁾	Rainfall (inches)⁽²⁾	Net Irrigation Requirement (inches)⁽³⁾	Percent of Annual (%)⁽⁴⁾
January	2.02	1.02	1.35	2
February	2.61	1.04	2.12	3
March	4.55	0.83	5.03	6
April	6.19	0.34	7.91	10
May	7.30	0.16	9.66	12
June	8.85	0.05	11.90	14
July	9.77	0.15	13.01	16
August	8.99	0.19	11.90	14
September	6.52	0.28	8.44	10
October	4.66	0.30	5.90	7
November	2.68	0.51	2.94	4
December	2.05	0.73	1.79	2
Total	66.19	5.60	81.95	100
			6.8 feet	

Notes:

- (1) California Irrigation Management Information Service, Station 117 Victorville.
- (2) Data from Western Regional Climate Center, Station 049325 Victorville.
- (3) [Evapotranspiration - Rainfall] * 1.15/0.85. Where 0.85 = 85 percent Irrigation Factor (Average value from Carlos and Guitjens, University of Nevada) and 1.15 = 15 percent Leaching Fraction (Average value from Ayers and Westcot, "Water Quality for Agriculture", Food and Agriculture Organization of the United Nations).
- (4) Current month net irrigation requirement divided by total net irrigation requirement.

As listed in Table 3.1, the net annual average landscape irrigation requirement in the study area is approximately 82 inches per year or 6.8 feet per year. Based on this data, recycled water demands were estimated at 6.8 acre-feet per year (acre-ft/yr) for each irrigated acre. This equates to 6,071 gpd per acre. Thus, the average day demand (ADD) of a 10-acre park was estimated at 68 acre-ft/yr or 0.06 mgd.

It should be noted that in many cases, existing landscape irrigation customers use less water than necessary because of conservation practices and cost considerations. Therefore, current water use data may not be accurate as an estimate of future recycled water irrigation use.

It should also be noted that irrigation requirements are subject to numerous variables; including plant species, wind patterns, and sun/fog prevalence. Coordination and direct contact with groundskeepers in charge of irrigation who would be receiving recycled water is therefore recommended.

3.2.3 Peaking Factors

The data listed in Table 3.1 was also used to estimate the seasonal variation in landscape demands. The irrigation season runs from March through October, a period of eight months. Landscape irrigation demand peaks in July at 13 inches, which is 1.91 times higher than the average irrigation requirement of 6.8 inches (82 inches/12 months). Based on this ratio, a Maximum Month Demand (MMD) peaking factor of 1.9 was used in this study.

In addition to seasonal demand variations, recycled water systems are characterized by substantial variations in demand during the day. Figures 3.1 through 3.4 present the diurnal curve of hourly demand for different types of irrigation and commercial customers.

As shown on Figure 3.1, the recycled water demand occurs for 12 hours during the night and morning, resulting in a peaking factor of two. It was assumed that commercial customers use recycled water for 12 hours during the day, also resulting in a peaking factor of two. Golf courses were separated in two groups, golf courses with and without lakes that can be used to buffer irrigation water. It was assumed that golf courses with lakes would receive recycled water at a flat rate during 24 hours, which equates to a peaking factor of 1.0. Golf courses without lakes would be irrigated at night during 8 hours, which equates to a peaking factor of 3.0. This shorter timeframe is based on the time available between the closure of a golf course at night and a dry golf field in the morning when the first players arrive. The peaking factors used in this master plan are summarized in Table 3.2.

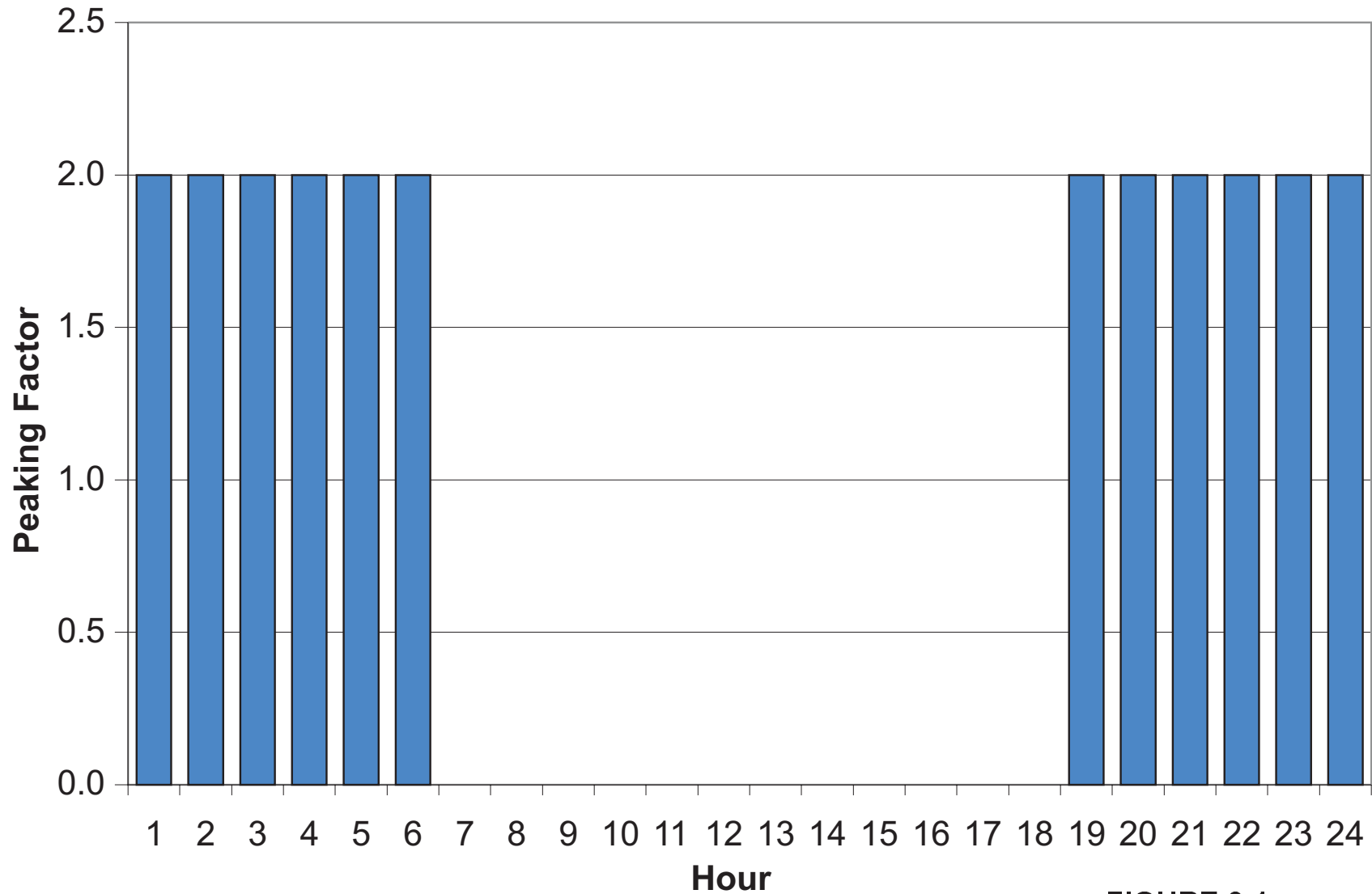


FIGURE 3.1
12-HOUR DIURNAL
CURVE FOR IRRIGATION



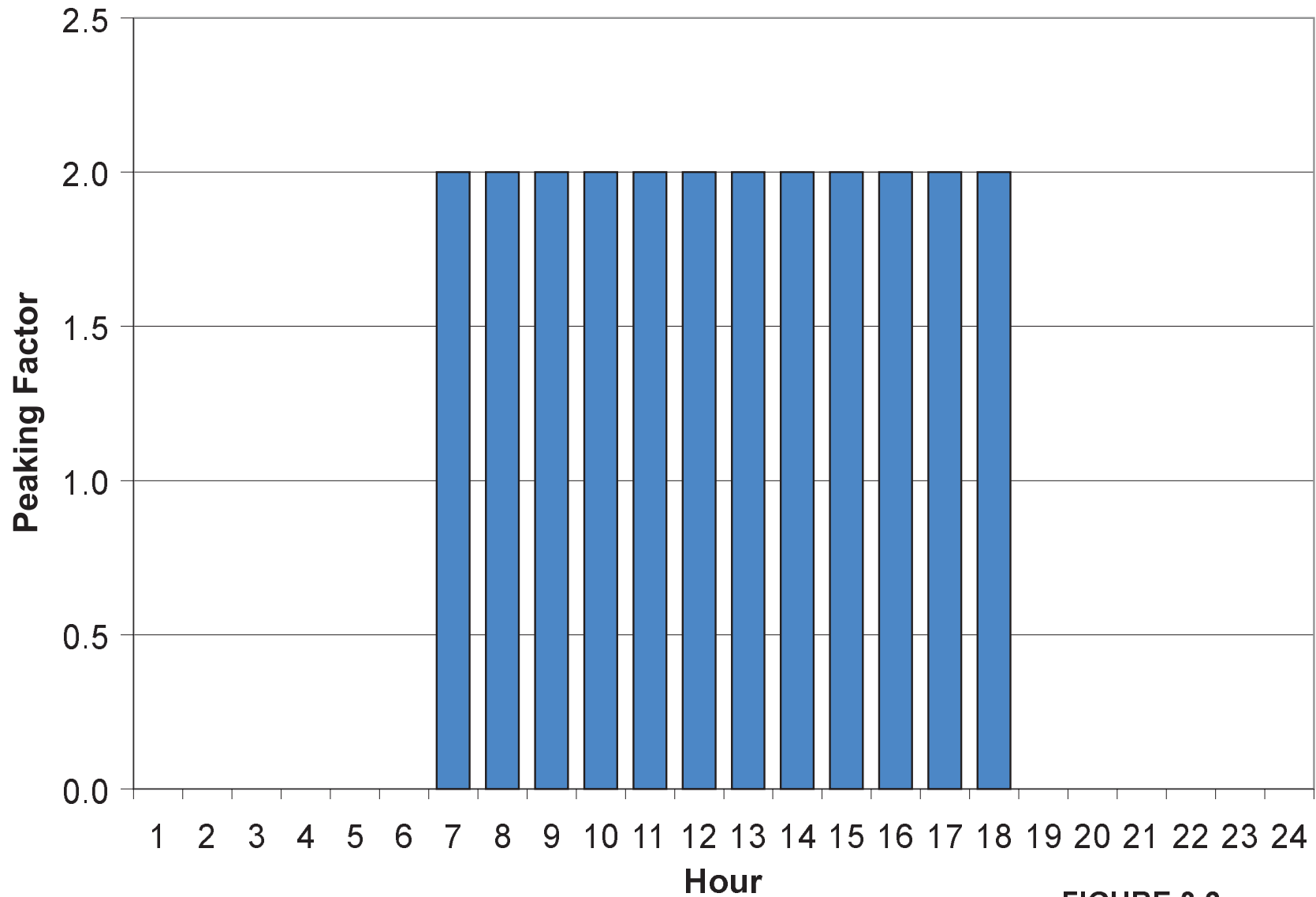


FIGURE 3.2
12-HOUR DIURNAL CURVE
FOR COMMERCIAL USERS



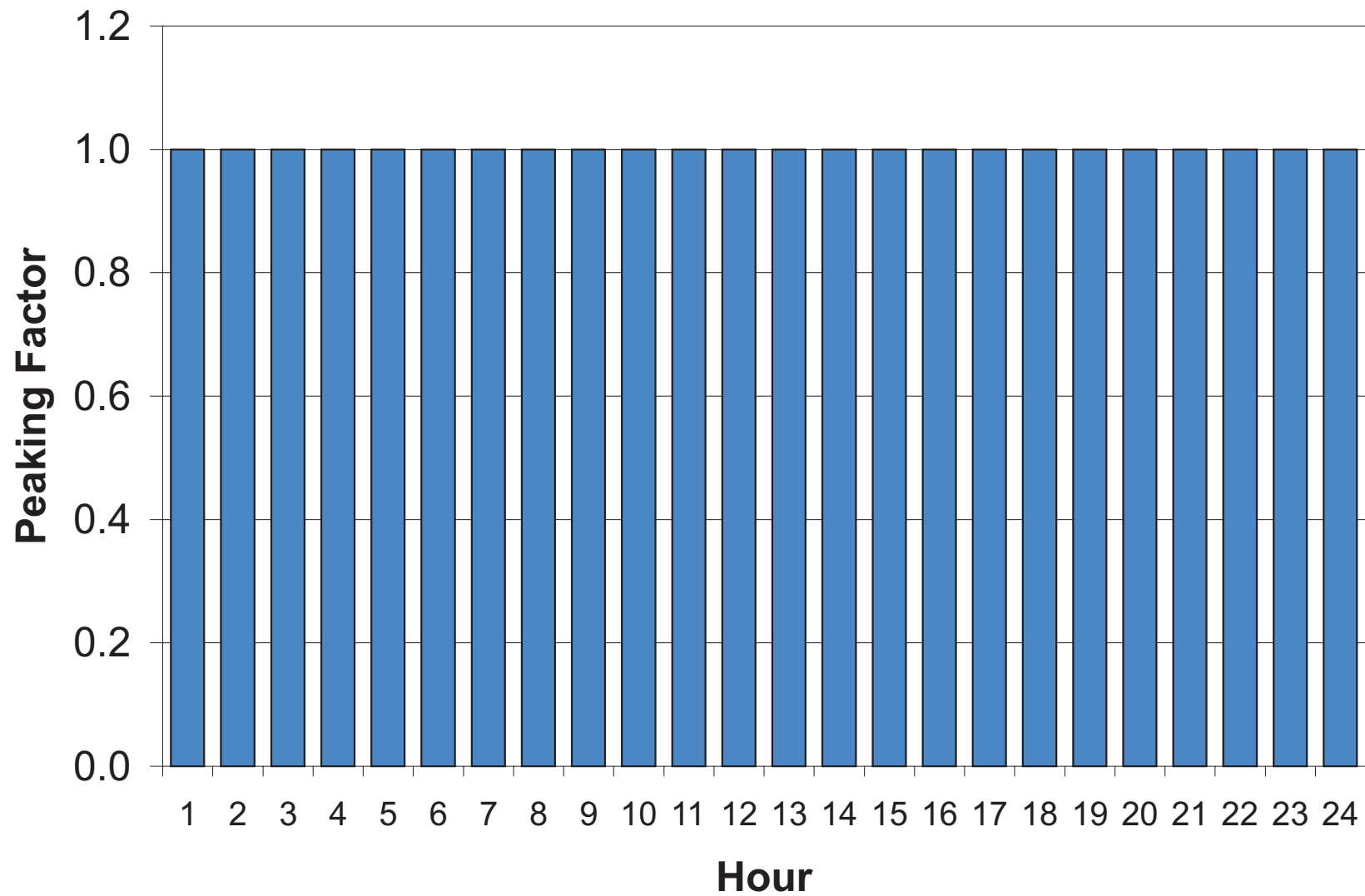


FIGURE 3.3
24-HOUR DIURNAL CURVE
FOR GOLF COURSES



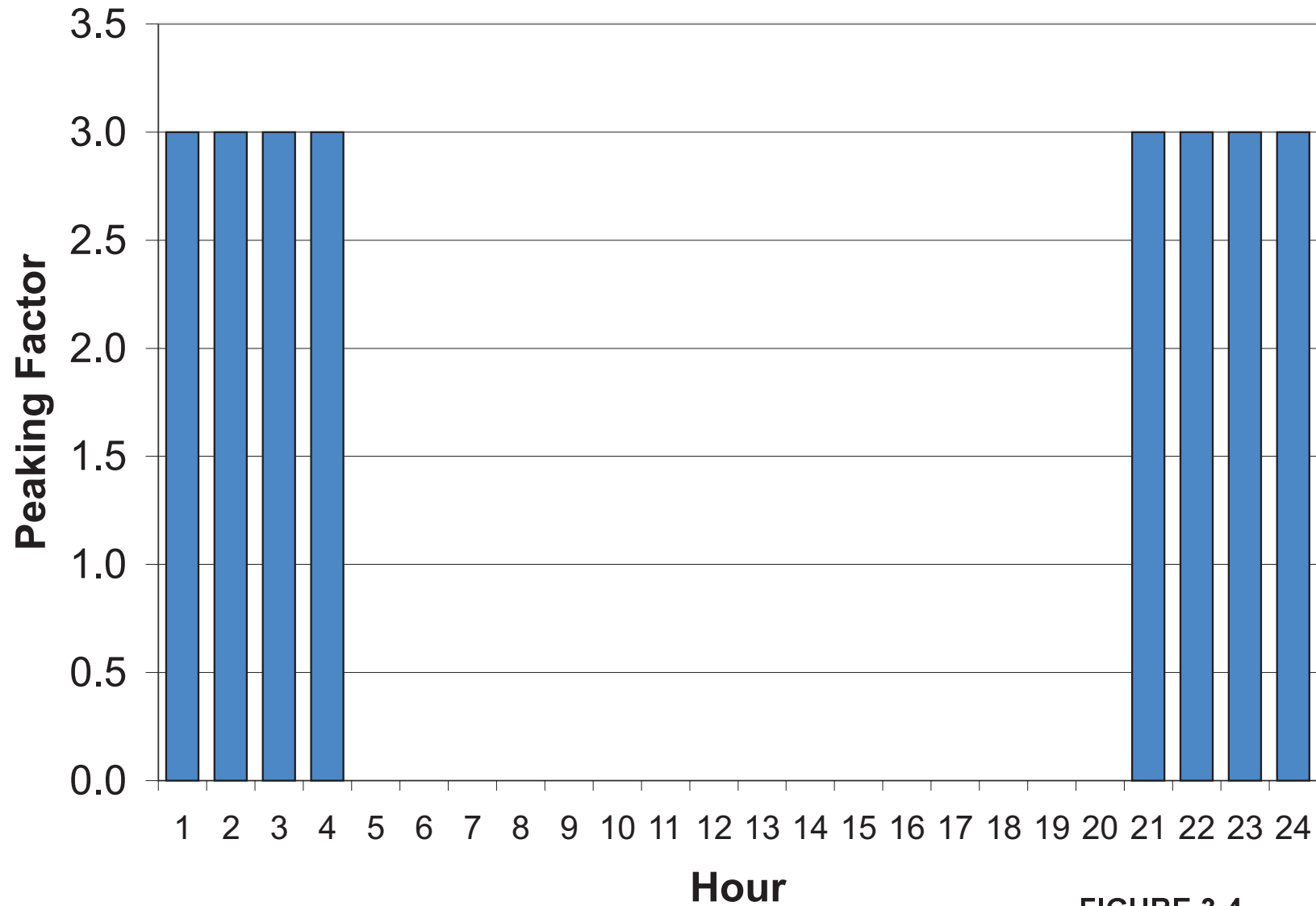


FIGURE 3.4
8-HOUR DIURNAL CURVE
FOR GOLF COURSES

Table 3.2 Peaking Factors Recycled Water Master Plan City of Hesperia	
Demand Condition	Peaking Factor
Average Day Demand	-
Maximum Month Demand	1.9*ADD
Peak Hour Demand	
8-hour irrigation ⁽¹⁾	3.0*MMD or 5.7*ADD
12-hour irrigation ⁽²⁾	2.0*MMD or 3.8*ADD
24-hour irrigation ⁽³⁾	1.0*MMD or 3.8*ADD
Notes: (1) Golf courses without lakes. (2) Highway medians, car washes, schools, parks, cemeteries, new developments and commercial. (3) Golf courses with lakes.	

3.3 GENERAL IRRIGATION USE GUIDELINES

Although water quality is often a concern of potential customers, it is important to understand that the successful long-term use of irrigation water depends much more on rainfall, leaching, soil drainage, irrigation water management, salt tolerance of plants, and soil management practices than upon water quality itself.

Since salinity problems may eventually develop from the use of any water, the following guidelines are given, should they be needed, to assist water users to better manage salinity in either agricultural or community-based irrigation:

1. Irrigate more frequently to maintain an adequate soil water supply.
2. Select plants that are tolerant of an existing or potential salinity level.
3. Routinely use extra water to satisfy the leaching requirements.
4. If possible, direct the spray pattern of sprinklers away from foliage. To reduce foliar absorption, try not to water during periods of high temperature and low humidity or during windy periods. Change time of irrigation to early morning, late afternoon, or night.
5. Maintain good downward water percolation by using deep tillage or artificial drainage to prevent the development of a perched water table.
6. Salinity may be easier to control under sprinkler and drip irrigation than under surface irrigation. However, sprinkler and drip irrigation may not be adapted to all qualities of water and all conditions of soil, climate, or plants.

General management/use guidelines were developed for landscape and crop irrigation based on the average constituent quantity. These constituents and management/use guidelines are:

1. **Bicarbonate (HCO_3):**

To reduce the potential for "whitewash" deposit to develop on foliage wetted by sprinkler irrigation, direct spray patterns away from foliage. If possible, irrigate during periods of cool temperatures such as early morning, late afternoon, or during the night. Avoid windy conditions and periods of low humidity when evaporative losses may be high.

2. **Electrical Conductivity (EC) and Total Dissolved Solids (TDS):**

On all but sensitive plants, salinity should not be a limiting factor. Crops should attain levels of productivity comparable to the use of water with lower salinity. Ornamental species should not exhibit foliar injury or excessive stunting. Normal irrigation inefficiencies and rainfall should provide adequate leaching to maintain a favorable salt balance in the root zone. Moderately sensitive and sensitive plants may require some modification of cultural practices to maintain a favorable salt balance in the root zone.

3. **Sodium Absorption Ratio (SAR):**

When the electrical conductivity of the water (EC), otherwise known as salinity, is considered in association with the sodium level, the water will experience a slight to moderate restriction on the water intake rate or permeability of the soil. Sodium should not affect the physical condition of the soil and its ability to adequately take water (infiltration rate). Infiltration may be reduced by soil compaction and surface crusting resulting from certain cultural practices. It is important to use appropriate tillage practices and control both the time and amount of equipment traffic on the soil. Best management practices would include maintaining an adequate level of organic matter in the surface soil and the periodic use of gypsum or other soil amendments that improve the rate of water infiltration.

4. **Chloride (Cl):**

Woody plant species, such as citrus, stone fruits and avocados, can be damaged by high levels of chloride applied through surface irrigation. The tolerances for Cl⁻ ion vary within the woody plant species. Vegetable, grain, forage, and fiber crops are tolerant of the presence of chloride. However, high enough concentrations of chloride can be detrimental to any crop. In the case of sprinkler irrigation, the tolerance of the woody plant species decreases at similarly high chloride levels.

5. **Ammonia (NH_4) and Nitrate (NO_3):**

Essential for optimum plant growth. Ornamentals and turf grasses may respond with excessive growth. The rate of application and timing of N fertilizer should be adjusted as needed to prevent the addition of excessive levels of combined nitrogen. Grasses

tend to absorb high levels of nitrogen, making them tolerant of excess amounts in the soil.

6. **Calcium (Ca) and Magnesium (Mg):**

Both elements are essential for optimum plant growth. Both elements serve to counteract the effects of sodium on reducing soil permeability.

7. **Sodium (Na):**

For surface irrigation, the level of sodium ion will result in a slight restriction from most tree crops and woody plants. Most annual crops are not sensitive to sodium. With overhead sprinkler irrigation and low humidity (less than 30 percent), there is slight to no restriction associated with sodium. It may be absorbed through the leaves of sensitive crops such as almond, apricot, citrus, and plum. Most grasses and landscape plants are tolerant to the levels of sodium ion present.

8. **Boron (B):**

An essential plant element. Plants, particularly citrus and stone fruits, vary in their tolerance to boron.

3.4 MARKET IDENTIFICATION AND QUANTIFICATION PROCESS

A total of 57 potential recycled water customers were located using a variety of techniques. Water usage data sets, provided by the City, were sorted to generate lists of the largest water users. Aerial photos, road maps, and lists of City parks were examined to locate potential irrigation customers. Potential customers identified from one source were crosschecked with another source to verify customer location and demand. Once the customer location, the irrigated area, and the potential water demand were verified, a number was assigned to each customer based on the order in which they were initially identified.

Current water usage data was available for about half of the proposed recycled water sites, as provided by the City. Residential users were not considered as potential irrigation customers but could be considered for future developments if ordinances are put in place. Housing complexes and apartment buildings were the exemption to this policy. Housing complexes and apartment buildings, who usually have multiple potable water accounts and devote certain accounts to landscape irrigation (determined via usage patterns), were included in the potential water customer list. Generally, only users who use over 20,000 gpd of water for irrigation during the summer months were included in the potential customer list. Customers that were not included in the potential customer list are by no means excluded from being serviced by recycled water. Although the list was used to determine recycled water service alternatives, non-identified customers located on or near recycled water pipelines can and should be added to the distribution network where feasible.

It should be noted that several of the potential recycled water users, use groundwater produced from private wells to fulfill their irrigation needs. Water usage projections for potential customers currently using groundwater were derived from total and irrigated acreage information in conjunction with evapotranspiration data. Water usage projections were also calculated for customers with existing water usage data. These projections were compared to actual usage data. The higher of the two values was chosen as the potential recycled water usage of the customer to size pipelines and facilities such that these can provide an adequate supply of recycled water.

As the identification and quantification process proceeded, potential customers were separated into several phases. Potential customers were placed in phases based on their location within the study area, potential quantity of recycled water use, and current and future development opportunity.

3.5 POTENTIAL CUSTOMERS

The 57 potential customers identified in the market assessment are divided into the following categories:

- Irrigation Customers.
- Commercial and Industrial Customers.
- Future Developments.

The following sections describe the identified potential customers for each of these three categories, while Figure 3.5 presents the location of the potential identified customers.

3.5.1 Potential Irrigation Customers

Carollo identified 55 potential landscape irrigation customers. These include 12 parks, 3 golf courses, 1 cemetery, 19 schools, 4 highway medians, 6 developing areas, and 10 others. These customers, the irrigated areas, and the estimated demands are listed in Tables 3.3 through 3.7.

The total estimated annual demand for the potential irrigation customers is approximately 4,480 acre-ft/yr. The estimated annual demand is based on a combination of past water usage and expected water usage calculations.

Although a number of the identified customers have a small potential expected recycled water demand, when taken as a whole, small customers could contribute a significant volume of recycled water use.

3.5.2 Potential Commercial and Industrial Customers

In many areas, industrial reuse is the predominant application of recycled water. The reused water can be used at industrial facilities for purposes such as processing, cooling,

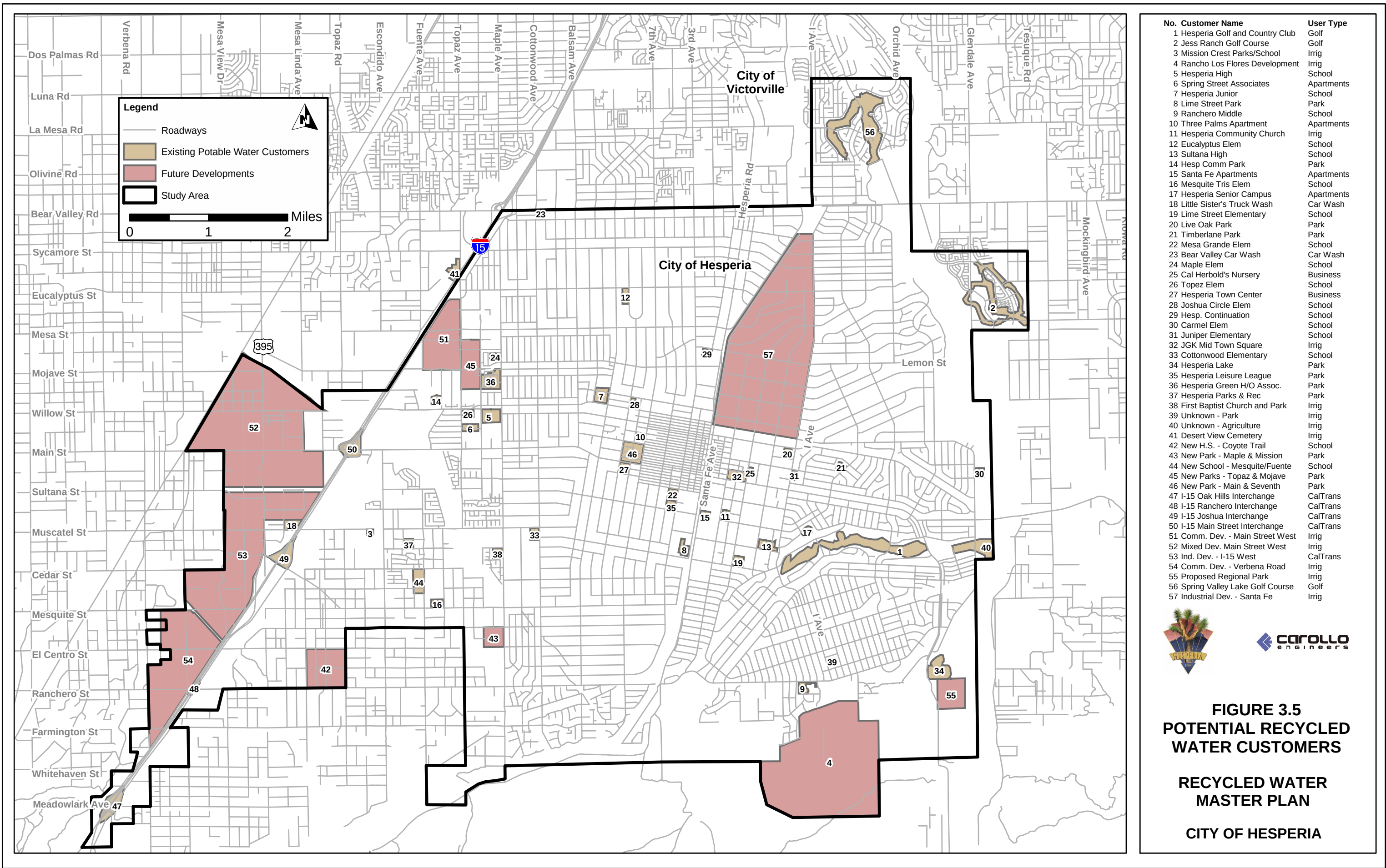


Table 3.3 Potential Customers - Parks Recycled Water Master Plan City of Hesperia						
Cust. No.	Customer	Irrig. Area (acres)	Average Annual Demand (mgd)	Max Day Demand (mgd)	Peak Hour Demand (gpm)	Notes
8	Lime Street Park	6	0.037	0.071	144	
11	Hesperia Community Church	5	0.033	0.063	129	
14	Hesperia Community Park	7	0.043	0.082	167	
20	Live Oak Park	5	0.030	0.057	118	
21	Timberlane Park	4	0.023	0.044	29	
34	Hesperia Lake Park	8	0.050	0.096	195	
37	Hesperia Parks and Recreation	7	0.045	0.086	174	
38	First Baptist Church and Park	4	0.023	0.044	89	
43	New Park - Maple and Mission	40	0.244	0.466	950	Future City Park
45	New Parks - Topaz and Mojave	20	0.121	0.231	472	Future City Park
46	Civic Plaza - Main and Seventh	5	0.030	0.057	118	Future City Park
55	Proposed Regional Park	20	0.122	0.233	475	Future Regional Park
Total		131	0.80	1.53	3,050	

Table 3.4 Potential Customers - Golf Courses and Cemetery Recycled Water Master Plan City of Hesperia						
Cust. No.	Customer	Irrig. Area (acres)	Average Annual Demand (mgd)	Max Day Demand (mgd)	Peak Hour Demand (gpm)	Notes
1	Hesperia Golf and Country Club	126	0.769	1.469	2,994	Groundwater User
2	Jess Ranch Golf Course	83	0.506	0.966	1,970	Groundwater User
41	Desert View Cemetery	12	0.074	0.141	286	
56	Spring Valley Lake Golf Course	107	0.651	1.243	2,534	Planned Apple Valley Reuse Customer
Total		328	2.00	3.820	7,780	

Table 3.5 Potential Customers - Schools Recycled Water Master Plan City of Hesperia						
Cust. No.	Customer	Irrig. Area (acres)	Average Annual Demand (mgd)	Max Day Demand (mgd)	Peak Hour Demand (gpm)	Notes
3	Mission Crest Park and School	16	0.096	0.183	374	
5	Hesperia High	22	0.137	0.262	531	
7	Hesperia Junior	5	0.030	0.057	118	
9	Ranchero Middle	6	0.036	0.069	141	
12	Eucalyptus Elementary	3	0.018	0.034	70	
13	Sultana High	13	0.080	0.153	312	
16	Mesquite Trails Elementary	3	0.018	0.034	71	
19	Lime Street Elementary	4	0.027	0.052	104	
22	Mesa Grande Elementary	3	0.017	0.032	66	
24	Maple Elementary	3	0.017	0.032	68	
26	Topaz Elementary	4	0.027	0.052	104	
28	Joshua Circle Elementary	2	0.014	0.027	54	
29	Hesperia Continuation	2	0.011	0.021	43	
30	Carmel Elementary	3	0.021	0.040	80	
31	Juniper Elementary	3	0.015	0.029	59	
33	Cottonwood Elementary	5	0.033	0.063	128	
39	Kingston Elementary	1	0.009	0.017	35	
42	New High School - Coyote Trail	10	0.061	0.117	237	Future Planned School
44	New School - Mesquite/Fuente	5	0.030	0.057	118	Future Planned School
Total		113	0.70	1.337	2,710	

Table 3.6 Potential Customers - Highway Medians Recycled Water Master Plan City of Hesperia						
Cust. No.	Customer	Irrig. Area (acres)	Average Annual Demand (mgd)	Max Day Demand (mgd)	Peak Hour Demand (gpm)	Notes
47	I-15 Oak Hills Interchange	4	0.024	0.046	94	
48	I-15 Ranchero Interchange	1	0.005	0.010	18	
49	I-15 Joshua Interchange	7	0.044	0.084	170	
50	I-15 Main Street Interchange	4	0.024	0.046	91	
Total		16	0.10	0.191	375	

Table 3.7 Potential Customers - Other Irrigation Recycled Water Master Plan City of Hesperia						
Cust. No.	Customer	Irrig. Area (acres)	Average Annual Demand (mgd)	Max Day Demand (mgd)	Peak Hour Demand (gpm)	Notes
6	Spring Street Associates	1	0.007	0.013	27	Apartment Complex
10	Three Palms Apartments	<1	0.003	0.006	11	Apartment Complex
15	Santa Fe Apartments	<1	0.002	0.004	6	Apartment Complex
17	Hesperia Senior Campus	1	0.009	0.017	34	Apartment Complex
25	Cal Herbold's Nursery	2	0.010	0.019	39	
27	Hesperia Town Center	1	0.003	0.006	13	Shopping Center
32	JGK Mid-Town Square	<1	0.006	0.011	22	Shopping Center
35	Hesperia Leisure League	<1	0.003	0.006	10	
36	Hesperia Green H/O Associates	3	0.020	0.038	79	Apartment Complex
40	Agricultural Area	47	0.287	0.548	1,120	
Total		57	0.35	0.669	1,390	

construction dust control, commercial laundries, car washes, concrete mixing, and sanitary sewer flushing.

Two potential commercial and industrial customers were identified based on water usage data from the City. These customers and their estimated demands are listed in Table 3.8. The total estimated annual demand for the commercial and individual customers is approximately 45 acre-ft/yr. Additional commercial uses of recycled water include car washes, hotel/motel uses, vehicle wash down, and toilet flushing. Commercial users with a daily water usage less than 20,000 gpd located on potential recycled water distribution routes can be identified from water usage data later.

3.5.3 Future Development Customers

With the assistance of City staff, six customers were identified as future development areas, including newly planned schools, parks, industrial parks, commercial development, and residential development. These future developments present a unique opportunity for recycled water use, as the installation of recycled water distribution can be conducted during initial construction, an economic advantage over existing customers.

These customers and their estimated demands are listed in Table 3.9. The total estimated annual demand for the commercial and industrial customers is approximately 1,568 acre-ft/yr.

3.5.4 Customer Summary

The estimated recycled water demands of the potential customers presented in Table 3.2 through Table 3.9 are summarized by category in Table 3.10. As shown, the total average annual demand is estimated to be over 6,000 acre-ft/yr or 5.4 mgd. This equates to a demand of approximately 10.1 mgd during the summer months.

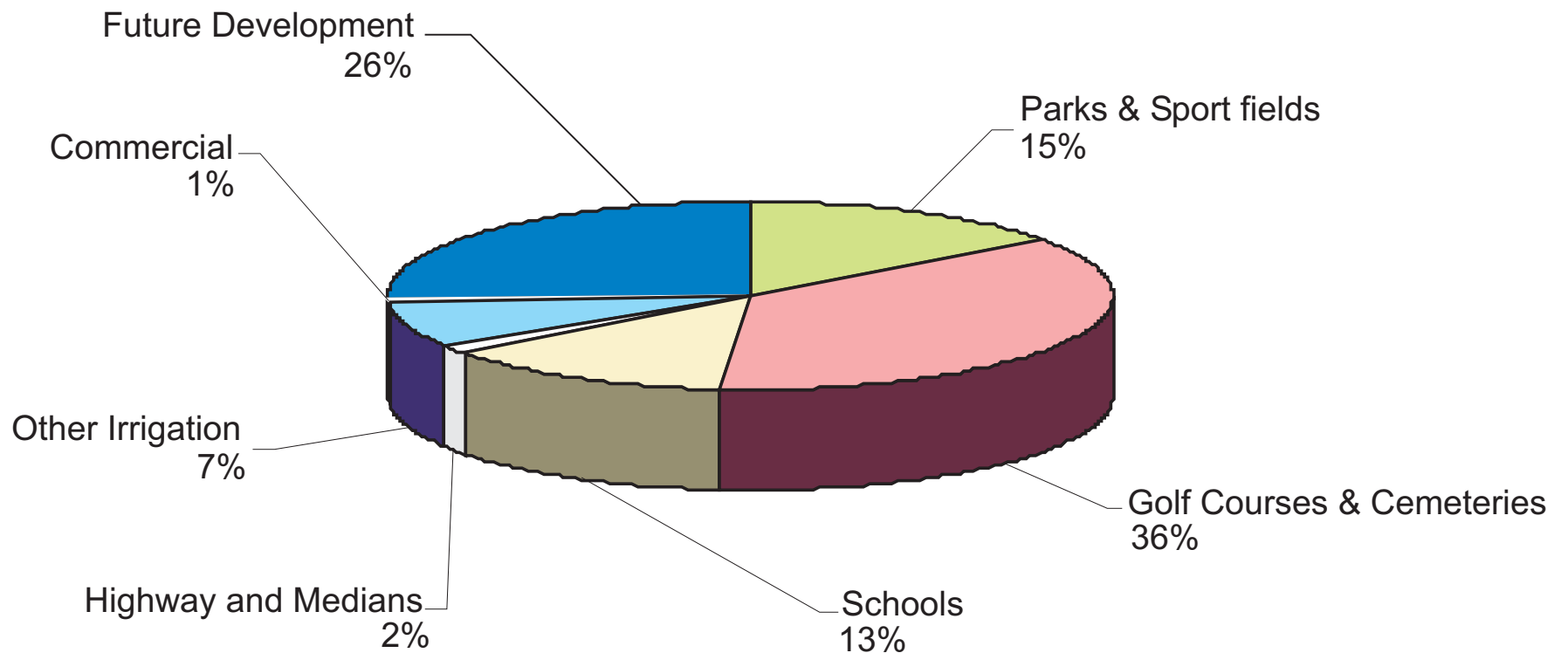
The three golf courses and the cemetery contribute to nearly 37 percent of the total recycled water demand potential. The future developments form the second largest demand category contributing to 26 percent of the total demand. Recycled water service to these large customers and new developments should therefore be the first priority when constructing a recycled water system.

The distribution of the demand by customer category based in Table 3.10 is shown on Figure 3.6.

Table 3.8 Potential Customers - Commercial Recycled Water Master Plan City of Hesperia						
Cust. No.	Customer	Irrig. Area (acres)	Average Annual Demand (acre-ft/yr)	Average Annual Demand (mgd)	Max Day Demand (mgd)	Peak Hour Demand (gpm)
18	Little Sister's Truck Wash	-	25	0.022	0.042	66
23	Bear Valley Car Wash	-	19	0.017	0.032	58
Total		N/A	44	0.039	0.074	125

Table 3.9 Potential Customers - Future Development Areas Recycled Water Master Plan City of Hesperia						
Cust. No.	Customer	Irrig. Area (acres)	Average Annual Demand (mgd)	Max Day Demand (mgd)	Peak Hour Demand (gpm)	Notes
4	Rancho Las Flores Development	100	0.610	1.165	2,376	
51	Commercial Development - Topaz and Mojave	9	0.054	0.103	211	
52	Mixed Development - Main Street West	12	0.072	0.138	281	
53	Industrial Development, I-15 West	8	0.050	0.096	195	
54	Commercial Development - Verbena Road	5	0.031	0.059	121	
57	Industrial Development - Santa Fe	100	0.610	1.165	2,376	
Total		234	1.4	2.674	5,560	
Notes:						
(1) Irrigable area estimated based on proposed development area and estimated irrigable percentage.						

Table 3.10 Potential Customers - Future Development Areas Recycled Water Master Plan City of Hesperia					
Customer Category	Irrigation Area⁽¹⁾ (acres)	Annual Demand⁽²⁾ (acre-ft/yr)	ADD⁽²⁾ (mgd)	MMD⁽³⁾ (mgd)	Peak Day Demand⁽⁴⁾ (gpm)
Parks and Sport fields	131	896	0.8	1.5	3,183
Golf Courses and Cemeteries	328	2,240	2.0	3.8	7,958
Schools	113	784	0.7	1.3	2,785
Highway and Medians	16	112	0.1	0.2	265
Other Irrigation	57	448	0.4	0.8	1,592
Commercial	N/A	45	0.04	0.1	106
Future Development	234	1,568	1.4	2.7	5,571
Total	879	6,090	5.4	10.4	21,460
Notes: (1) Irrigable area estimated based on proposed development area and estimated irrigable percentage. (2) The Annual Demand and ADD are the same, but expressed in different units. (3) The MMD is 1.91 times ADD. (4) The PHD is 1, 2, or 3 times MMD, depending on the user type per Table 3.2.					



**FIGURE 3.6
PERCENT DEMAND BY
CUSTOMER CATEGORY**



RECYCLED WATER MODEL

4.1 INTRODUCTION

This section includes a discussion of the creation of a hydraulic model for the recycled water system, a summary of the hydraulic evaluation and sizing criteria, and the hydraulic modeling analysis. This chapter concludes with a description of the potential recycled water distribution system that serves all 57 customers identified in the market assessment described in Chapter 3. The cost estimates of this potential system are presented in Chapter 5. A cost-benefit analysis is also included in Chapter 5 to determine which portions of the potential recycled water system are most cost-effective, and which portions should be deferred and not constructed due to relatively high unit cost. Hence, the potential system described in this chapter is not the same as the proposed system, which is described in Chapter 5.

4.2 RECYCLED WATER MODEL

This section described the creation of the hydraulic model, the allocation of the recycled water demands, the input of recycled water supplies, and the development of the recycled water system.

4.2.1 Model Creation

Hydraulic network analysis is a powerful tool used in all aspects of water distribution planning, design, operation, management, emergency response, system reliability analysis, fire flow capacity evaluation, as well as water quality simulations. The recycled water hydraulic model was developed to size the future recycled water facilities. The model analyzes the overall hydraulic capacity of the recycled water distribution system, based on a general layout of distribution piping and customer locations. Minor modifications or changes to the pipeline alignments in the future would typically not significantly affect the system hydraulics or pipeline sizing and cost.

In master planning, hydraulic models are used to predict hydraulic parameters, such as system pressures, pipeline velocities, or tank levels. These parameters are used to size pipelines, reservoirs, and booster stations. The model also allows numerous scenarios to be analyzed relatively quickly and easily and provides answers to many “what if” questions.

The City of Hesperia’s (City’s) recycled water model was created using H₂ONET[®] Version 6.0 and consists of the following three main parts:

1. Geographic Data File: The geographic data file includes the water system facility locations. This file is typically represented as an AutoCAD or Geographic Information Systems (GIS) file. The six basic elements included in this file are pipes, junctions,

valves, pumps, tanks, and reservoirs. These elements are combined to model a recycled water system network.

2. Model Database: The model database includes recycled water system information such as recycled water demands, usage patterns, pipeline sizing, facility sizing, and operational characteristics. Facility sizing and geometries include length and diameter of pipe, tank dimensions, valve sizing, and pumping curves. Operational characteristics include parameters that control how facilities move recycled water through the system, such as pump control settings, control valve settings, or main line valve closures. In addition, customized database fields were added to the model database to include information such as customer names, pressure zone designations, and the phasing of pipelines and facilities.
3. Computer Program "Calculator": The computer program "calculator" is used to solve a series of hydraulic equations to balance flows, pressures, and hydraulic grade lines. The calculator analyzes the hydraulic information in the database file and generates results for pressures, flow rates, and operating status. The key to maximizing use of the hydraulic model is to correctly interpret results and understand how the recycled water distribution system is being impacted. The model output generated by the calculator is used to modify the system configuration and facility sizing to develop the most optimum recycled water system that meets the hydraulic evaluation criteria and serves as many customers as practicably feasible.

The City provided a drawing with street centerlines, a parcel map, and a topography layer. These background files were used to determine the most practical location of reservoirs and pipeline alignments.

As this Recycled Water Master Plan (RWMP) was developed concurrent with the water and wastewater master plans, the model creation could be based on the most up-to-date information, including the three proposed Water Reclamation Plants (WRPs) and the future potable water system pressure zone boundaries. In addition, the pipeline and facility sizing was based on the same hydraulic criteria that were developed for the Water Master Plan.

The hydraulic model creation consisted of the following steps:

1. Input of all customers with their recycled water demands and diurnal patterns.
2. Input of the three WRPs with their respective capacities over time (2012, 2017, 2022, and 2032).
3. Input of pipelines that connects all customers via the shortest pipeline routes.
4. Input of ground elevations for all model nodes.
5. Defining pressure zones and their respective hydraulic grade lines (HGLs).
6. Input of reservoirs, booster stations, and pressure-reducing stations.

7. Preliminary sizing of pipelines, booster stations, and reservoirs.
8. Using model results to finalize the sizing of pipelines, booster stations, and reservoirs.

4.2.2 Recycled Water Demands

As described in Chapter 3, a total of 57 recycled water customers were identified with an estimated average day demand (ADD) of 5.4 mgd and a maximum month demand (MMD) of 10.4 mgd. Table 4.1 shows the estimated ADD, maximum day demand (MDD), and the peak hour demand (PHD) by customer category for all potential customers that were included in the hydraulic model.

Table 4.1 Potential Customers - Summary Recycled Water Master Plan City of Hesperia					
Customer Category	ADD⁽¹⁾ (mgd)	MDD/ADD Peaking Factor	MDD⁽¹⁾ (mgd)	PHD/MMD⁽²⁾ Peaking Factor	PHD (gpm)
Parks, Cemetery	0.8	1.91	1.7	2	70,530
Golf Courses with Lakes	1.2	1.91	2.4	1	1,633
Golf Courses without Lakes	0.8	1.91	1.5	3	3,060
Schools	0.7	1.91	1.3	2	1,857
Highway and Medians	0.1	1.91	0.2	2	265
Future Development	1.4	1.91	2.7	2	3,714
Other Irrigation	0.4	1.91	0.8	2	1,061
Commercial	0.04	1.91	0.1	2	106
Total	5.4	N/A	10.4	N/A	82,226
Notes: (1) Based on Table 3.10. (2) PHD/MMD = 3.0 for users with 8-hour irrigation, PHD/MMD = 2.0 for users with 12-hour irrigation, and PHD/MDD = 1.0 for users with a 24-hour delivery.					

4.2.3 Recycled Water Supplies

The City's wastewater is treated by the Victor Valley Wastewater Reclamation Authority (VWVRA), which owns and operates a 12.5-mgd wastewater reclamation plant in the City of Victorville, approximately 15 miles north of the northern City boundary. Due to the far distance, the City does not readily have access to recycled water from this plant. To create a local source of recycled water, the City plans to construct three wastewater reclamation plants (WRPs) within the City to treat its wastewater to tertiary standards. It is anticipated that solids from WRP-1 and WRP-2 would be discharged into the VWVRA interceptor for treatment at the VWVRA plant. Table 4.2 lists the location information of these WRPs, while more details on these WRPs are included in the Wastewater Master Plan.

Table 4.2 Treatment Facility Locations Recycled Water Master Plan City of Hesperia			
Facility ID	APN Number	Parcel Size (ac)	Location
WRP-1	3064-471-02	44	Near the intersection of Main Street and Cataba Road
WRP-2	TBD	20	Near the intersection of Osbrink Drive and Santa Fe East Avenue
WRP-3	TBD	TBD	In the northeastern portion of the RLF development, approximately 2 miles south of Rancho Road ⁽¹⁾ .
Notes: Source: Final Draft <i>Wastewater Master Plan</i> [12]. (1) An alternate location would be near Hesperia Lakes [12].			

Table 4.3 lists the projected wastewater flows to each treatment plant. The flows for WRP-3 are based on the flows of Planning Areas 15 and 16 as defined in the Wastewater Master Plan [12].

Table 4.3 Treatment Facility Sizing Recycled Water Master Plan City of Hesperia			
Plant No.	Average Annual Flow (mgd)⁽¹⁾	Maximum Month Flow (mgd)⁽¹⁾	Peak Hour Flow (mgd)⁽¹⁾
WRP-1	5.6	6.3	12.8
WRP-2	6.5	7.2	15.0
WRP-3	3.7	4.0	8.0
Total	15.8	17.5	35.8
Notes: (1) Based on Table 6.3 of the 2006 WWMP [12] 100 percent of modeled flow for year 2032.			

Based on the MMF data presented in Table 4.3, the capacity of WRP-1 should be 7.4 mgd (6.3/0.85), the capacity of WRP-2 should be 8.5 mgd (7.2/0.85), and the capacity of WRP-3 is estimated at 4.7 mgd (4.0/0.85). WRP-1 is planned to be operational by 2012, while WRP-2 and WRP-3 are planned to be operational by 2017. Table 4.4 shows the phasing information for each plant.

The three WRPs were input into the model as fixed grade nodes (unlimited source of supplies) with flow control valves to regulate the appropriate amount of flow for each planning year in the model (2012, 2017, 2022, and 2032).

Table 4.4 Treatment Facilities Phasing Recycled Water Master Plan City of Hesperia						
Description	2005 (mgd)	2012 (mgd)	2017 (mgd)	2022 (mgd)	2027 (mgd)	2032 (mgd)
VVWRA	2.1	2.8	0.0	0.0	0.0	0.0
WRP-1	N/A	2.3	3.8	4.8	5.5	5.7
WRP-2	N/A	N/A	4.1	5.1	5.9	6.5
WRP-3	N/A	N/A	2.5	2.9	3.3	3.7
Total	2.1	5.1	10.4	12.8	14.7	15.9
Notes: Source: Wastewater Master Plan Update [12].						

4.2.4 Recycled Water System

The recycled water system consists of pipelines, tanks, pumps, and valves using a configuration that aligns and operates within the proposed pressure zone boundaries established for the above mentioned recycled water customers. Prior to establishing locations of facilities, it was necessary to create pressure zones to develop maximum and minimum system static pressures within desired operational ranges.

4.2.5 Pressure Zones

The locations of the projected recycled water customers guided the creation of the proposed recycled water system pressure zones. Given the pressure design criteria established in this plan, pressure zones were established to produce static pressures within the higher ranges of the targeted pressure limits, to create a buffer for system headlosses. When the system is active and irrigation is prevalent, the system experiences its greatest headloss. Therefore, this scenario would experience the lowest system pressures as well. Zones were established to account for system losses and meet the pressure criteria under peak demand conditions.

System topology slopes from the northwest to southeast. Therefore, zones with the highest HGLs are located in the northwest, while zones with lower HGLs are located in the southeast. This is consistent with the potable water system zoning.

Based on topography and user locations, seven pressure zones were created, as summarized in Table 4.5 and shown on Figure 4.1.

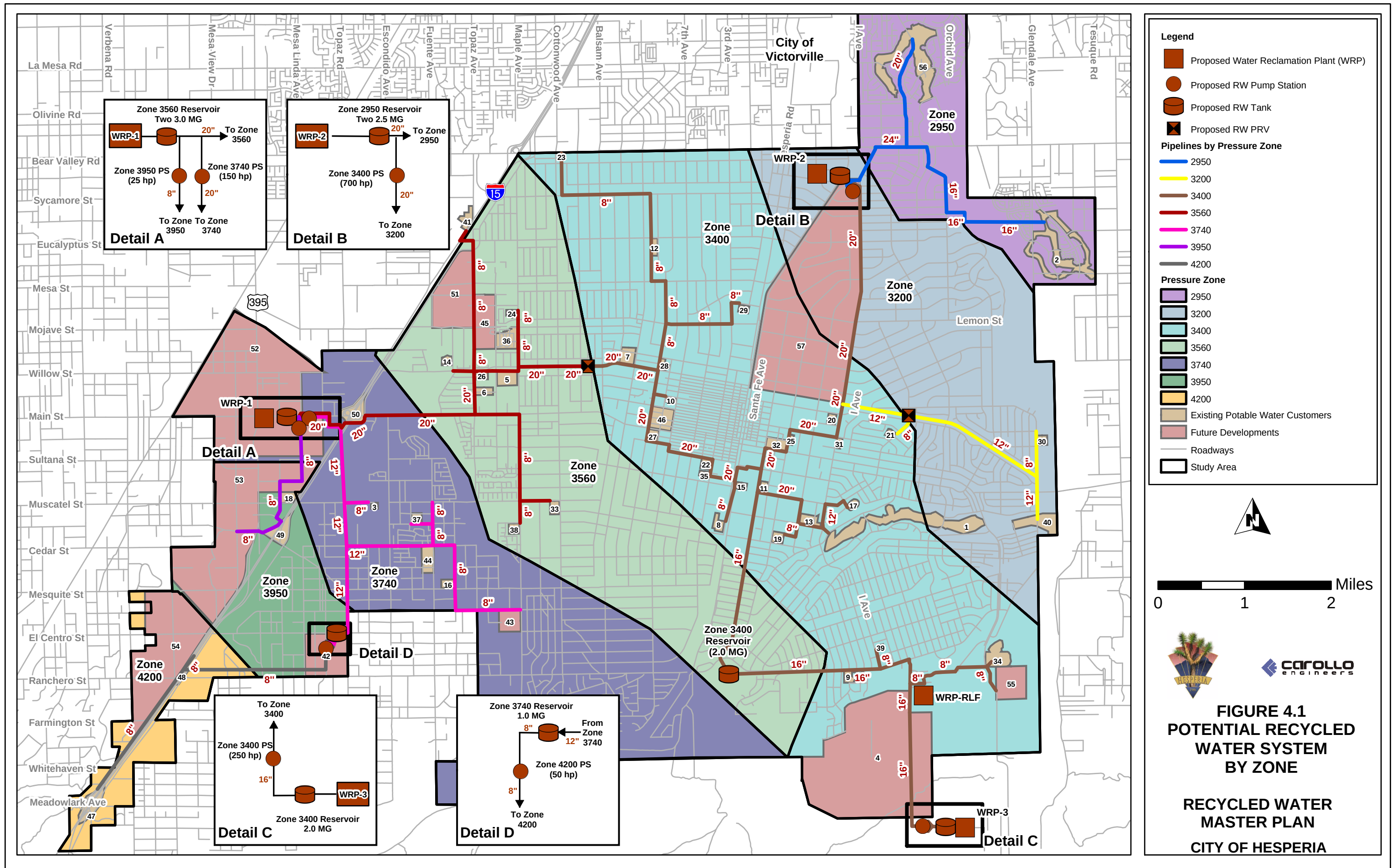


Table 4.5 Pressure Zone Summary Recycled Water Master Plan City of Hesperia						
Pressure Zone	Zone HGL (ft-msl)	Maximum Elevation (ft-msl)	Minimum Elevation (ft-msl)	Maximum Pressure (psi)	Minimum Pressure (psi)	Supply Sources
1A	2,950	2,870	2,603	150	35	WRP-2 by gravity
1	3,200	3,061	2,853	150	60	WRP-2
2A	3,400	3,069	3,271	150	60	WRP-2
2B	3,400	3,053	3,261	150	60	WRP-3
3	3,560	3,421	3,213	150	60	WRP-1 by gravity
4	3,740	3,602	3,394	150	60	WRP-1
5	3,950	3,811	3,603	150	60	WRP-1
6	4,280	4,140	3,841	190	61	WRP-1

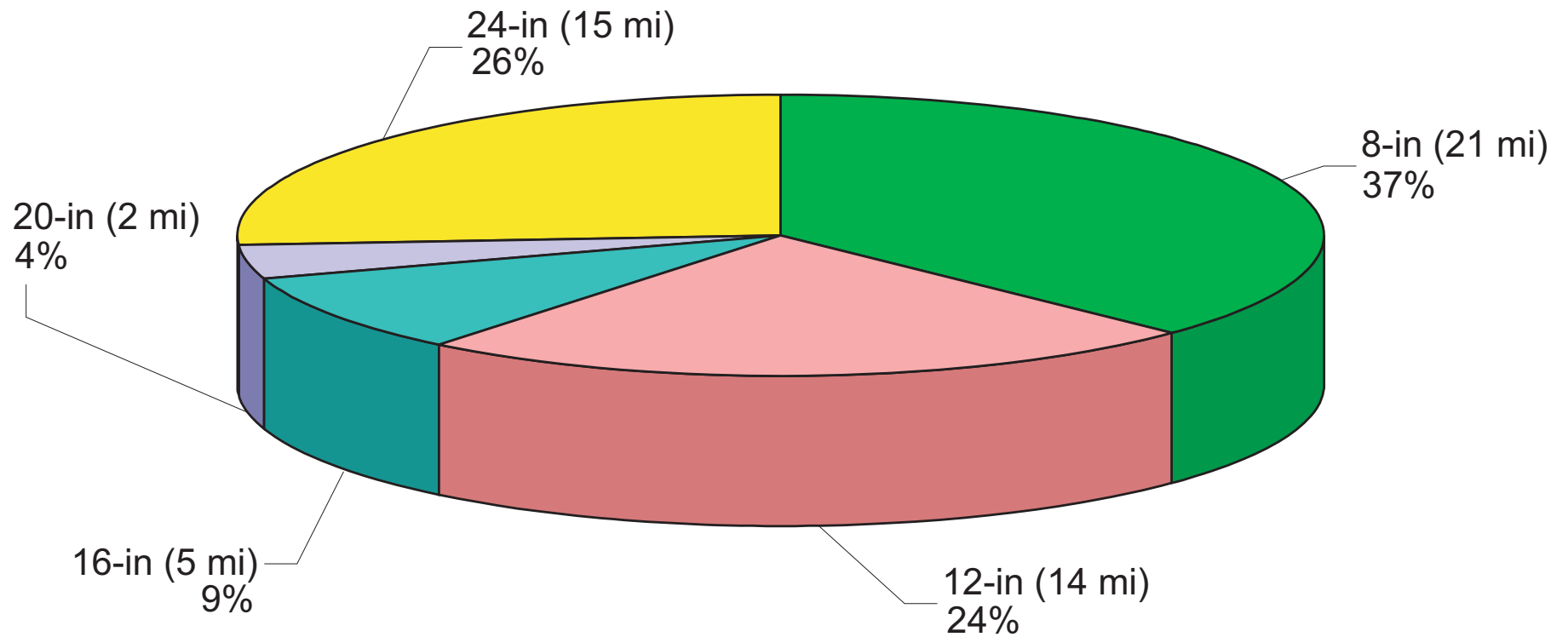
4.2.5.1 Pipelines

Recycled water system pipelines have been aligned to achieve the shortest route to the proposed recycled water customers. Recycled water system pipelines were all located in public streets to avoid potential right-of-way or easement conflicts. When all 57 customers are connected, the total system pipeline length is approximately 54 miles. The distribution of pipelines by diameter is shown on Figure 4.2.

4.2.6 Storage Reservoirs

The potential recycled water system contains six reservoir sites with a combined storage volume of 10.5 million gallons (MG). Tanks are located at the WRP sites where possible. In addition, two tank sites are located within the distribution system to provide gravity storage and to function as a pump station forebay for the next higher pressure zone. The proposed reservoirs and the respective volumes are summarized in Table 4.6, while their locations are shown on Figure 4.1.

Table 4.6 Reservoir Summary Recycled Water Master Plan City of Hesperia				
Tank Name	Zone Served	High Water Level (ft-msl)	Volume (MG)	Number of Tanks
WRP-1 Reservoir	Zone 3560 (3) by gravity Zone 3740 (4) by pumping Zone 3950 (5) by pumping	3,560	3.0	one 3.0 MG
WRP-2 Reservoir	Zone 2950 (1A) by gravity Zone 3200 (1) by pumping Zone 3400 (2) by pumping	2,950	2.0	one 2.0 MG



**FIGURE 4.2
DISTRIBUTION
OF PIPELINE DIAMETERS**



Table 4.6 Reservoir Summary (Continued) Recycled Water Master Plan City of Hesperia				
Tank Name	Zone Served	High Water Level (ft-msl)	Volume (MG)	Number of Tanks
WRP-3 Reservoir	Zone 3400 (2) by pumping	3,400	1.0	one 1.0 MG
Zone 3740 Reservoir	Zone 3740 (4) by gravity Zone 4200 (6) by pumping	3,740	1.5	one 1.5 MG
Zone 3400 Reservoir	Zone 3400 (2) by gravity	3,400	3.0	two 1.5 MG

4.2.7 Pump Stations

Four booster pump stations are proposed, including one dual-zone pump station at the Zone 3740 Reservoir site. All pump stations are located at a reservoir site for ease of supply and maximum space efficiency. Pump stations are proposed for application to this recycled water system to both fill gravity storage tanks and serve as the sole source of supply for a pressure zone. Table 4.7 provides a summary of the proposed booster stations.

Table 4.7 Pump Station Summary Recycled Water Master Plan City of Hesperia						
Pump Station	Location	From Zone	To Zone	Design Flow (gpm)	Design Head (ft)	Design Capacity (hp)
3740 PS	WRP-1	WRP-1	3740	1,870	205	150
3950 PS	WRP-1	WRP-1	3950	180	415	25
3400 PS	WRP-2	WRP-2	3400	6,000	410	900
4200 PS	Zone 3740 Reservoir	3740	4200	605	500	100
3400 PS	WRP-3	WRP-3	3400	1,740	300	200

4.2.8 Pressure-Reducing Stations

Pressure-reducing stations (PRSS) consist of one or multiple pressure-reducing valves (PRVs) that can feed a downstream pressure zone from a higher-pressure zone. There are two PRSS included in the City's proposed recycled water system.

One PRS supplies Zone 3400 from Zone 3560. This station allows water from WRP-1 into Zone 3400, which is primarily supplied from WRP-2. Due to the higher location of WRP-1, it is beneficial to supplement this zone through a PRV. This station also provides more operational flexibility.

The second PRS supplies a few customers in Zone 3200 from Zone 3400. Due to the small demand in Zone 3200, it is not cost-effective to create another gravity storage tank and additional booster stations. Instead, a PRS is recommended near the intersection of Live Oak Street and Timberlane Avenue.

4.3 EVALUATION AND SIZING CRITERIA

Hydraulic planning criteria and assumptions discussed in this subsection are network configuration, standard pipeline sizes, system pressures, pipeline velocity, pipeline headloss, storage sizing criteria, and pump station sizing criteria.

4.3.1 Network Configuration

The distribution system will consist of a network of pressurized pipelines that connect WRP-1, WRP-2, and WRP-3.

The main network configuration (served from WRP-1 and WRP-2) will comprise a single transmission main, the backbone system that connects the City's recycled water sources with the gravity storage reservoirs in each pressure zone. The customers in the southern part of Zone 3400 are planned to be served from WRP-3, which is interconnected with the northern part of the distribution system through the Zone 3400 reservoir. The recycled water systems that should serve the future develop mounts in PA-15 and PA-16 (Rancho Las Flores, North Summit Valley, and Summit Valley Ranch) can be connected to the Zone 3400 to provide optimal operational flexibility in terms of recycled water supply when all local WRPs are constructed.

The backbone system will provide turnouts to connect smaller distribution system pipelines that will serve individual customers or groups of customers. The feasibility of some of these dead-end distribution system pipelines is evaluated in Section 5.

4.3.2 Standard Pipeline Sizes

Pipeline sizes are based on the City's standard diameters, as listed in Table 4.8. The non-standard 20-inch diameter pipeline is considered as an alternative to 24 inches with respect to potential cost savings. As shown in Table 4.8, the smallest pipeline considered is 8 inches in diameter.

Table 4.8 Standard Pipeline Sizes Recycled Water Master Plan City of Hesperia	
Pipe Diameter	Type Size
8 inches	Standard Size
12 inches	Standard Size
16 inches	Standard Size

Table 4.8 Standard Pipeline Sizes (Continued) Recycled Water Master Plan City of Hesperia	
Pipe Diameter	Type Size
20 inches	Non-standard Size
24 inches	Standard Size
30 inches	Standard Size

4.3.3 System Pressures

The system pressure in a recycled water system is typically designed to be slightly lower than the system pressure in the potable water system pipelines that are located in close vicinity of the recycled water pipelines to reduce the risk of contamination in the event of a pipeline break and low disinfectant residual in the recycled water system. However, this requirement can not often be met due to the following two reasons:

1. System pressure in potable water systems vary and pressure zone boundaries of potable and recycled water systems often do not overlap.
2. It is preferred to maintain a minimum pressure in the recycled water system of approximately 60 psi to meet the operating requirements for most sprinkler systems. However, the minimum pressure in potable water systems is typically 40 psi.

As the chance of cross contamination is minimal due to disinfection and a minimum horizontal separation of 10 feet between potable and recycled water pipelines, it is assumed that the recycled water system does not need to be coordinated with the existing potable water system pressure ranges.

The minimum system pressure used for pipeline sizing in this Master Plan is 60 psi under PHD conditions. The maximum system pressure is 150 psi, to avoid the need for more costly high-pressure class pipelines. All recycled water system pipelines are sized to meet PHD. The discharge pressure at golf courses with lakes can be as low as 10 psi, as water used for irrigation would be pumped from the lake rather than from the distribution system. The use of golf course lakes for storage allows for smaller pipelines due to the lower peaking factor and delivery pressure.

4.3.4 Pipeline Velocities

The maximum pipe velocity should not exceed 5 feet per second (ft/s) under PHD conditions with the entire distribution network in service.

4.3.5 Pipeline Headloss

The maximum headloss should not exceed 5 feet per thousand feet (ft/kft) under PHD conditions with the entire distribution network in service.

4.3.6 Storage Sizing Criteria

To operate a recycled water system with gravity reservoirs that is supplied from the local WRPs, three types of storage are required. These are:

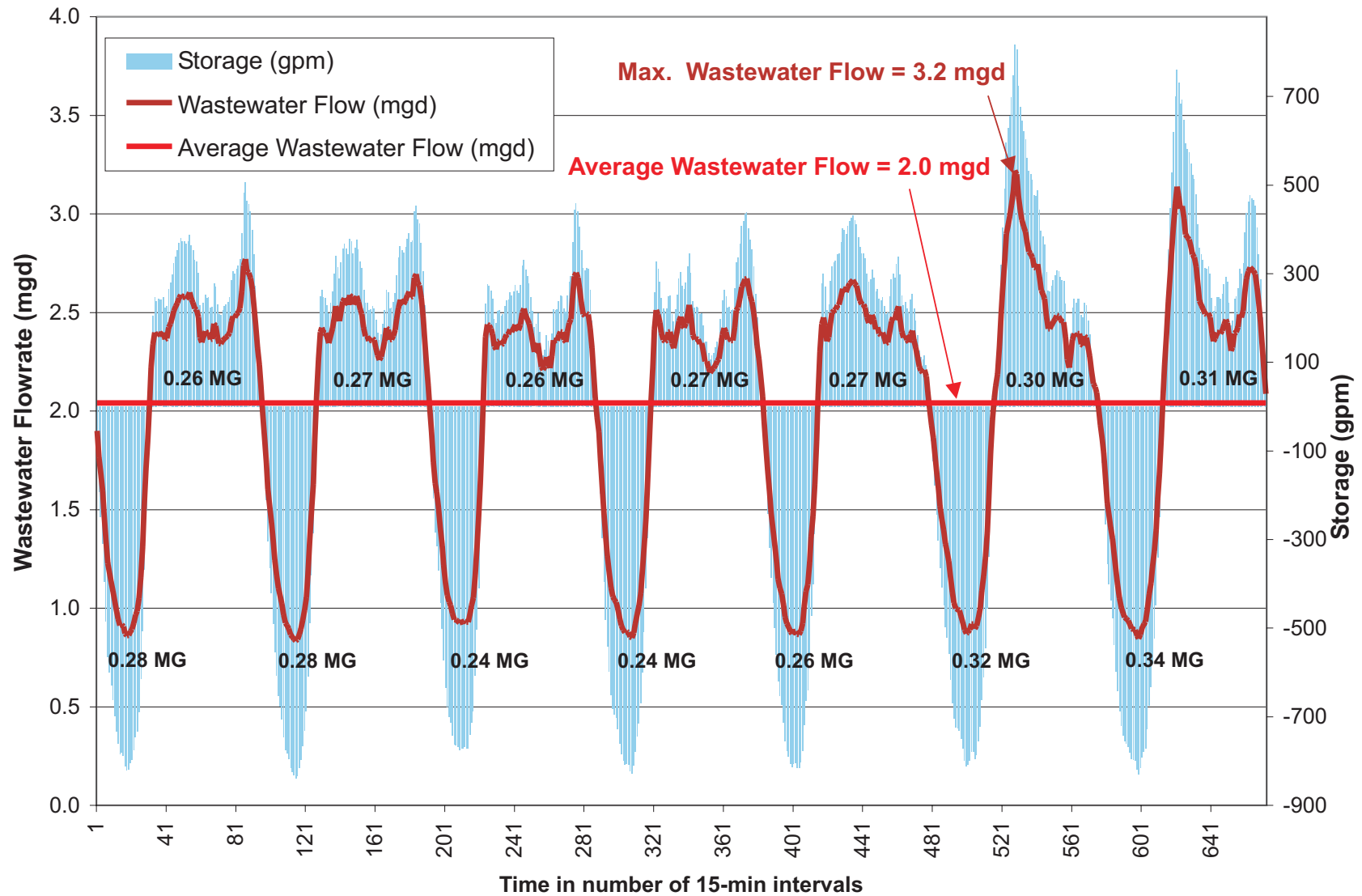
1. Storage required to attenuate the hourly variation in wastewater flow and to provide a constant recycled water supply. With wastewater flows primarily occurring during the day and recycled water demands during the night, this storage component can be significant. The presence of primary or secondary storage at the WRPs could affect the volume required for this storage component, which will typically be provided as a pump station forebay.
2. Storage reservoirs required to buffer demand fluctuations under MDD conditions, including the difference between PHD and MDD. The volume required for this storage component is highly dependent upon the hourly variation of the customers' demand or the composite diurnal curve of each pressure zone.
3. Storage volume required protecting reservoirs from complete drainage. This "dead" storage provides operational flexibility and it protects pumps from pumping air, which can cause cavitation problems.

The first storage component, equalization storage, was calculated based on hourly wastewater flows collected for the calibration of the sewer hydraulic model. These flows were recorded from May 24 through May 30, 2006 [13]. The total flows that were discharged to VVWRA are shown on Figure 4.3. As shown on this figure, the average flow rate was 2.0, while the maximum flow rate was 3.2 mgd. The maximum amount of equalization storage that was calculated for this week was 0.34 MG, which is 17 percent of the average flow rate. As this data only represents one week of flows, it was decided to use 20 percent of the average daily flow as equalization storage criterion.

The second storage component, operational storage, is calculated based on the estimated water demand of the potential customers and their associated diurnal patterns. Based on the assumption that the majority of customers (irrigation users) will only use recycled water in a 12-hour demand period, it can be calculated that the operational storage need to be sized for 50 percent of the MMD of each pressure zone. To be conservative and allow customers to irrigate during 8 hours, operational storage was sized at 67 percent of MDD.

The third storage component, dead storage, is required for both the equalization and operational storage. The depth of all reservoirs is increased by 10 feet to account for dead storage, with a maximum storage tank height of 30 feet.

It should be noted that recycled water systems do not require storage for fire flow or emergencies, as the potable water system storage is sized for these components.



**FIGURE 4.3
HISTORICAL WASTEWATER
FLOW VARIATION**

4.3.7 Pump Station Sizing Criteria

Two pump station sizing criteria were used for the system analysis in this Master Plan, depending on the location of reservoir storage:

1. Pressure zones with gravity reservoir storage have the benefit that reservoirs provide additional supply during the peak hours of MDD (reservoir drainage) and provide buffer capacity during the minimum hours of MDD (reservoir filling). This allows pump station sizing for the average hour demand of MDD. Hence, all pump stations that pump into a zone with gravity storage are sized for MDD.
2. Pressure zones without gravity reservoir storage do not provide the benefit of additional supply from reservoirs during the peak hours of MDD. Hence, all pump stations that pump into a zone without gravity storage (closed system) need to be sized for PHD.

It is assumed that booster stations do not require backup pumping capacity for emergencies, as irrigation water supply could temporary be interrupted and the existing customers could fall back on their potable water connection if needed. The golf courses planned in the new developments are assumed to use their lakes for operational storage, which should also provide operational flexibility during pump station temporary failures.

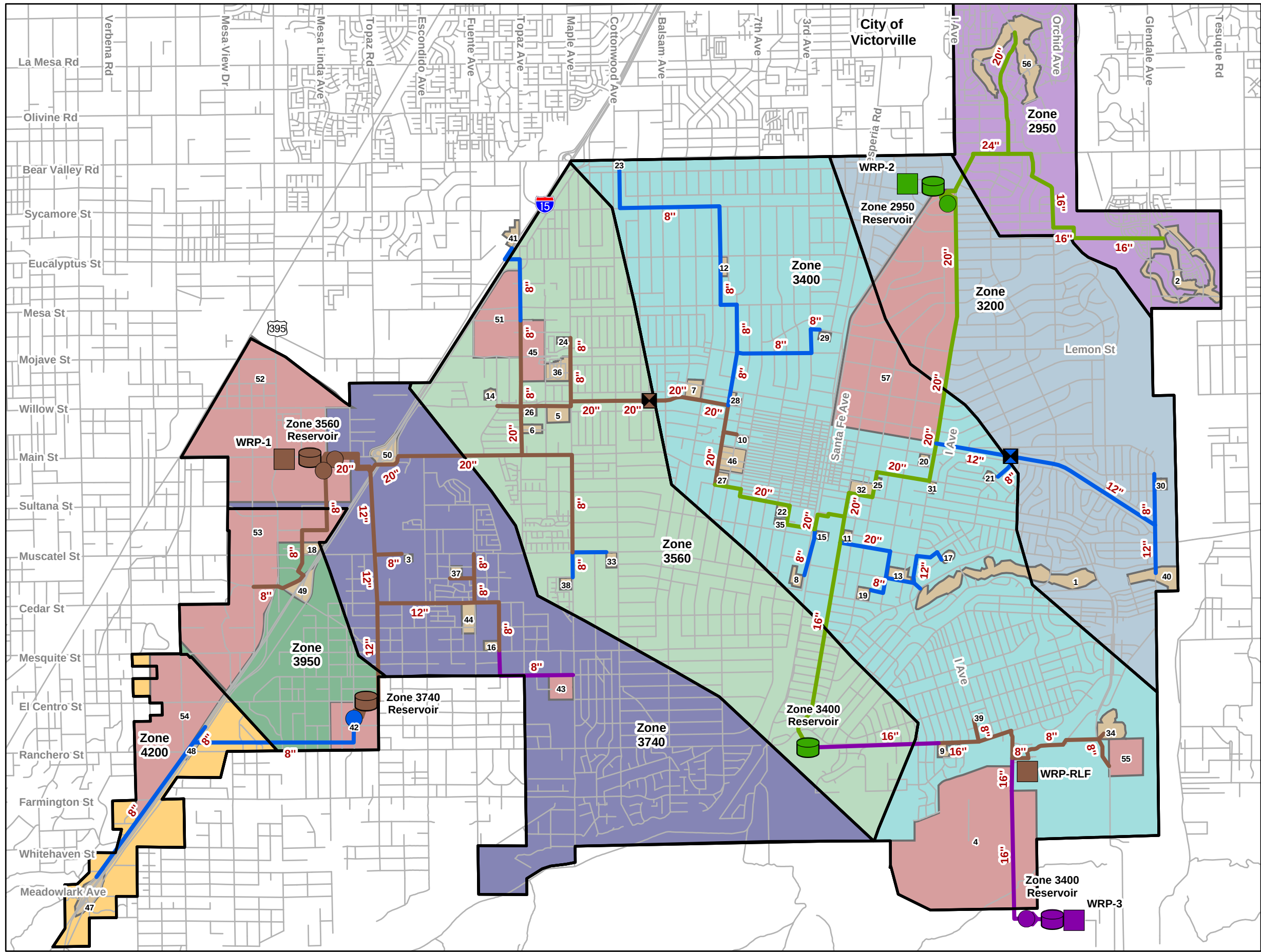
4.4 RECYCLED WATER SYSTEM ANALYSIS

Hydraulic model alternatives were guided by the projected phasing and locations of recycled water customers. Approximately 17 percent of the recycled water demand is projected to be online by the end of planning year 2012, approximately 65 percent online by 2022, and the remaining 18 percent to be online by 2032. This timing also coincides with the availability of tertiary treated wastewater.

With the proposed configuration, WRP-1 will supply an average day demand of 0.91 mgd in 2012 to Zones 3400, 3560, 3740, and 3590.

Once WRP-2 is online in 2017, the system can be expanded to serve Zones 2950 and 3200 and the rest of Zone 3400. WRP-2 has a larger capacity and thus can supply more demand. The booster station at WRP-2 will be used to fill the Zone 3200 Reservoir to supplement flows under peak demand conditions. Due to its lower elevation location, additional pumping is required to move water westward into Zones 3400, 3560, etc.

The phasing of the proposed recycled water system is shown on Figure 4.4. As shown in this figure, the majority of infrastructure could be constructed after the completion of WRP-1 in 2012. However, the three largest customers (the golf courses) cannot be served until after the construction of WRP-2 and the associated pipelines.



Legend

Proposed Water Reclamation Plant (WRP)

- WRP 1/WRP RLF (2012)
- WRP 2 (2017)
- WRP 3 (2032)

Proposed RW Pump Station

- 2017
- 2012
- 2022
- 2032

Proposed RW Tank

- 2012
- 2017
- 2032

Proposed RW PRV

- 2012
- 2022

Potential Recycled Water System

- 2012
- 2017
- 2022
- 2032

Pressure Zone

- 2950
- 3200
- 3400
- 3560
- 3740
- 3950
- 4200
- Existing Potable Water Customers
- Future Developments
- Roadways
- Study Area

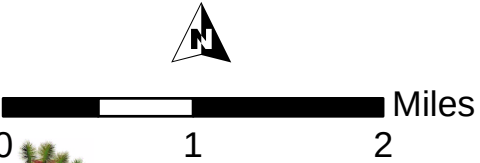


FIGURE 4.4
POTENTIAL RECYCLED
WATER SYSTEM
BY PHASE
RECYCLED WATER
MASTER PLAN
CITY OF HESPERIA

As discussed previously, the potential recycled water system shown on Figure 4.4 is the ultimate system that serves all 57 potential customers, without the consideration of cost. The cost of this system is presented in Chapter 5, along with a feasibility analysis that determines the unit costs for some of the smaller dead-end distribution pipelines that connect to relatively small customers. The findings of this feasibility study and the proposed system are presented in Chapter 5.

CAPITAL IMPROVEMENT PROGRAM

5.1 INTRODUCTION

The capital improvement program (CIP) summarizes the recommended improvements, phasing, cost estimates, and the allocation of project cost for the recommended recycled water system. The purpose of this CIP is to provide the City of Hesperia (City) with a guideline for the planning and budgeting of its recycled water system, which will assist the City in accommodating future growth as it offsets the need for some of the projected potable water supplies. Due to the increasing scarcity and cost of potable water in Southern California, it is recommended that the City work closely with the upcoming development to implement this CIP and continue to provide a reliable water supply to the City's customers.

5.2 COST ESTIMATES

5.2.1 General Project Costs

Cost estimates presented in this master plan are based on the current Engineering News Record (ENR) cost index for the Los Angeles metropolitan area of 8,871 published in January 2007. Future adjustments of cost estimates presented in this report can be estimated by increasing the estimated capital cost by the ratio of the future ENR to 8,871.

Total project cost estimates include estimated costs for construction, engineering, legal, administration, construction management, and contingency. Estimated construction costs are based on historical bids submitted by contractors for similar projects for Carollo Engineers (Carollo). A contingency of 25 percent of the estimated construction cost is included in the cost estimates. In addition, the capital cost for each project includes the estimated costs of engineering, legal, administration, and construction management and were assumed to be 35 percent of the estimated construction and contingency cost. These cost assumptions are listed in Table 5.1.

Table 5.1 General Project Cost Assumptions Recycled Water Master Plan City of Hesperia	
Description	Value
Contingency	25% of the construction cost (CC) ⁽¹⁾
Engineering, Administration, Legal, and Construction Management	35% of the CC plus contingency ⁽²⁾
Capital Cost	169% of the CC
Notes: (1) CC is the cost of materials and installation only. (2) Construction cost includes direct construction cost and contingency cost. (3) Capital Cost include the construction cost, contingency, engineering, administration, legal, and construction management cost.	

The cost estimates are based on current perceptions of conditions at the project locations. These estimates reflect Carollo's professional opinion of costs at this time and are subject to change as the project design matures. Carollo has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding, or market conditions, practices, or bidding strategies. Carollo cannot, and does not, warrant or guarantee that proposals, bids, or actual construction costs will not vary for the costs presented herein.

5.2.2 Construction Costs

Capital costs of the recycled water system are divided into the following elements:

- Customer Connections.
- Customer Retrofits.
- Distribution System Cost.
- Pumping Cost.
- Storage Cost.
- Treatment Cost.

Each element is discussed below. Cost estimates were based on previous project experience.

5.2.2.1 Customer Connections

Connections are required for serving recycled water from the distribution pipelines to customer properties. Items included in the connection cost are: tapping the distribution mains and installing service laterals, meters, pressure reducing valves (PRVs), and backflow prevention devices on the potable water system. It is assumed that the average size for laterals, meters, and PRVs will be 1 1/2 inches. Customer connection costs are estimated to be \$1,600 each plus \$2,000 each for the installation of a backflow prevention device, totaling \$3,600 per customer connection.

5.2.2.2 Customer Retrofits

Retrofit costs are associated with separating the customer's existing water system from a new recycled water system. An example would be a park where restroom and drinking fountain water supply pipes would need to be isolated from an existing irrigation system. Additional costs include posting signs that identify where recycled water is being used. Customer retrofits are one-time costs and are a function of existing irrigation systems at each individual site. If the site has existing separate systems, then the retrofit cost is assumed to be zero. Retrofits for most customers were estimated at \$25,000. However these could vary from \$10,000 to \$75,000 depending on the extent of system replacements.

The customers with no potable water demand and 100 percent recycled water demand have no retrofit costs because there is no need to separate an existing potable water system from a new recycled water system. The customers with no retrofit costs are the highway median and future development area customers.

5.2.2.3 Distribution System Costs

Construction costs for the distribution system include pipe material, excavation, installation, bedding material, backfill material, transport, and paving where applicable. Valves and appurtenances are also included in the unit pipeline cost. The costs of acquiring easements for pipeline construction are not included in this estimate, although most distribution pipeline routings are within existing City street right-of-ways. The range for pipeline capital costs is from 8-inch diameter pipelines at \$70 per linear foot (LF), to 30-inch diameter pipelines at \$210/LF. Table 5.2 lists the unit cost used for all pipeline diameter sizes.

Table 5.2 Cost Estimating Assumptions Recycled Water Master Plan City of Hesperia	
Category	Unit Cost
Pipelines	\$/linear ft
8-inch diameter	\$70
12-inch diameter	\$90
16-inch diameter	\$115
20-inch diameter	\$140
24-inch diameter	\$170
30-inch diameter	\$210
Pump Stations	\$/hp
<100 hp	\$6,200
100 - 500 hp	\$4,130
600 - 1,000 hp	\$3,100
Storage Tanks	\$/gallon
≤1 MG	\$2.10
1.1 - 3.0 MG	\$1.60
3.1 - 5.0 MG	\$1.30
5.1 – 10 MG	\$1.10
Land Acquisition	\$/acre
Per 1-acre site	\$250,000
Customer Connection	\$/Customer
Per connection	\$3,600
Customer Retrofits	\$/Customer
Per connection	\$25,000

5.2.2.4 Pump Stations

Pump station costs are based on capacity, in horsepower (hp), of the station, including the spare pump unit. The recommended pump station capacity ranges from 25 to 900 hp. As shown in Table 5.2, the unit pump station cost ranges from \$3,100/hp to \$6,200/hp.

5.2.2.5 Storage Tanks

Storage tanks are required to attenuate wastewater effluent flows at the water reclamation plants (WRPs) (equalization storage) and provide a buffer for daily recycled water demand variations (operational storage). Cost varies by tank size (see Table 5.2), and the recommended tanks in this report range from 1 MG (\$2.10/gallon) to 3 MG (\$1.60/gallon).

5.2.2.6 Land Acquisition

Land acquisition does not require contingency or mark-up costs and is estimated at \$250,000/acre. Land required for the WRP, storage at the WRP sites, and PS at the WRP sites are not included in this Master Plan, as these costs are already included in the WWMP CIP. However, land required for gravity storage reservoirs and the associated PSs in the distribution system are included in this RWMP CIP. It was assumed that reservoir sites would have a minimum of 100 feet of clearance around the circular tanks to allow access and on-site facilities, such as PSs.

5.2.2.7 Treatment

Treatment costs are included in the wastewater CIP [12] as the primary, secondary and tertiary treatment is required for wastewater treatment.

5.2.2.8 Cost Assumptions

The cost estimates presented in this report are based on the unit construction costs listed in Table 5.2. All unit costs were assumed to include material and installation. Costs for engineering, legal, administration, construction management, and contingency were not included in the listed unit costs.

5.2.3 Operation and Maintenance Cost

Operation and Maintenance (O&M) costs are comprised of the following items:

- Purchased Power for Pumping.
- Distribution System Maintenance.
- General Administration.

No additional labor costs are included as treatment plant facilities and operation are considered under a separate cover.

5.2.3.1 Purchased Power

The average recycled water demands were used to determine power consumption. Costs for electricity are based on a unit price of \$0.14 per kilowatt-hour. While calculating purchase power price per kilowatt-hour, it was assumed for conservative purposes that Zone 3400 was not served with recycled water by gravity from WRP-1, but entirely supplied from WRP-2 through pump stations. Therefore, purchased power was calculated for WRP-1 pumping to Zones 3740 and 3950, WRP-2 pumping to Zone 3400, WRP-3 pumping to Zone 3400, and Zone 3740 Reservoir pumping to Zone 4200.

5.2.3.2 Distribution System Maintenance

The average annual maintenance expense for the recycled water distribution system was based on an assumed value of \$2,800 per mile per year, which is a typical industry value.

5.2.3.3 General Administration

General administration includes costs associated with customer accounting, meter reading, and other miscellaneous costs associated with operating a water system. General administration costs are estimated at \$1,500 per mile of distribution pipeline per year.

Estimates of the O&M costs for planning years 2012, 2017, 2022, and 2032 CIPs are presented in Table 5.3.

Table 5.3 Estimated Operation and Maintenance Costs Recycled Water Master Plan City of Hesperia				
Description	2007 - 2012	2013 - 2017	2018 - 2022	2023 - 2032
Purchased Power	-	\$35,000	\$176,000	\$337,000
Distribution System Maintenance	\$46,000	\$105,000	\$158,000	\$161,000
General Administration	\$25,000	\$56,000	\$85,000	\$86,000
Subtotal⁽¹⁾	\$71,000	\$196,000	\$419,000	\$584,000
Contingency (25%)	\$18,000	\$49,000	\$105,000	\$146,000
Total O&M Cost⁽²⁾	\$89,000	\$245,000	\$524,000	\$730,000
Notes:				
(1) O&M costs include costs for distribution only, not treatment. O&M cost estimates include power costs to serve customer and costs for upkeep of the distribution system facilities.				
(2) O&M cost estimates are inclusive of previous phase costs, e.g., 2018-2022 costs include the 2007-2012 and the 2013-2017 costs, etc.				

5.2.4 Potential System Cost

The estimated costs for the pipelines, storage, pump stations, and the three WRPs are presented in Tables 5.4 through 5.7.

Table 5.4 Estimated Pipeline Costs Recycled Water Master Plan City of Hesperia			
Pipeline Diameter (inches)	Pipeline Length (linear feet)	Unit Cost (\$/linear-ft)	Capital Cost⁽¹⁾ (\$M)
8	112,500	\$70	\$13.3
12	71,000	\$90	\$10.8
16	27,500	\$115	\$5.3
20	12,000	\$140	\$2.8
24	79,000	\$170	\$22.7
Total	284,000	N/A	\$54.9
Notes:			
(1) Capital Cost includes construction cost, contingency, and mark-ups per Table 5.2.			

Table 5.5 Estimated Storage Costs Recycled Water Master Plan City of Hesperia				
Storage Tanks	No. of Tanks	Storage Capacity (MG)	Unit Cost (\$/gal)	Capital Cost⁽¹⁾ (\$M)
WRP-1 Reservoir	1	3.0	\$1.60	\$8.1
WRP-2 Reservoir	1	2.0	\$1.60	\$5.4
WRP-3 Reservoir	1	1.0	\$2.10	\$3.5
Zone 3740 Reservoir	1	1.5	\$1.60	\$4.1
Zone 3400 Reservoir	2	3.0	\$1.60	\$16.2
Total	6	10.5	N/A	\$37.3
Notes:				
(1) Capital Cost includes construction cost, contingency, and mark-ups per Table 5.2.				

Table 5.6 Estimated Pump Station Costs Recycled Water Master Plan City of Hesperia						
Pump Stations	Location	Design Flow (gpm)	Design Head (ft)	Design Capacity (hp)	Unit Cost (\$/hp)	Capital Cost (\$M)
3740 PS	WRP-1	1,870	205	150	\$4,130	\$1.0
3950 PS	WRP-1	180	415	25	\$6,200	\$0.3
3400 PS	WRP-2	6,000	410	900	\$3,100	\$4.7
4200 PS	Zone 3740 Reservoir	605	500	100	\$4,130	\$0.7
3400 PS (south)	WRP-3	1,737	300	200	\$4,132	\$1.4
Total	N/A	10,392	N/A	N/A	N/A	\$8.1

Table 5.7 Estimated Land Acquisition Costs Recycled Water Master Plan City of Hesperia				
Storage Tanks	Storage Capacity (MG)	Parcel Size (acres)	Unit Cost (\$/acre)	Capital Cost⁽¹⁾ (\$M)
Zone 3740 Reservoir	1.5	2.00	\$250,000	\$0.5
Zone 3400 Reservoir	3.0	3.25	\$250,000	\$0.8
Total	10.5	5.25	N/A	\$1.3
Notes: (1) Land costs do not include any contingencies or mark-ups.				

Table 5.8 summarizes the estimated total cost for the potential recycled water system as shown on Figure 4.4.

Table 5.8 Total Capital Cost Recycled Water Master Plan City of Hesperia	
Category	Capital Cost (\$M)
Pipelines	\$54.9
Storage Tanks	\$37.3
Pump Stations	\$8.1
Land Acquisition	\$1.3
Customer Connection (3,600 x 57)	\$0.2
Customer Retrofits (25,000 x 47)	\$1.2
Total	\$103.0

5.3 FEASIBILITY ANALYSIS

The unit cost (in dollars per acre-foot (acre-ft)) of the entire potential recycled water system as shown on Figure 4.4 was estimated. This unit cost was based on a depreciation period of 50 years, total capital cost of \$103.0 million, and an average demand of 5.4 mgd. The unit cost of the entire system is \$931/acre-ft. To increase the cost-effectiveness of the recycled water system, small diameter dead-end pipelines serving relatively small demands were analyzed by comparing their unit cost in dollars per acre-ft per year to the unit cost of the entire potential recycled water system. Table 5.9 shows the capital cost and cost per acre-ft of the pipelines serving these customers.

Table 5.9 Cost Benefit of Pipelines Recycled Water Master Plan City of Hesperia

Customers Served ⁽¹⁾	Year	Length (ft)	Capital Cost	Total Demand (acre-ft/yr)	Unit Cost ⁽²⁾ (\$/acre-ft)	Feasible?
12, 23, and 29	2022	25,500	\$3,001,000	51	\$3,223	No
24 and 36	2012	3,500	\$406,000	43	\$516	Yes
18, 49, and 53	2012	10,000	\$1,180,000	125	\$517	Yes
33 and 38	2022	11,500	\$1,317,000	63	\$1,145	No
47, 48, and 54	2022	21,000	\$2,451,000	67	\$2,003	No
43	2032	5,500	\$630,000	273	\$126	Yes
Total Unfeasible	N/A	45,500	\$6,769,000	181	N/A	No
Total Feasible	N/A	19,000	\$2,216,000	441	N/A	Yes
Notes: (1) Customer numbers and locations are shown on Figure 3.3. (2) Based on amortized capital cost using a depreciation period of 50 years and a 5 percent interest rate.						

Based on the information presented in Table 5.9, it can be concluded that the pipelines serving Customers 12, 23, 29, 33, 38, 47, 48, and 54 are not cost-effective and therefore should be removed from the potential recycled water system. Customers 47 and 48 also have a pump station with an estimated capital cost of \$700,000. By eliminating these customers, the pump station can also be avoided. Subtracting these costs results in a new total capital cost of \$95.5 million. This equates to a unit cost of \$890 per acre-ft. Table 5.10 summarizes the cost differences between the potential (all 57 customers) and recommended (50 customers) recycled water systems. Figure 5.1 shows the recommended recycled water system as well as the eliminated pipelines (dashed) and all 57 potential customers.

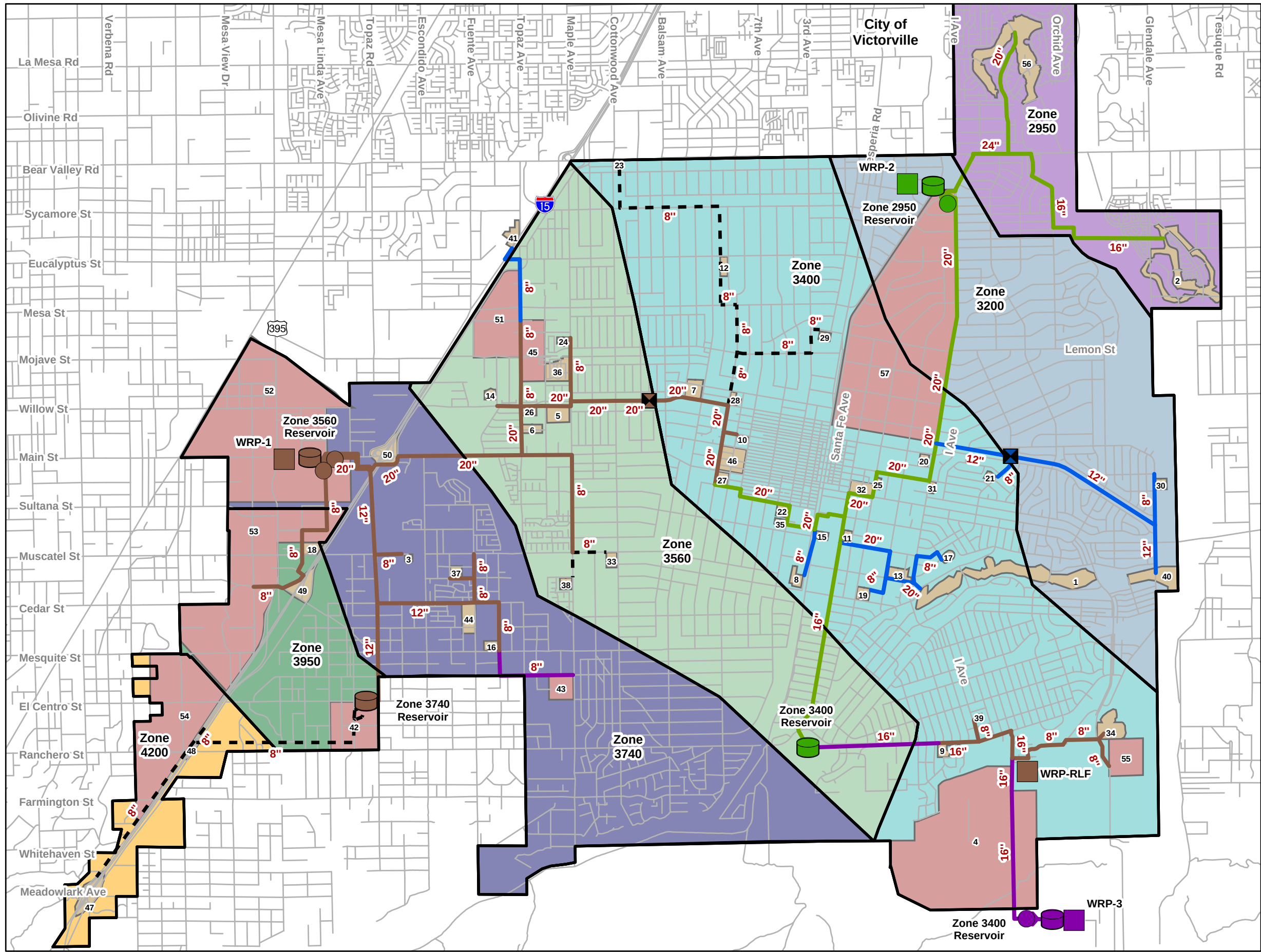
Table 5.10 Cost Comparison of Initial and Recommended System Recycled Water Master Plan City of Hesperia			
Project	Total Demand (acre-ft/yr)	Capital Cost (\$M/yr) ⁽¹⁾	Unit Cost (\$/acre-ft)
Potential Recycled Water System	6,060	\$103.0	\$931
Eliminated Pipelines	-181	-\$6.77	\$2,048
Eliminated Pump Stations	N/A	-\$0.70	-\$569
Proposed Recycled Water System	5,879	\$95.5	\$890
Notes: (1) Based on the present worth value using a period of 50 years and a 5-percent interest rate. (2) The reduced demand is already included under "eliminated pipelines."			

5.4 CAPITAL IMPROVEMENT PROGRAM

5.4.1 Project Phasing

The recommended recycled water system phasing is based on the available flow of the WRPs. Table 4.4 presents the phasing of the three treatment facilities, reaching a total flow of 15.9 mgd in 2032. The pipeline projects and facilities were phased such that a maximum number of customers are served based on the available recycled water supply. Similar to the water and wastewater CIPs that are prepared concurrently, the project was divided into four phasing periods.

- Phase 1, Present – 2012: No recycled water service. Construction of WRP-1.
- Phase 2, 2013 – 2017: Construction of WRP-2 and WRP-3. WRP-1 recycled water service of up to 2.3 mgd.
- Phase 3, 2018 – 2022: Construction of pipes in Zones 3200 and 3400. Combined WRP-1 and WRP-2 recycled water service of up to 7.9 mgd. The recycled water from WRP-3 is projected to reach up to 2.5 mgd.
- Phase 4, 2023 – 2032: Expansion of system due to flow increases. The combined recycled water supply from WRP-1 and WRP-2 is projected to reach up to 12.2 mgd. The recycled water from WRP-3 is projected to reach up to 3.7 mgd.



Legend

Proposed Water Reclamation Plant (WRP)

- WRP 1/WRP RLF (2012)
- WRP 2 (2017)
- WRP 3 (2032)

Proposed RW Pump Station

- 2012
- 2017
- 2022
- 2032

Proposed RW Tank

- 2012
- 2017
- 2032

Proposed RW PRV

- 2012
- 2022

Potential Recycled Water System

- 2012
- 2017
- 2022
- 2032
- Eliminated Pipelines Per Feasibility Study

Pressure Zone

- 2950
- 3200
- 3400
- 3560
- 3740
- 3950
- 4200
- Existing Potable Water Customers
- Future Developments
- Roadways
- Study Area

0 1 2 Miles

**FIGURE 5.1
PROPOSED RECYCLED
WATER SYSTEM
BY PHASE
RECYCLED WATER
MASTER PLAN
CITY OF HESPERIA**

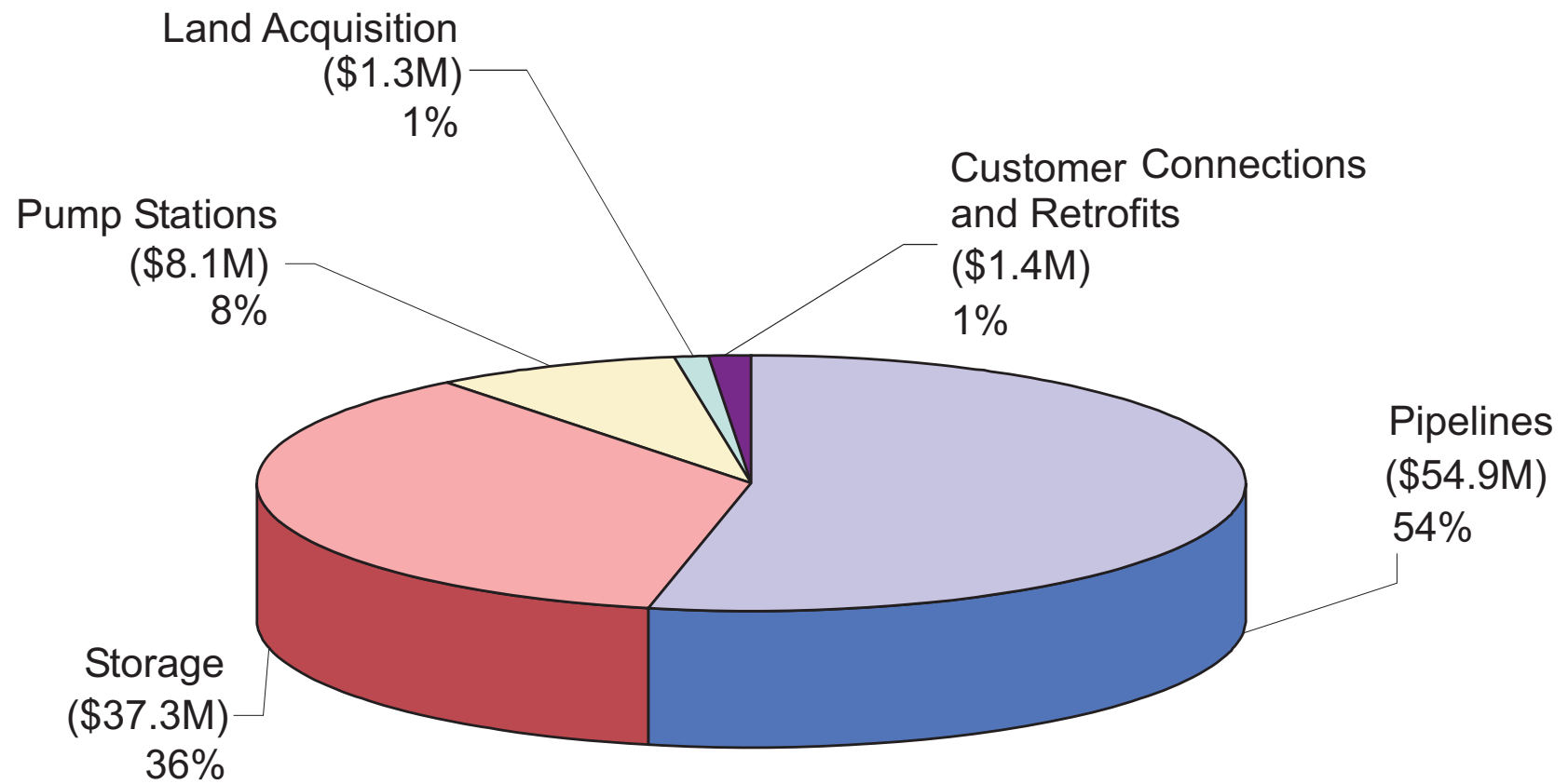
Table 5.11 summarizes the phasing of the proposed recycled water system according to customers served, total demand, and pipeline length. The phasing is also shown on Figure 5.1.

Table 5.11 Recycled Water System by Phase Recycled Water Master Plan City of Hesperia				
Phase	Customers Served	Total Demand (mgd)	Pipe Length (mi)	
2007 – 2012	None	None	16	
2013 – 2017	3, 5, 6, 7, 10, 14, 16, 18, 24, 26, 27, 28, 36, 37, 44, 45, 46, 49, 50, 51, 52, 53	0.91	36	
2018 – 2022	Above and 2, 4, 9, 20, 22, 25, 31, 32, 34, 35, 39, 55, 56, 57	3.58	53	
2023 - 2032	Above and 1, 8, 11, 12, 13, 15, 17, 19, 21, 23, 29, 30, 33, 38, 40, 41, 42, 43, 47, 48, 54	5.41	54	

5.4.2 Phasing of Project Cost

The cost for each of the phasing periods is summarized in Table 5.12. As shown, the period 2013 to 2017 requires the highest capital investment of all phases with \$48 million, or 47 percent of the total. Pipelines are the most costly by component with \$55 million, or 53 percent of the total capital cost. Figure 5.2 presents the distribution of capital cost by component.

Table 5.12 Phasing of Capital Costs Recycled Water Master Plan City of Hesperia					
System Component	2007-2012 (\$M)	2013-2017 (\$M)	2018-2022 (\$M)	2023-2032 (\$M)	Total
Pipelines	\$16.7	\$24.3	\$13.1	\$0.84	\$54.9
Storage	\$15.7	\$21.6	-	-	\$37.3
Pump Stations	-	\$1.31	\$6.10	\$0.70	\$8.1
Land Acquisition	\$0.50	\$0.81	-	-	\$1.3
Customer Connections and Retrofits	\$0.50	\$0.35	\$0.50	\$0.03	\$1.4
Total	\$33.4	\$48.3	\$19.7	\$1.6	\$103.0



Total Capital Cost = \$103.0 M

**FIGURE 5.2
DISTRIBUTION OF
CAPITAL COST**



As shown in Table 5.12, the unit cost of the recycled water system decreases over time from \$4,415/ac-ft to \$913/acre-ft by 2032. The unit costs are initially very high due to the high up-front cost required for the construction of the backbone system. Once the backbone facilities are in-place, new customers can be added with relatively low investments, while increasing the overall system demand.

Table 5.12 Phasing of Unit Costs Recycled Water Master Plan City of Hesperia				
System Component	2007–2012	2013–2017	2018–2022	2023–2032
Capital Cost by Phase (\$M)	\$33.4	\$48.3	\$19.7	\$1.6
Cumulative Capital Cost (\$M)	\$33.4	\$81.7	\$101.4	\$103.0
Recycled Water Demand by Phase (acre-ft/yr)	-	1,014	2,996	2,047
Cumulative Recycled Water Demand (acre-ft/yr)	-	1,014	4,011	6,058
Unit Cost (\$/acre-ft) ⁽¹⁾	-	\$2,610	\$360	\$42
Cumulative Unit Cost (\$/acre-ft) ⁽¹⁾	-	\$4,415	\$1,385	\$913
Notes: (1) Based on the present worth value using a depreciation period of 50 years and a 5-percent interest rate.				

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